1. Introduction

A Joint WHO/FAO Expert Consultation on Diet, Nutrition and the Prevention of Chronic Diseases met in Geneva from 28 January to 1 February 2002. The meeting was opened by Dr D. Yach, Executive Director, Noncommunicable Diseases and Mental Health, WHO, on behalf of the Directors-General of the Food and Agriculture Organization of the United Nations and the World Health Organization. The Consultation followed up the work of a WHO Study Group on Diet, Nutrition and Prevention of Noncommunicable Diseases, which had met in 1989 to make recommendations regarding the prevention of chronic diseases and the reduction of their impact (*1*). The Consultation recognized that the growing epidemic of chronic disease afflicting both developed and developing countries was related to dietary and lifestyle changes and undertook the task of reviewing the considerable scientific progress that has been made in different areas. For example, there is better epidemiological evidence for determining certain risk factors, and the results of a number of new controlled clinical trials are now available. The mechanisms of the chronic disease process are clearer, and interventions have been demonstrated to reduce risk.

During the past decade, rapid expansion in a number of relevant scientific fields and, in particular, in the amount of population-based epidemiological evidence has helped to clarify the role of diet in preventing and controlling morbidity and premature mortality resulting from noncommunicable diseases (NCDs). Some of the specific dietary components that increase the probability of occurrence of these diseases in individuals, and interventions to modify their impact, have also been identified.

Furthermore, rapid changes in diets and lifestyles that have occurred with industrialization, urbanization, economic development and market globalization, have accelerated over the past decade. This is having a significant impact on the health and nutritional status of populations, particularly in developing countries and in countries in transition. While standards of living have improved, food availability has expanded and become more diversified, and access to services has increased, there have also been significant negative consequences in terms of inappropriate dietary patterns, decreased physical activities and increased tobacco use, and a corresponding increase in diet-related chronic diseases, especially among poor people.

Food and food products have become commodities produced and traded in a market that has expanded from an essentially local base to an increasingly global one. Changes in the world food economy are

reflected in shifting dietary patterns, for example, increased consumption of energy-dense diets high in fat, particularly saturated fat, and low in unrefined carbohydrates. These patterns are combined with a decline in energy expenditure that is associated with a sedentary lifestyle – motorized transport, labour-saving devices in the home, the phasing out of physically demanding manual tasks in the workplace, and leisure time that is preponderantly devoted to physically undemanding pastimes.

Because of these changes in dietary and lifestyle patterns, chronic NCDs – including obesity, diabetes mellitus, cardiovascular disease (CVD), hypertension and stroke, and some types of cancer – are becoming increasingly significant causes of disability and premature death in both developing and newly developed countries, placing additional burdens on already overtaxed national health budgets.

The Consultation provided an opportune moment for FAO and WHO to draw on the latest scientific evidence available and to update recommendations for action to governments, international agencies and concerned partners in the public and private sectors. The overall aim of these recommendations is to implement more effective and sustainable policies and strategies to deal with the increasing public health challenges related to diet and health.

The Consultation articulated a new platform, not just of dietary and nutrient targets, but of a concept of the human organism's subtle and complex relationship to its environment in relation to chronic diseases. The discussions took into account ecological, societal and behavioural aspects beyond causative mechanisms. The experts looked at diet within the context of the macroeconomic implications of public health recommendations on agriculture, and the global supply and demand for foodstuffs, both fresh and processed. The role of diet in defining the expression of genetic susceptibility to NCDs, the need for responsible and creative partnerships with both traditional and non-traditional partners, and the importance of addressing the whole life course, were all recognized.

Nutrition is coming to the fore as a major modifiable determinant of chronic disease, with scientific evidence increasingly supporting the view that alterations in diet have strong effects, both positive and negative, on health throughout life. Most importantly, dietary adjustments may not only influence present health, but may determine whether or not an individual will develop such diseases as cancer, cardiovascular disease and diabetes much later in life. However, these concepts have not led to a change in policies or in practice. In many developing countries, food policies remain focused only on undernutrition and are not addressing the prevention of chronic disease.

Although the primary purpose of the Consultation was to examine and develop recommendations for diet and nutrition in the prevention of chronic diseases, the need for sufficient physical activity was also discussed and is therefore emphasized in the report. This emphasis is consistent with the trend to consider physical activity alongside the complex of diet, nutrition and health. Some relevant aspects include:

- Energy expenditure through physical activity is an important part of the energy balance equation that determines body weight. A decrease in energy expenditure through decreased physical activity is likely to be one of the major factors contributing to the global epidemic of overweight and obesity.
- Physical activity has great influence on body composition – on the amount of fat, muscle and bone tissue.
- To a large extent, physical activity and nutrients share the same metabolic pathways and can interact in various ways that influence the risk and pathogenesis of several chronic diseases.
- Cardiovascular fitness and physical activity have been shown to reduce significantly the effects of overweight and obesity on health.
- Physical activity and food intake are both specific and mutually interacting behaviours that are and can be influenced partly by the same measures and policies.
- Lack of physical activity is already a global health hazard and is a prevalent and rapidly increasing problem in both developed and developing countries, particularly among poor people in large cities.

In order to achieve the best results in preventing chronic diseases, the strategies and policies that are applied must fully recognize the essential role of diet, nutrition and physical activity.

This report calls for a shift in the conceptual framework for developing strategies for action, placing nutrition – together with the other principal risk factors for chronic disease, namely, tobacco use and alcohol consumption – at the forefront of public health policies and programmes.

Reference

1. *Diet, nutrition, and the prevention of chronic diseases. Report of a WHO Study Group*. Geneva, World Health Organization, 1990 (WHO Technical Report Series, No. 797).

2. Background

2.1 The global burden of chronic diseases

Diet and nutrition are important factors in the promotion and maintenance of good health throughout the entire life course. Their role as determinants of chronic NCDs is well established and they therefore occupy a prominent position in prevention activities (*1*).

The latest scientific evidence on the nature and strength of the links between diet and chronic diseases is examined and discussed in detail in the following sections of this report. This section gives an overall view of the current situation and trends in chronic diseases at the global level. The chronic diseases considered in this report are those that are related to diet and nutrition and present the greatest public health burden, either in terms of direct cost to society and government, or in terms of disability-adjusted life years (DALYs). These include obesity, diabetes, cardiovascular diseases, cancer, osteoporosis and dental diseases.

The burden of chronic diseases is rapidly increasing worldwide. It has been calculated that, in 2001, chronic diseases contributed approximately 60% of the 56.5 million total reported deaths in the world and approximately 46% of the global burden of disease (*1*). The proportion of the burden of NCDs is expected to increase to 57% by 2020. Almost half of the total chronic disease deaths are attributable to cardiovascular diseases; obesity and diabetes are also showing worrying trends, not only because they already affect a large proportion of the population, but also because they have started to appear earlier in life.

The chronic disease problem is far from being limited to the developed regions of the world. Contrary to widely held beliefs, developing countries are increasingly suffering from high levels of public health problems related to chronic diseases. In five out of the six regions of WHO, deaths caused by chronic diseases dominate the mortality statistics (*1*). Although human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS), malaria and tuberculosis, along with other infectious diseases, still predominate in sub-Saharan Africa and will do so for the foreseeable future, 79% of all deaths worldwide that are attributable to chronic diseases are already occurring in developing countries (*2*).

It is clear that the earlier labelling of chronic diseases as "diseases of affluence" is increasingly a misnomer, as they emerge both in poorer countries and in the poorer population groups in richer countries. This shift in the pattern of disease is taking place at an accelerating rate; furthermore, it is occurring at a faster rate in developing countries than it did in the industrialized regions of the world half a century ago (*3*). This

rapid rate of change, together with the increasing burden of disease, is creating a major public health threat which demands immediate and effective action.

It has been projected that, by 2020, chronic diseases will account for almost three-quarters of all deaths worldwide, and that 71% of deaths due to ischaemic heart disease (IHD), 75% of deaths due to stroke, and 70% of deaths due to diabetes will occur in developing countries (*4*). The number of people in the developing world with diabetes will increase by more than 2.5-fold, from 84 million in 1995 to 228 million in 2025 (*5*). On a global basis, 60% of the burden of chronic diseases will occur in developing countries. Indeed, cardiovascular diseases are even now more numerous in India and China than in all the economically developed countries in the world put together (*2*). As for overweight and obesity, not only has the current prevalence already reached unprecedented levels, but the rate at which it is annually increasing in most developing regions is substantial (*3*). The public health implications of this phenomenon are staggering, and are already becoming apparent.

The rapidity of the changes in developing countries is such that a double burden of disease may often exist. India, for example, at present faces a combination of communicable diseases and chronic diseases, with the burden of chronic diseases just exceeding that of communicable diseases. Projections nevertheless indicate that communicable diseases will still occupy a critically important position up to 2020 (*6*). Another eloquent example is that of obesity, which is becoming a serious problem throughout Asia, Latin America and parts of Africa, despite the widespread presence of undernutrition. In some countries, the prevalence of obesity has doubled or tripled over the past decade.

Chronic diseases are largely preventable diseases. Although more basic research may be needed on some aspects of the mechanisms that link diet to health, the currently available scientific evidence provides a sufficiently strong and plausible basis to justify taking action now. Beyond the appropriate medical treatment for those already affected, the public health approach of primary prevention is considered to be the most cost-effective, affordable and sustainable course of action to cope with the chronic disease epidemic worldwide. The adoption of a common risk-factor approach to chronic disease prevention is a major development in the thinking behind an integrated health policy. Sometimes chronic diseases are considered communicable at the risk factor level (*7*). Modern dietary patterns and physical activity patterns are risk behaviours that travel across countries and are transferable from one population to another like an infectious disease, affecting disease patterns globally.

While age, sex and genetic susceptibility are non-modifiable, many of the risks associated with age and sex are modifiable. Such risks include behavioural factors (e.g. diet, physical inactivity, tobacco use, alcohol consumption); biological factors (e.g. dyslipidemia, hypertension, overweight, hyperinsulinaemia); and finally societal factors, which include a complex mixture of interacting socioeconomic, cultural and other environmental parameters.

Diet has been known for many years to play a key role as a risk factor for chronic diseases. What is apparent at the global level is that great changes have swept the entire world since the second half of the twentieth century, inducing major modifications in diet, first in industrial regions and more recently in developing countries. Traditional, largely plant-based diets have been swiftly replaced by high-fat, energy-dense diets with a substantial content of animal-based foods. But diet, while critical to prevention, is just one risk factor. Physical inactivity, now recognized as an increasingly important determinant of health, is the result of a progressive shift of lifestyle towards more sedentary patterns, in developing countries as much as in industrialized ones. Recent data from São Paulo, Brazil, for example, indicate that 70–80% of the population are remarkably inactive (*8*). The combination of these and other risk factors, such as tobacco use, is likely to have an additive or even a multiplier effect, capable of accelerating the pace at which the chronic disease epidemic is emerging in the developing countries.

The need for action to strengthen control and prevention measures to counter the spread of the chronic disease epidemic is now widely recognized by many countries, but the developing countries are lagging behind in implementing such measures. Encouragingly, however, efforts to counteract the rise in chronic diseases are increasingly being assigned a higher priority. This situation is reflected by the growing interest of Member States, the concerned international and bilateral agencies as well as nongovernmental organizations in addressing food and nutrition policy, health promotion, and strategy for the control and prevention of chronic diseases, as well as other related topics such as promoting healthy ageing and tobacco control. The 1992 International Conference on Nutrition specifically identified the need to prevent and control the increasing public health problems of chronic diseases by promoting appropriate diets and healthy lifestyles (*9–11*). The need to address chronic disease prevention from a broad-based perspective was also recognized by the World Health Assembly in 1998 (*12*) and again in 1999 (*13*). In 2000, the World Health Assembly passed a further resolution on the broad basis of the prevention and control of noncommunicable diseases (*14*), and in 2002 adopted a resolution that urged Member States to collaborate with WHO to develop "...a global strategy on diet,

physical activity and health for the prevention and control of noncommunicable diseases, based on evidence and best practices, with special emphasis on an integrated approach...'' (*15*).

Several factors have constrained progress in the prevention of chronic diseases. These include underestimation of the effectiveness of interventions, the belief of there being a long delay in achieving any measurable impact, commercial pressures, institutional inertia and inadequate resources. These aspects need to be taken seriously and combated. One example is provided by Finland. In North Karelia, age-adjusted mortality rates of coronary heart disease dropped dramatically between the early 1970s and 1995 (*16*). Analyses of the three main risk factors (smoking, high blood pressure, raised plasma cholesterol) indicate that diet — operating through lowering plasma cholesterol and blood pressure levels — accounted for the larger part of this substantial decline in cardiovascular disease. The contribution made by medication and treatment (antilipid and hypotensive drugs, surgery) was very small. Rather, the decline was largely achieved through community action and the pressure of consumer demand on the food market. The Finnish and other experience indicates that interventions can be effective, that dietary changes are important, that these changes can be strengthened by public demand, and finally that appreciable changes can take place very rapidly. The experience of the Republic of Korea is also notable since the community has largely maintained its traditional high-vegetable diet despite major social and economic change (*17*). The Republic of Korea has lower rates of chronic diseases and lower than expected level of fat intake and obesity prevalence than other industrialized countries with similar economic development (*18*).

There are several opportunities for new global and national actions, including strengthened interaction and partnerships; regulatory, legislative and fiscal approaches; and more stringent accountability mechanisms.

The broad parameters for a dialogue with the food industries are: less saturated fat; more fruits and vegetables; effective food labelling; and incentives for the marketing and production of healthier products. In working with advertising, media and entertainment partners, there is a need to stress the importance of clear and unambiguous messages to children and youths. Global ''health and nutrition literacy'' requires a vast increase in attention and resources.

Many studies show a relationship between health and income, with the poorest sections of the population being the most vulnerable. Poor people are at an increased social disadvantage in terms of the incidence of chronic diseases, as well as access to treatment. They also show lower

rates of acceptance of health-promoting behaviours compared with other sectors of society. Thus, policies need to favour the poor and appropriately targeted, as poor people are most at risk and have the least power to effect change.

2.2 The double burden of diseases in the developing world

Hunger and malnutrition remain among the most devastating problems facing the majority of the world's poor and needy people, and continue to dominate the health of the world's poorest nations. Nearly 30% of humanity are currently suffering from one or more of the multiple forms of malnutrition (*19*).

The tragic consequences of malnutrition include death, disability, stunted mental and physical growth, and as a result, retarded national socioeconomic development. Some 60% of the 10.9 million deaths each year among children aged under five years in the developing world are associated with malnutrition (*20*). Iodine deficiency is the greatest single preventable cause of brain damage and mental retardation worldwide, and is estimated to affect more than 700 million people, most of them located in the less developed countries (*21*). Over 2000 million people have iron deficiency anaemia (*22*). Vitamin A deficiency remains the single greatest preventable cause of needless childhood blindness and increased risk of premature childhood mortality from infectious diseases, with 250 million children under five years of age suffering from subclinical deficiency (*23*). Intrauterine growth retardation, defined as birth weight below the 10th percentile of the birth-weight-for-gestational-age reference curve, affects 23.8% or approximately 30 million newborn babies per year, profoundly influencing growth, survival, and physical and mental capacity in childhood (*24*). It also has major public health implications in view of the increased risk of developing diet-related chronic diseases later in life (*25–31*).

Given the rapidity with which traditional diets and lifestyles are changing in many developing countries, it is not surprising that food insecurity and undernutrition persist in the same countries where chronic diseases are emerging as a major epidemic. The epidemic of obesity, with its attendant comorbidities — heart disease, hypertension, stroke, and diabetes — is not a problem limited to industrialized countries (*32*). Children are in a similar situation; a disturbing increase in the prevalence of overweight among this group has taken place over the past 20 years in developing countries as diverse as India, Mexico, Nigeria and Tunisia (*33*). The increasing prevalence of obesity in developing countries also indicates that physical inactivity is an increasing problem in those countries as well.

In the past, undernutrition and chronic diseases were seen as two totally separate problems, despite being present simultaneously. This dichotomy has obstructed effective action to curb the advancing epidemic of chronic diseases. For example, the prevailing approach of measuring child undernutrition on the basis of the underweight indicator (weight-for-age) can lead to gross underestimation of the presence of obesity in populations that have a high prevalence of stunting. Use of this indicator could lead aid programmes to feed apparently underweight people, with the undesirable outcome of further aggravating obesity. In Latin America, close to 90 million people are beneficiaries of food programmes (*34*) but that group actually comprises only 10 million truly underweight people (after correcting for height). The two facets of nutrition-related problems need to be brought together and treated in the context of the whole spectrum of malnutrition.

2.3 An integrated approach to diet-related and nutrition-related diseases

The root causes of malnutrition include poverty and inequity. Eliminating these causes requires political and social action of which nutritional programmes can be only one aspect. Sufficient, safe and varied food supplies not only prevent malnutrition but also reduce the risk of chronic diseases. It is well known that nutritional deficiency increases the risk of common infectious diseases, notably those of childhood, and vice versa (*35, 36*). There is, therefore, complementarity in terms of public health approaches and public policy priorities, between policies and programmes designed to prevent chronic diseases and those designed to prevent other diet-related and nutrition-related diseases.

The double burden of disease is most effectively lifted by a range of integrated policies and programmes. Such an integrated approach is the key to action in countries where modest public health budgets will inevitably remain mostly devoted to prevention of deficiency and infection. Indeed, there is no country, however privileged, in which combating deficiency and infection are no longer public health priorities. High-income countries accustomed to programmes designed to prevent chronic diseases can amplify the effectiveness of the programmes by applying them to the prevention of nutritional deficiency and food-related infectious diseases.

Guidelines designed to give equal priority to the prevention of nutritional deficiency and chronic diseases, have already been established for the Latin American region (*37*). Recent recommendations to prevent cancer are reckoned also to reduce the risk of nutritional

deficiency and food-related infectious diseases (*38*), and dietary guidelines for the Brazilian population give equal priority to the prevention and control of nutritional deficiency, food-related infectious diseases, and chronic diseases (*39*).

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3. Global and regional food consumption patterns and trends

3.1 Introduction

Promoting healthy diets and lifestyles to reduce the global burden of noncommunicable diseases requires a multisectoral approach involving the various relevant sectors in societies. The agriculture and food sector figures prominently in this enterprise and must be given due importance in any consideration of the promotion of healthy diets for individuals and population groups. Food strategies must not merely be directed at ensuring food security for all, but must also achieve the consumption of adequate quantities of safe and good quality foods that together make up a healthy diet. Any recommendation to that effect will have implications for all components in the food chain. It is therefore useful at this juncture to examine trends in consumption patterns worldwide and deliberate on the potential of the food and agriculture sector to meet the demands and challenges posed by this report.

Economic development is normally accompanied by improvements in a country's food supply and the gradual elimination of dietary deficiencies, thus improving the overall nutritional status of the country's population. Furthermore, it also brings about qualitative changes in the production, processing, distribution and marketing of food. Increasing urbanization will also have consequences for the dietary patterns and lifestyles of individuals, not all of which are positive. Changes in diets, patterns of work and leisure – often referred to as the "nutrition transition" – are already contributing to the causal factors underlying noncommunicable diseases even in the poorest countries. Moreover, the pace of these changes seems to be accelerating, especially in the low-income and middle-income countries.

The dietary changes that characterize the "nutrition transition" include both quantitative and qualitative changes in the diet. The adverse dietary changes include shifts in the structure of the diet towards a higher energy density diet with a greater role for fat and added sugars in foods, greater saturated fat intake (mostly from animal sources), reduced intakes of complex carbohydrates and dietary fibre, and reduced fruit and vegetable intakes (*1*). These dietary changes are compounded by lifestyle changes that reflect reduced physical activity at work and during leisure time (*2*). At the same time, however, poor countries continue to face food shortages and nutrient inadequacies.

Diets evolve over time, being influenced by many factors and complex interactions. Income, prices, individual preferences and beliefs, cultural traditions, as well as geographical, environmental, social and economic

factors all interact in a complex manner to shape dietary consumption patterns. Data on the national availability of the main food commodities provide a valuable insight into diets and their evolution over time. FAO produces annual Food Balance Sheets which provide national data on food availability (for almost all commodities and for nearly all countries). Food Balance Sheets give a complete picture of supply (including production, imports, stock changes and exports) and utilization (including final demand in the form of food use and industrial non-food use, intermediate demand such as animal feed and seed use, and waste) by commodity. From these data, the average per capita supply of macronutrients (i.e. energy, protein, fats) can be derived for all food commodities. Although such average per capita supplies are derived from national data, they may not correspond to actual per capita availability, which is determined by many other factors such as inequality in access to food. Likewise, these data refer to "average food available for consumption", which, for a number of reasons (for example, waste at the household level), is not equal to average food intake or average food consumption. In the remainder of this chapter, therefore, the terms "food consumption" or "food intake" should be read as "food available for consumption".

Actual food availability may vary by region, socioeconomic level and season. Certain difficulties are encountered when estimating trade, production and stock changes on an annual scale. Hence three-year averages are calculated in order to reduce errors. The FAO statistical database (FAOSTAT), being based on national data, does not provide information on the distribution of food within countries, or within communities and households.

3.2 Developments in the availability of dietary energy

Food consumption expressed in kilocalories (kcal) per capita per day is a key variable used for measuring and evaluating the evolution of the global and regional food situation. A more appropriate term for this variable would be "national average apparent food consumption" since the data come from national Food Balance Sheets rather than from food consumption surveys. Analysis of FAOSTAT data shows that dietary energy measured in kcals per capita per day has been steadily increasing on a worldwide basis; availability of calories per capita from the mid-1960s to the late 1990s increased globally by approximately 450 kcal per capita per day and by over 600 kcal per capita per day in developing countries (see Table 1). This change has not, however, been equal across regions. The per capita supply of calories has remained almost stagnant in sub-Saharan Africa and has recently fallen in the countries in economic transition. In contrast, the per capita supply of energy has risen dramatically in East Asia

(by almost 1000 kcal per capita per day, mainly in China) and in the Near East/North Africa region (by over 700 kcal per capita per day).

Table 1
Global and regional per capita food consumption (kcal per capita per day)

Region	1964–1966	1974–1976	1984–1986	1997–1999	2015	2030
World	2358	2435	2655	2803	2940	3050
Developing countries	2054	2152	2450	2681	2850	2980
Near East and North Africa	2290	2591	2953	3006	3090	3170
Sub-Saharan Africa[a]	2058	2079	2057	2195	2360	2540
Latin America and the Caribbean	2393	2546	2689	2824	2980	3140
East Asia	1957	2105	2559	2921	3060	3190
South Asia	2017	1986	2205	2403	2700	2900
Industrialized countries	2947	3065	3206	3380	3440	3500
Transition countries	3222	3385	3379	2906	3060	3180

[a] Excludes South Africa.

Source: reproduced, with minor editorial amendments from reference *3* with the permission of the publisher.

In short, it would appear that the world has made significant progress in raising food consumption per person. The increase in the world average consumption would have been higher but for the declines in the transition economies that occurred in the 1990s. It is generally agreed, however, that those declines are likely to revert in the near future. The growth in food consumption has been accompanied by significant structural changes and a shift in diet away from staples such as roots and tubers towards more livestock products and vegetable oils (*4*). Table 1 shows that current energy intakes range from 2681 kcal per capita per day in developing countries, to 2906 kcal per capita per day in transition countries and 3380 kcal per capita per day in industrialized countries. Data shown in Table 2 suggest that per capita energy supply has declined from both animal and vegetable sources in the countries in economic transition, while it has increased in the developing and industrialized countries.

Table 2
Vegetable and animal sources of energy in the diet (kcal per capita per day)

Region	1967–1969			1977–1979			1987–1989			1997–1999		
	T	V	A	T	V	A	T	V	A	T	V	A
Developing countries	2059	1898	161	2254	2070	184	2490	2248	242	2681	2344	337
Transition countries	3287	2507	780	3400	2507	893	3396	2455	941	2906	2235	671
Industrialized countries	3003	2132	871	3112	2206	906	3283	2333	950	3380	2437	943

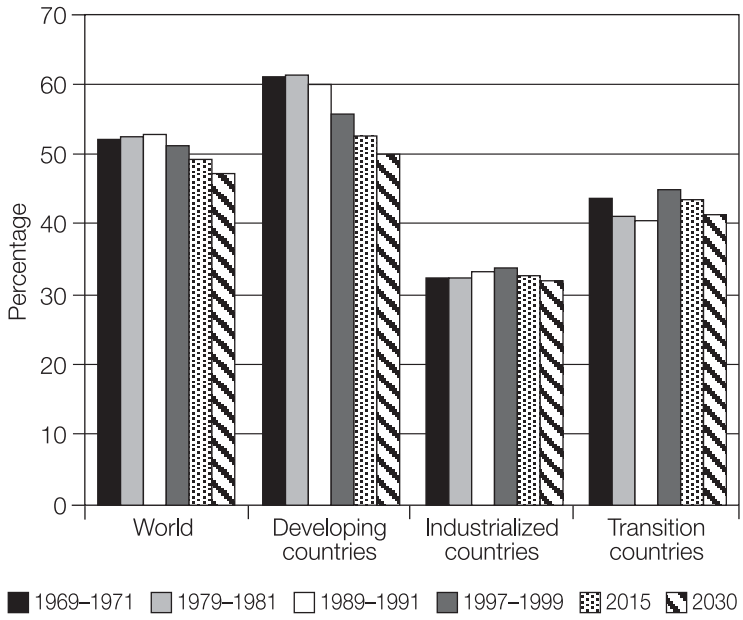
T, total kcal; V, kcal of vegetable origin; A, kcal of animal origin (including fish products).

Source: FAOSTAT, 2003.

Similar trends are evident for protein availability; this has increased in both developing and industrialized countries but decreased in the transition countries. Although the global supply of protein has been increasing, the distribution of the increase in the protein supply is unequal. The per capita supply of vegetable protein is slightly higher in developing countries, while the supply of animal protein is three times higher in industrialized countries.

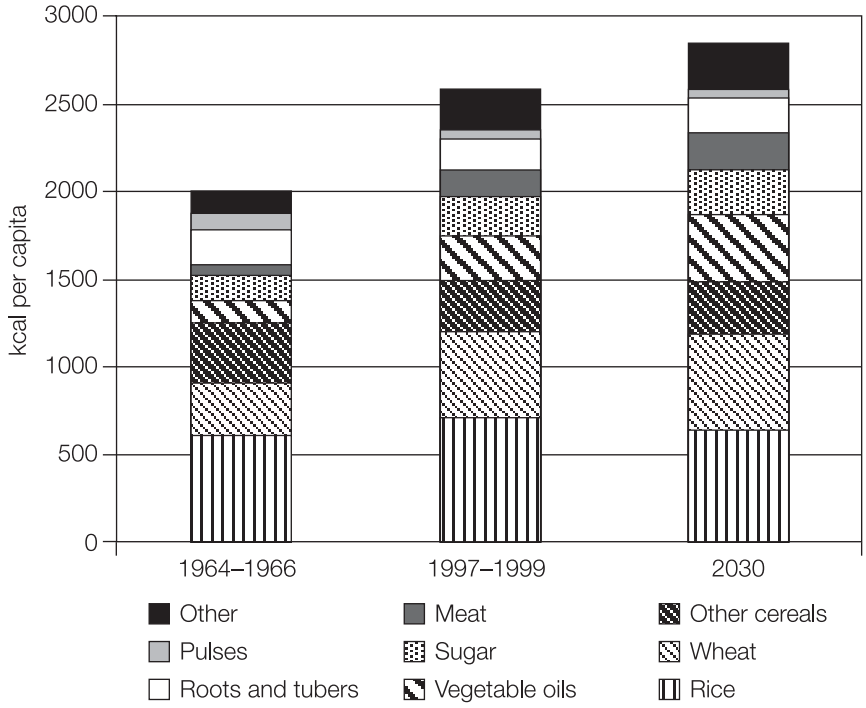
Globally, the share of dietary energy supplied by cereals appears to have remained relatively stable over time, representing about 50% of dietary energy supply. Recently, however, subtle changes appear to be taking place (see Fig. 1). A closer analysis of the dietary energy intake shows a decrease in developing countries, where the share of energy derived from cereals has fallen from 60% to 54% in a period of only 10 years. Much of this downwards trend is attributable to cereals, particularly wheat and rice, becoming less preferred foods in middle-income countries such as Brazil and China, a pattern likely to continue over the next 30 years or so. Fig. 2 shows the structural changes in the diet of developing countries over the past 30–40 years and FAO's projections to the year 2030 (*3*).

Figure 1
The share of dietary energy derived from cereals



Source: adapted from reference *4* with the permission of the publisher. WHO 03.19

Figure 2
Calories from major commodities in developing countries



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3.3 Availability and changes in consumption of dietary fat

The increase in the quantity and quality of the fats consumed in the diet is an important feature of nutrition transition reflected in the national diets of countries. There are large variations across the regions of the world in the amount of total fats (i.e. fats in foods, plus added fats and oils) available for human consumption. The lowest quantities consumed are recorded in Africa, while the highest consumption occurs in parts of North America and Europe. The important point is that there has been a remarkable increase in the intake of dietary fats over the past three decades (see Table 3) and that this increase has taken place practically everywhere except in Africa, where consumption levels have stagnated. The per capita supply of fat from animal foods has increased, respectively, by 14 and 4 g per capita in developing and industrialized countries, while there has been a decrease of 9 g per capita in transition countries.

Table 3
Trends in the dietary supply of fat

Region	Supply of fat (g per capita per day)				
	1967–1969	1977–1979	1987–1989	1997–1999	Change between 1967–1969 and 1997–1999
World	53	57	67	73	20
North Africa	44	58	65	64	20
Sub-Saharan Africa[a]	41	43	41	45	4
North America	117	125	138	143	26
Latin America and the Caribbean	54	65	73	79	25
China	24	27	48	79	55
East and South-East Asia	28	32	44	52	24
South Asia	29	32	39	45	16
European Community	117	128	143	148	31
Eastern Europe	90	111	116	104	14
Near East	51	62	73	70	19
Oceania	102	102	113	113	11

[a] Excludes South Africa

Source: FAOSTAT, 2003.

The increase in dietary fat supply worldwide exceeds the increase in dietary protein supply. The average global supply of fat has increased by 20 g per capita per day since 1967–1969. This increase in availability has been most pronounced in the Americas, East Asia, and the European Community. The proportion of energy contributed by dietary fats exceeds 30% in the industrialized regions, and in nearly all other regions this share is increasing.

The fat-to-energy ratio (FER) is defined as the percentage of energy derived from fat in the total supply of energy (in kcal). Country-specific analysis of FAO data for 1988–1990 (*5*) found a range for the FER of 7–46%. A total of 19 countries fell below the minimum recommendation of 15% dietary energy supply from fat, the majority of these being in sub-Saharan Africa and the remainder in South Asia. In contrast, 24 countries were above the maximum recommendation of 35%, the majority of these countries being in North America and Western Europe. It is useful to note that limitations of the Food Balance Sheet data may contribute much of this variation in the FER between countries. For instance, in countries such as Malaysia with abundant availability of vegetable oils at low prices, Food Balance Sheet data may not reflect real consumption at the individual household level.

Rising incomes in the developing world have also led to an increase in the availability and consumption of energy-dense high-fat diets. Food balance data can be used to examine the shift in the proportion of energy from fat over time and its relationship to increasing incomes (*6*).

In 1961–1963, a diet providing 20% of energy from fat was associated only with countries having at least a per capita gross national product of US$ 1475. By 1990, however, even poor countries having a gross national product of only US$ 750 per capita had access to a similar diet comprising 20% of energy from fat. (Both values of gross national product are given in 1993 US$.) This change was mainly the result of an increase in the consumption of vegetable fats by poor countries, with smaller increases occurred in middle-income and high-income countries. By 1990, vegetable fats accounted for a greater proportion of dietary energy than animal fats for countries in the lowest per capita income category. Changes in edible vegetable oil supply, in prices and in consumption equally affected rich and poor countries, although the net impact was relatively much greater in low-income countries. An equally large and important shift in the proportion of energy from added sugars in the diets of low-income countries was also a feature of the nutrition transition (*1*).

Examinations of the purchasing habits of people, aimed at understanding the relationship between level of education or income and the different amounts or types of commodities purchased at different times were also revealing. Research conducted in China shows that there have been profound shifts in purchasing practices in relation to income over the past decade. These analyses show how extra income in China affects poor people and rich people in a differential manner, enhancing the fat intake of the poor more than that of the rich (*7*).

A variable proportion of these fat calories are provided by saturated fatty acids. Only in the two of the most affluent regions (i.e. in parts of North America and Europe) is the intake of saturated fat at or above 10% of energy intake level. In other less affluent regions, the proportion of dietary energy contributed by saturated fatty acids is lower, ranging from 5% to 8%, and generally not changing much over time. National dietary surveys conducted in some countries confirm these data. The ratio of dietary fat from animal sources to total fat is a key indicator, since foods from animal sources are high in saturated fat. Data sets used to calculate country-specific FERs can also be used to calculate proportions of animal fat in total fat. Such analysis indicated that the proportion of animal fat in total fat was lower than 10% in some countries (Democratic Republic of Congo, Mozambique, Nigeria, Sao Tome and Principe, and Sierra Leone), while it is above 75% in some other countries (Denmark, Finland, Hungary, Mongolia, Poland and Uruguay). These findings are not strictly divided along economic lines, as not all of the countries in the high range represent the most affluent countries. Country-specific food availability and cultural dietary preferences and norms to some extent determine these patterns.

The types of edible oils used in developing countries are also changing with the increasing use of hardened margarines (rich in trans fatty acids) that do not need to be refrigerated. Palm oil is becoming an increasingly important edible oil in the diets of much of South-East Asia and is likely to be a major source in the coming years. Currently, palm oil consumption is low and the FER ranges between 15% and 18%. At this low level of consumption, the saturated fatty acid content of the diet comprises only 4% to 8%. Potential developments in the edible oil sector could affect all stages of the oil production process from plant breeding to processing methods, including the blending of oils aimed at producing edible oils that have a healthy fatty acid composition.

Olive oil is an important edible oil consumed largely in the Mediterranean region. Its production has been driven by rising demand, which has increasingly shifted olive cultivation from traditional farms to more intensive forms of cultivation. There is some concern that the intensive cultivation of olives may have adverse environmental impacts, such as soil erosion and desertification (*8*). However, agricultural production methods are being developed to ensure less harmful impacts on the environment.

3.4 Availability and changes in consumption of animal products

There has been an increasing pressure on the livestock sector to meet the growing demand for high-value animal protein. The world's livestock sector is growing at an unprecedented rate and the driving force behind this enormous surge is a combination of population growth, rising incomes and urbanization. Annual meat production is projected to increase from 218 million tonnes in 1997–1999 to 376 million tonnes by 2030.

There is a strong positive relationship between the level of income and the consumption of animal protein, with the consumption of meat, milk and eggs increasing at the expense of staple foods. Because of the recent steep decline in prices, developing countries are embarking on higher meat consumption at much lower levels of gross domestic product than the industrialized countries did some 20–30 years ago.

Urbanization is a major driving force influencing global demand for livestock products. Urbanization stimulates improvements in infrastructure, including cold chains, which permit trade in perishable goods. Compared with the less diversified diets of the rural communities, city dwellers have a varied diet rich in animal proteins and fats, and characterized by higher consumption of meat, poultry, milk and other dairy products. Table 4 shows trends in per capita consumption of livestock products in different regions and country groups. There has been a remarkable increase in the consumption of animal products in

countries such as Brazil and China, although the levels are still well below the levels of consumption in North American and most other industrialized countries.

As diets become richer and more diverse, the high-value protein that the livestock sector offers improves the nutrition of the vast majority of the world. Livestock products not only provide high-value protein but are also important sources of a wide range of essential micronutrients, in particular minerals such as iron and zinc, and vitamins such as vitamin A. For the large majority of people in the world, particularly in developing countries, livestock products remain a desired food for nutritional value and taste. Excessive consumption of animal products in some countries and social classes can, however, lead to excessive intakes of fat.

Table 4
Per capita consumption of livestock products

Region	Meat (kg per year)			Milk (kg per year)		
	1964–1966	1997–1999	2030	1964–1966	1997–1999	2030
World	24.2	36.4	45.3	73.9	78.1	89.5
Developing countries	10.2	25.5	36.7	28.0	44.6	65.8
Near East and North Africa	11.9	21.2	35.0	68.6	72.3	89.9
Sub-Saharan Africa[a]	9.9	9.4	13.4	28.5	29.1	33.8
Latin America and the Caribbean	31.7	53.8	76.6	80.1	110.2	139.8
East Asia	8.7	37.7	58.5	3.6	10.0	17.8
South Asia	3.9	5.3	11.7	37.0	67.5	106.9
Industrialized countries	61.5	88.2	100.1	185.5	212.2	221.0
Transition countries	42.5	46.2	60.7	156.6	159.1	178.7

[a] Excludes South Africa.

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The growing demand for livestock products is likely to have an undesirable impact on the environment. For example, there will be more large-scale, industrial production, often located close to urban centres, which brings with it a range of environmental and public health risks. Attempts have been made to estimate the environmental impact of industrial livestock production. For instance, it has been estimated that the number of people fed in a year per hectare ranges from 22 for potatoes and 19 for rice to 1 and 2, respectively, for beef and lamb (*9*). The low energy conversion ratio from feed to meat is another concern, since some of the cereal grain food produced is diverted to livestock production. Likewise, land and water requirements for meat production are likely to become a major concern, as the increasing demand for animal products results in more intensive livestock production systems (*10*).

3.5 Availability and consumption of fish

Despite fluctuations in supply and demand caused by the changing state of fisheries resources, the economic climate and environmental conditions, fisheries, including aquaculture, have traditionally been, and remain an important source of food, employment and revenue in many countries and communities (*11*). After the remarkable increase in both marine and inland capture of fish during the 1950s and 1960s, world fisheries production has levelled off since the 1970s. This levelling off of the total catch follows the general trend of most of the world's fishing areas, which have apparently reached their maximum potential for fisheries production, with the majority of stocks being fully exploited. It is therefore very unlikely that substantial increases in total catch will be obtained in the future. In contrast, aquaculture production has followed the opposite path. Starting from an insignificant total production, inland and marine aquaculture production has been growing at a remarkable rate, offsetting part of the reduction in the ocean catch of fish.

The total food fish supply and hence consumption has been growing at a rate of 3.6% per year since 1961, while the world's population has been expanding at 1.8% per year. The proteins derived from fish, crustaceans and molluscs account for between 13.8% and 16.5% of the animal protein intake of the human population. The average apparent per capita consumption increased from about 9 kg per year in the early 1960s to 16 kg in 1997. The per capita availability of fish and fishery products has therefore nearly doubled in 40 years, outpacing population growth.

As well as income-related variations, the role of fish in nutrition shows marked continental, regional and national differences. In industrialized countries, where diets generally contain a more diversified range of animal proteins, a rise in per capita provision from 19.7 kg to 27.7 kg seems to have occurred. This represents a growth rate close to 1% per year. In this group of countries, fish contributed an increasing share of total protein intake until 1989 (accounting for between 6.5% and 8.5%), but since then its importance has gradually declined and, in 1997, its percentage contribution was back to the level prevailing in the mid-1980s. In the early 1960s, per capita fish supply in low-income food-deficit countries was, on average, only 30% of that of the richest countries. This gap has been gradually reduced, such that in 1997, average fish consumption in these countries was 70% of that of the more affluent economies. Despite the relatively low consumption by weight in low-income food-deficit countries, the contribution of fish to total animal protein intake is considerable (nearly 20%). Over the past four decades, however, the share of fish proteins in animal proteins has declined slightly, because of faster growth in the consumption of other animal products.

Currently, two-thirds of the total food fish supply is obtained from capture fisheries in marine and inland waters, while the remaining one-third is derived from aquaculture. The contribution of inland and marine capture fisheries to per capita food supply has stabilized, around 10 kg per capita in the period 1984–1998. Any recent increases in per capita availability have, therefore, been obtained from aquaculture production, from both traditional rural aquaculture and intensive commercial aquaculture of high-value species.

Fish contributes up to 180 kcal per capita per day, but reaches such high levels only in a few countries where there is a lack of alternative protein foods grown locally or where there is a strong preference for fish (examples are Iceland, Japan and some small island states). More typically, fish provides about 20–30 kcal per capita per day. Fish proteins are essential in the diet of some densely populated countries where the total protein intake level is low, and are very important in the diets of many other countries. Worldwide, about a billion people rely on fish as their main source of animal proteins. Dependence on fish is usually higher in coastal than in inland areas. About 20% of the world's population derives at least one-fifth of its animal protein intake from fish, and some small island states depend almost exclusively on fish.

Recommending the increased consumption of fish is another area where the feasibility of dietary recommendations needs to be balanced against concerns for sustainability of marine stocks and the potential depletion of this important marine source of high quality nutritious food. Added to this is the concern that a significant proportion of the world fish catch is transformed into fish meal and used as animal feed in industrial livestock production and thus is not available for human consumption.

3.6 Availability and consumption of fruits and vegetables

Consumption of fruits and vegetables plays a vital role in providing a diversified and nutritious diet. A low consumption of fruits and vegetables in many regions of the developing world is, however, a persistent phenomenon, confirmed by the findings of food consumption surveys. Nationally representative surveys in India (*12*), for example, indicate a steady level of consumption of only 120–140 g per capita per day, with about another 100 g per capita coming from roots and tubers, and some 40 g per capita from pulses. This may not be true for urban populations in India, who have rising incomes and greater access to a diverse and varied diet. In contrast, in China, – a country that is undergoing rapid economic growth and transition – the amount of fruits and vegetables consumed has increased to 369 g per capita per day by 1992.

At present, only a small and negligible minority of the world's population consumes the generally recommended high average intake of fruits and vegetables. In 1998, only 6 of the 14 WHO regions had an availability of fruits and vegetables equal to or greater than the earlier recommended intake of 400 g per capita per day. The relatively favourable situation in 1998 appears to have evolved from a markedly less favourable position in previous years, as evidenced by the great increase in vegetable availability recorded between 1990 and 1998 for most of the regions. In contrast, the availability of fruit generally decreased between 1990 and 1998 in most regions of the world.

The increase in urbanization globally is another challenge. Increasing urbanization will distance more people from primary food production, and in turn have a negative impact on both the availability of a varied and nutritious diet with enough fruits and vegetables, and the access of the urban poor to such a diet. Nevertheless, it may facilitate the achievement of other goals, as those who can afford it can have better access to a diverse and varied diet. Investment in periurban horticulture may provide an opportunity to increase the availability and consumption of a healthy diet.

Global trends in the production and supply of vegetables indicate that the current production and consumption vary widely among regions, as indicated in Table 5. It should be noted that the production of wild and indigenous vegetables is not taken into account in production statistics and might therefore be underestimated in consumption statistics. In 2000, the global annual average per capita vegetable supply was 102 kg, with the highest level in Asia (116 kg), and the lowest levels in South America (48 kg) and Africa (52 kg). These figures also include the large amount of horticultural produce that is consumed on the farm. Table 5 and Figure 3 illustrate the regional and temporal variations in the per capita availability of vegetables per capita over the past few decades.

Table 5
Supply of vegetables per capita, by region, 1979 and 2000 (kg per capita per year)

Region	1979	2000
World	66.1	101.9
Developed countries	107.4	112.8
Developing countries	51.1	98.8
Africa	45.4	52.1
North and Central America	88.7	98.3
South America	43.2	47.8
Asia	56.6	116.2
Europe	110.9	112.5
Oceania	71.8	98.7

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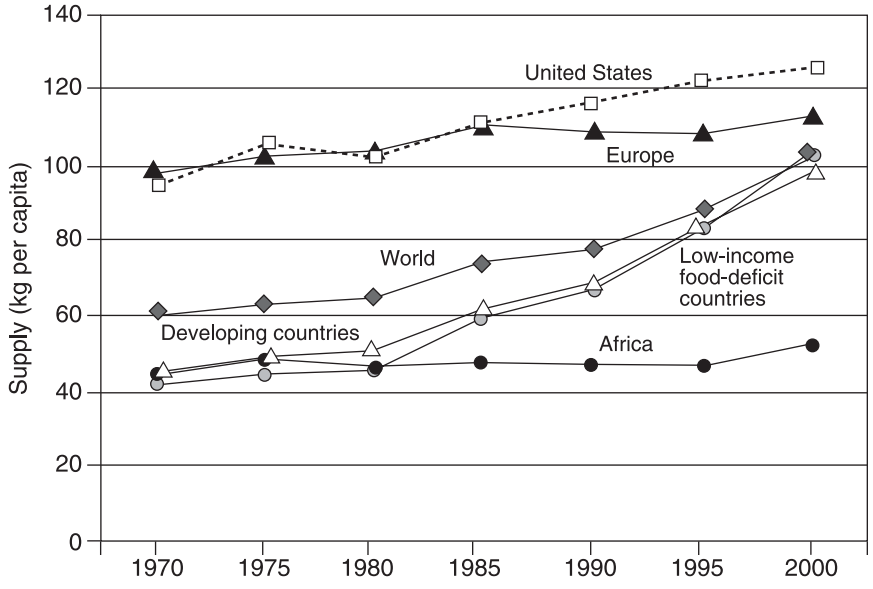
Figure 3
Trends in the supply of vegetables per capita, by region, 1970–2000



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3.7 Future trends in demand, food availability and consumption

In recent years the growth rates of world agricultural production and crop yields have slowed. This has raised fears that the world may not be able to grow enough food and other commodities to ensure that future populations are adequately fed. However, the slowdown has occurred not because of shortages of land or water but rather because demand for agricultural products has also slowed. This is mainly because world population growth rates have been declining since the late 1960s, and fairly high levels of food consumption per person are now being reached in many countries, beyond which further rises will be limited. It also true that a high share of the world's population remains in poverty and hence lacks the necessary income to translate its needs into effective demand. As a result, the growth in world demand for agricultural products is expected to fall from an average 2.2% per year over the past 30 years to an average 1.5% per year for the next 30 years. In developing countries the slowdown will be more dramatic, from 3.7% per year to 2% per year, partly as a result of China having passed the phase of rapid growth in its demand for food. Global food shortages are unlikely, but serious problems already exist at national and local levels, and may worsen unless focused efforts are made.

The annual growth rate of world demand for cereals has declined from 2.5% per year in the 1970s and 1.9% per year in the 1980s to only 1% per

year in the 1990s. Annual cereal use per person (including animal feeds) peaked in the mid-1980s at 334 kg and has since fallen to 317 kg. The decline is not a cause for alarm, it is largely the natural result of slower population growth and shifts in human diets and animal feeds. During the 1990s, however, the decline was accentuated by a number of temporary factors, including serious economic recessions in the transition countries and in some East and South-East Asian countries.

The growth rate in the demand for cereals is expected to rise again to 1.4% per year up until 2015, slowing to 1.2% per year thereafter. In developing countries overall, cereal production is not expected to keep pace with demand. The net cereal deficits of these countries, which amounted to 103 million tonnes or 9% of consumption in 1997–1999, could rise to 265 million tonnes by 2030, when they will be 14% of consumption. This gap can be bridged by increased surpluses from traditional grain exporters, and by new exports from the transition countries, which are expected to shift from being net importers to being net exporters.

Oil crops have seen the fastest increase in area of any crop sector, expanding by 75 million hectares between the mid-1970s and the end of the 1990s, while cereal area fell by 28 million hectares over the same period. Future per capita consumption of oil crops is expected to rise more rapidly than that of cereals. These crops will account for 45 out of every 100 extra kilocalories added to average diets in developing countries between now and 2030.

There are three main sources of growth in crop production: expanding the land area, increasing the frequency at which it is cropped (often through irrigation), and boosting yields. It has been suggested that growth in crop production may be approaching the ceiling of what is possible in respect of all three sources. A detailed examination of production potentials does not support this view at the global level, although in some countries, and even in whole regions, serious problems already exist and could deepen.

Diets in developing countries are changing as incomes rise. The share of staples, such as cereals, roots and tubers, is declining, while that of meat, dairy products and oil crops is rising. Between 1964–1966 and 1997–1999, per capita meat consumption in developing countries rose by 150% and that of milk and dairy products by 60%. By 2030, per capita consumption of livestock products could rise by a further 44%. Poultry consumption is predicted to grow the fastest. Productivity improvements are likely to be a major source of growth. Milk yields should improve, while breeding and improved management should increase average carcass weights and off-take rates. This will allow increased production with lower growth in animal numbers, and a corresponding

slowdown in the growth of environmental damage from grazing and animal wastes.

In developing countries, demand is predicted to grow faster than production, resulting in a growing trade deficit. In meat products this deficit will rise steeply, from 1.2 million tonnes per year in 1997–1999 to 5.9 million tonnes per year in 2030 (despite growing meat exports from Latin America), while in the case of milk and dairy products, the rise will be less steep but still considerable, from 20 million tonnes per year in 1997–1999 to 39 million tonnes per year in 2030. An increasing share of livestock production will probably come from industrial enterprises. In recent years, production from this sector has grown twice as fast as that from more traditional mixed farming systems and more than six times faster than that from grazing systems.

World fisheries production has kept ahead of population growth over the past three decades. Total fish production has almost doubled, from 65 million tonnes in 1970 to 125 million tonnes in 1999, when the world average intake of fish, crustaceans and molluscs reached 16.3 kg per person. By 2030, annual fish consumption is likely to rise to some 150–160 million tonnes, or between 19–20 kg per person. This amount is significantly lower than the potential demand, as environmental factors are expected to limit supply. During the 1990s the marine catch levelled out at 80–85 million tonnes per year, and by the turn of the century, three-quarters of ocean fish stocks were overfished, depleted or exploited up to their maximum sustainable yield. Further growth in the marine catch can only be modest.

Aquaculture compensated for this marine slowdown, doubling its share of world fish production during the 1990s. It is expected to continue to grow rapidly, at rates of 5–7% per year up to 2015. In all sectors of fishing it will be essential to pursue forms of management conducive to sustainable exploitation, especially for resources under common ownership or no ownership.

3.8 Conclusions

A number of conclusions can be drawn from the preceding discussion.

- Most of the information on food consumption has hitherto been obtained from national Food Balance Sheet data. In order to better understand the relationship between food consumption patterns, diets and the emergence of noncommunicable diseases, it is crucial to obtain more reliable information on actual food consumption patterns and trends based on representative consumption surveys.

- There is a need to monitor how the recommendations in this report influence the behaviour of consumers, and what further action is needed to change their diets (and lifestyles) towards more healthy patterns.
- The implications for agriculture, livestock, fisheries and horticulture will have to be assessed and action taken to deal with potential future demands of an increasing and more affluent population. To meet the specified levels of consumption, new strategies may need to be developed. For example, a realistic approach to the implementation of the recommendation concerning high average intake of fruit and vegetables, requires attention to be paid to crucial matters such as where would the large quantities needed be produced, how can the infrastructure be developed to permit trade in these perishable products, and would large-scale production of horticultural products be sustainable?
- A number of more novel matters will need to be dealt with, such as:
  - the positive and negative impacts on noncommunicable diseases of intensive production systems, not only in terms of health (e.g. nitrite in vegetables, heavy metals in irrigation water and manure, pesticide use), but also in terms of dietary quality (e.g. leaner meats in intensive poultry production);
  - the effects of longer food chains, in particular of longer storage and transport routes, such as the higher risk of deterioration (even if most of this may be bacterial and hence not a factor in chronic diseases), and the use and misuse of conserving agents and contaminants;
  - the effects of changes in varietal composition and diversity of consumption patterns, for example, the loss of traditional crop varieties and, perhaps even more significantly, the declining use of foods from "wild" sources.
- Trade aspects need to be considered in the context of improving diet, nutrition and the prevention of chronic diseases. Trade has an important role to play in improving food and nutrition security. On the import side, lower trade barriers reduce domestic food prices, increase the purchasing power of consumers and afford them a greater variety of food products. Freer trade can thus help enhance the availability and affordability of food and contribute to a better-balanced diet. On the export side, access to markets abroad creates new income opportunities for domestic farmers and food processors. Farmers in developing countries in particular stand to benefit from the removal of trade barriers for commodities such as sugar, fruits and vegetables, as well as tropical beverages, all these being products for which they have a comparative advantage.
- The impact that agricultural policies, particularly subsidies, have on the structure of production, processing and marketing systems — and

ultimately on the availability of foods that support healthy food consumption patterns – should not be overlooked.

All these issues and challenges need to be addressed in a pragmatic and intersectoral manner. All sectors in the food chain, from "farm to table", will need to be involved if the food system is to respond to the challenges posed by the need for changes in diets to cope with the burgeoning epidemic of noncommunicable diseases.

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4. Diet, nutrition and chronic diseases in context

4.1 Introduction

The diets people eat, in all their cultural variety, define to a large extent people's health, growth and development. Risk behaviours, such as tobacco use and physical inactivity, modify the result for better or worse. All this takes place in a social, cultural, political and economic environment that can aggravate the health of populations unless active measures are taken to make the environment a health-promoting one.

Although this report has taken a disease approach for convenience, the Expert Consultation was mindful in all its discussions that diet, nutrition and physical activity do not take place in a vacuum. Since the publication of the earlier report in 1990 (*1*), there have been great advances in basic research, considerable expansion of knowledge, and much community and international experience in the prevention and control of chronic diseases. At the same time, the human genome has been mapped and must now enter any discussion of chronic disease.

Concurrently there has been a return to the concept of the basic life course, i.e. of the continuity of human lives from fetus to old age. The influences in the womb work differently from later influences, but clearly have a strong effect on the subsequent manifestation of chronic disease. The known risk factors are now recognized as being amenable to alleviation throughout life, even into old age. The continuity of the life course is seen in the way that both undernutrition and overnutrition (as well as a host of other factors) play a role in the development of chronic disease. The effects of man-made and natural environments (and the interaction between the two) on the development of chronic diseases are increasingly recognized. Such factors are also being recognized as happening further and further "upstream" in the chain of events predisposing humans to chronic disease. All these broadening perceptions not only give a clearer picture of what is happening in the current epidemic of chronic diseases, but also present many opportunities to address them. The identities of those affected are now better recognized: those most disadvantaged in more affluent countries, and – in numerical terms far greater – the populations of the developing and transitional worlds.

There is a continuity in the influences contributing to chronic disease development, and thus also to the opportunities for prevention. These influences include the life course; the microscopic environment of the gene to macroscopic urban and rural environments; the impact of social and political events in one sphere affecting the health and diet of populations far distant; and the way in which already stretched agriculture and oceanic systems will affect the choices available and

the recommendations that can be made. For chronic diseases, risks occur at all ages; conversely, all ages are part of the continuum of opportunities for their prevention and control. Both undernutrition and overnutrition are negative influences in terms of disease development, and possibly a combination is even worse; consequently the developing world needs additional targeting. Those with least power need different preventive approaches from the more affluent. Work has to start with the individual risk factors, but, critically, attempts at prevention and health promotion must also take account of the wider social, political and economic environment. Economics, industry, consumer groups and advertising all must be included in the prevention equation.

4.2 Diet, nutrition and the prevention of chronic diseases through the life course

The rapidly increasing burden of chronic diseases is a key determinant of global public health. Already 79% of deaths attributable to chronic diseases are occurring in developing countries, predominantly in middle-aged men (*2*). There is increasing evidence that chronic disease risks begin in fetal life and continue into old age (*3–9*). Adult chronic disease, therefore, reflects cumulative differential lifetime exposures to damaging physical and social environments.

For these reasons a life-course approach that captures both the cumulative risk and the many opportunities to intervene that this affords, was adopted by the Expert Consultation. While accepting the imperceptible progression from one life stage to the next, five stages were identified for convenience. These are: fetal development and the maternal environment; infancy; childhood and adolescence; adulthood; and ageing and older people.

4.2.1 *Fetal development and the maternal environment*

The four relevant factors in fetal life are: (i) intrauterine growth retardation (IUGR); (ii) premature delivery of a normal growth for gestational age fetus; (iii) overnutrition in utero; and (iv) intergenerational factors. There is considerable evidence, mostly from developed countries, that IUGR is associated with an increased risk of coronary heart disease, stroke, diabetes and raised blood pressure (*9–20*). It may rather be the pattern of growth, i.e. restricted fetal growth followed by very rapid postnatal catch-up growth, that is important in the underlying disease pathways. On the other hand, large size at birth (macrosomia) is also associated with an increased risk of diabetes and cardiovascular disease (*16, 21*). Among the adult population in India, an association was found between impaired glucose tolerance and high ponderal index (i.e. fatness) at birth (*22*). In Pima Indians, a U-shaped relationship to birth

weight was found, whereas no such relationship was found amongst Mexican Americans (*21, 23*). Higher birth weight has also been related to an increased risk of breast and other cancers (*24*).

In sum, the evidence suggests that optimal birth weight and length distribution should be considered, not only in terms of immediate morbidity and mortality but also in regard to long-term outcomes such as susceptibility to diet-related chronic disease later in life.

4.2.2 *Infancy*

Retarded growth in infancy can be a reflected in a failure to gain weight and a failure to gain height. Both retarded growth and excessive weight or height gain (''crossing the centiles'') can be factors in later incidence of chronic disease. An association between low growth in early infancy (low weight at 1 year) and an increased risk of coronary heart disease (CHD) has been described, irrespective of size at birth (*3, 25*). Blood pressure has been found to be highest in those with retarded fetal growth and greater weight gain in infancy (*26*). Short stature, a reflection of socioeconomic deprivation in childhood (*27*), is also associated with an increased risk of CHD and stroke, and to some extent, diabetes (*10, 15, 28–34*). The risk of stroke, and also of cancer mortality at several sites, including breast, uterus and colon, is increased if shorter children display an accelerated growth in height (*35, 36*).

Breastfeeding

There is increasing evidence that among term and pre-term infants, breastfeeding is associated with significantly lower blood pressure levels in childhood (*37, 38*). Consumption of formula instead of breast milk in infancy has also been shown to increase diastolic and mean arterial blood pressure in later life (*37*). Nevertheless, studies with older cohorts (*22*) and the Dutch study of famine (*39*) have not identified such associations. There is increasingly strong evidence suggesting that a lower risk of developing obesity (*40–43*) may be directly related to length of exclusive breastfeeding although it may not become evident until later in childhood (*44*). Some of the discrepancy may be explained by socioeconomic and maternal education factors confounding the findings.

Data from most, but not all, observational studies of term infants have generally suggested adverse effects of formula consumption on the other risk factors for cardiovascular disease (as well as blood pressure), but little information to support this finding is available from controlled clinical trials (*45*). Nevertheless, the weight of current evidence indicates adverse effects of formula milk on cardiovascular disease risk factors; this is consistent with the observations of increased mortality among older adults who were fed formula as infants (*45–47*). The risk for several

chronic diseases of childhood and adolescence (e.g. type 1 diabetes, coeliac disease, some childhood cancers, inflammatory bowel disease) have also been associated with infant feeding on breast-milk substitutes and short-term breastfeeding (*48*).

There has been great interest in the possible effect of high-cholesterol feeding in early life. Reiser et al. (*49*) proposed the hypothesis that high-cholesterol feeding in early life may serve to regulate cholesterol and lipoprotein metabolism in later life. Animal data in support of this hypothesis are limited, but the idea of a possible metabolic imprinting served to trigger several retrospective and prospective studies in which cholesterol and lipoprotein metabolism in infants fed human milk were compared with those fed formula. Studies in suckling rats have suggested that the presence of cholesterol in the early diet may serve to define a metabolic pattern for lipoproteins and plasma cholesterol that could be of benefit later in life. The study by Mott, Lewis & McGill (*50*) on differential diets in infant baboons, however, provided evidence to the contrary in terms of benefit. Nevertheless, the observation of modified responses of adult cholesterol production rates, bile cholesterol saturation indices, and bile acid turnover, depending on whether the baboons were fed breast milk or formula, served to attract further interest. It was noted that increased atherosclerotic lesions associated with increased levels of plasma total cholesterol were related to increased dietary cholesterol in early life. No long-term human morbidity and mortality data supporting this notion have been reported.

Short-term human studies have been in part confounded by diversity in solid food weaning regimens, as well as by the varied composition of fatty acid components of the early diet. The latter are now known to have an impact on circulating lipoprotein cholesterol species (*51*). Mean plasma total cholesterol by age 4 months in infants fed breast milk reached 180 mg/dl or greater, while cholesterol values in infants fed formula tended to remain under 150 mg/dl. In a study by Carlson, DeVoe & Barness (*52*), infants receiving predominantly a linoleic acid-enriched oil blend exhibited a mean cholesterol concentration of approximately 110 mg/dl. A separate group of infants in that study who received predominantly oleic acid had a mean cholesterol concentration of 133 mg/dl. Moreover, infants who were fed breast milk and oleic acid-enriched formula had higher high-density lipoprotein (HDL) cholesterol and apoproteins A-I and A-II than the predominantly linoleic acid-enriched oil diet group. The ratio of low-density lipoprotein (LDL) cholesterol plus very low-density lipoprotein (VLDL) cholesterol to HDL cholesterol was lowest for infants receiving the formula in which oleic acid was predominant. Using a similar oleic acid predominant formula, Darmady, Fosbrooke & Lloyd (*53*) reported

a mean value of 149 mg/dl at age 4 months, compared with 196 mg/dl in a parallel breast-fed group. Most of those infants then received an uncontrolled mixed diet and cow's milk, with no evident differences in plasma cholesterol levels by 12 months, independent of the type of early feeding they had received. A more recent controlled study (*54*) suggests that the specific fatty acid intake plays a predominant role in determining total and LDL cholesterol. The significance of high dietary cholesterol associated with exclusive human milk feeding during the first 4 months of life has no demonstrated adverse effect. Measurements of serum lipoprotein concentrations and LDL receptor activity in infants suggests that it is the fatty acid content rather than the cholesterol in the diet which regulates cholesterol homeostasis. The regulation of endogenous cholesterol synthesis in infants appears to be regulated in a similar manner to that of adults (*55, 56*).

4.2.3 *Childhood and adolescence*

An association between low growth in childhood and an increased risk of CHD has been described, irrespective of size at birth (*3, 25*). Although based only on developed country research at this point, this finding gives credence to the importance that is currently attached to the role of immediate postnatal factors in shaping disease risk. Growth rates in infants in Bangladesh, most of whom had chronic intrauterine undernourishment and were breastfed, were similar to growth rates of breastfed infants in industrialized countries, but catch-up growth was limited and weight at 12 months was largely a function of weight at birth (*57*).

In a study of 11–12 year-old Jamaican children (*26*), blood pressure levels were found to be highest in those with retarded fetal growth and greater weight gain between the ages of 7 and 11 years. Similar results were found in India (*58*). Low birth weight Indian babies have been described as having a characteristic poor muscle but high fat preservation, so-called "thin-fat" babies. This phenotype persists throughout the postnatal period and is associated with an increased central adiposity in childhood that is linked to the highest risk of raised blood pressure and disease (*59–61*). In most studies, the association between low birth weight and high blood pressure has been found to be particularly strong if adjusted to current body size – body mass index (BMI) – suggesting the importance of weight gain after birth (*62*).

Relative weight in adulthood and weight gain have been found to be associated with increased risk of cancer of the breast, colon, rectum, prostate and other sites (*36*). Whether there is an independent effect of childhood weight is difficult to determine, as childhood overweight is usually continued into adulthood. Relative weight in adolescence was

significantly associated with colon cancer in one retrospective cohort study (*63*). Frankel, Gunnel & Peters (*64*), in the follow-up to an earlier survey by Boyd Orr in the late 1930s, found that for both sexes, after accounting for the confounding effects of social class, there was a significant positive relationship between childhood energy intake and adult cancer mortality. The recent review by the International Agency for Research on Cancer (IARC) in Lyon, France, concluded that there was clear evidence of a relationship between onset of obesity (both early and later) and cancer risk (*65*).

Short stature (including measures of childhood leg length), a reflection of socioeconomic deprivation in childhood, is associated with an increased risk of CHD and stroke, and to some extent diabetes (*10, 15, 28–34*). Given that short stature, and specifically short leglength, are particularly sensitive indicators of early socioeconomic deprivation, their association with later disease very likely reflects an association between early undernutrition and infectious disease load (*27, 66*).

Height serves partly as an indicator of socioeconomic and nutritional status in childhood. As has been seen, poor fetal development and poor growth during childhood have been associated with increased cardiovascular disease risk in adulthood, as have indicators of unfavourable social circumstances in childhood. Conversely, a high calorie intake in childhood may be related to an increased risk of cancer in later life (*64*). Height is inversely associated with mortality among men and women from all causes, including coronary heart disease, stroke and respiratory disease (*67*).

Height has also been used as a proxy for usual childhood energy intake, which is particularly related to body mass and the child's level of activity. However, it is clearly an imperfect proxy because when protein intake is adequate (energy appears to be important in this regard only in the first 3 months of life), genetics will define adult height (*36*). Protein, particularly animal protein, has been shown to have a selective effect in promoting height growth. It has been suggested that childhood obesity is related to excess protein intake and, of course, overweight or obese children tend to be in the upper percentiles for height. Height has been shown to be related to cancer mortality at several sites, including breast, uterus and colon (*36*). The risk of stroke is increased by accelerated growth in height during childhood (*35*). As accelerated growth has been linked to development of hypertension in adult life, this may be the mechanism (plus an association with low socioeconomic status).

There is a higher prevalence of raised blood pressure not only in adults of low socioeconomic status (*68–74*), but also in children from low socioeconomic backgrounds, although the latter is not always associated

with higher blood pressure later in life (*10*). Blood pressure has been found to track from childhood to predict hypertension in adulthood, but with stronger tracking seen in older ages of childhood and in adolescence (*75*).

Higher blood pressure in childhood (in combination with other risk factors) causes target organ and anatomical changes that are associated with cardiovascular risk, including reduction in artery elasticity, increased ventricular size and mass, haemodynamic increase in cardiac output and peripheral resistance (*10, 76, 77*). High blood pressure in children is strongly associated with obesity, in particular central obesity, and clusters and tracks with an adverse serum lipid profile (especially LDL cholesterol) and glucose intolerance (*76, 78, 79*). There may be some ethnic differences, although these often seem to be explained by differences in body mass index. A retrospective mortality follow-up of a survey of family diet and health in the United Kingdom (1937–1939) identified significant associations between childhood energy intake and mortality from cancer (*64*).

The presence and tracking of high blood pressure in children and adolescents occurs against a background of unhealthy lifestyles, including excessive intakes of total and saturated fats, cholesterol and salt, inadequate intakes of potassium, and reduced physical activity, often accompanied by high levels of television viewing (*10*). In adolescents, habitual alcohol and tobacco use contributes to raised blood pressure (*76, 80*).

There are three critical aspects of adolescence that have an impact on chronic diseases: (i) the development of risk factors during this period; (ii) the tracking of risk factors throughout life; and, in terms of prevention, (iii) the development of healthy or unhealthy habits that tend to stay throughout life, for example physical inactivity because of television viewing. In older children and adolescents, habitual alcohol and tobacco use contribute to raised blood pressure and the development of other risk factors in early life, most of which track into adulthood.

The clustering of risk factor variables occurs as early as childhood and adolescence, and is associated with atherosclerosis in young adulthood and thus risk of later cardiovascular disease (*81, 82*). This clustering has been described as the metabolic – or "syndrome X" – clustering of physiological disturbances associated with insulin resistance, including hyperinsulinaemia, impaired glucose tolerance, hypertension, elevated plasma triglyceride and low HDL cholesterol (*83, 84*). Raised serum cholesterol both in middle age and in early life are known to be associated with an increased risk of disease later on. The Johns Hopkins Precursor Study showed that serum cholesterol levels in adolescents and young white males were strongly related to subsequent risk of cardiovascular disease mortality and morbidity (*85*).

Although the risk of obesity does not apparently increase in adults who were overweight at 1 and 3 years old, the risk rises steadily thereafter, regardless of parental weight (*86*). Tracking has also been reported in China, where overweight children were 2.8 times as likely to become overweight adolescents; conversely, underweight children were 3.6 times as likely to remain underweight as adolescents (*87*). The study found that parental obesity and underweight, and the child's initial body mass index, dietary fat intake and family income helped predict tracking and changes. However, in a prospective cohort study conducted in the United Kingdom, little tracking from childhood overweight to adulthood obesity was found when using a measure of fatness (percentage body fat for age) that was independent of build (*88*). The authors also found that only children obese at 13 years of age had an increased risk of obesity as adults, and that there was no excess adult health risk from childhood or adolescent overweight. Interestingly, they found that in the thinnest children, the more obese they became as adults, the greater was their subsequent risk of developing chronic diseases.

The real concern about these early manifestations of chronic disease, besides the fact that they are occurring earlier and earlier, is that once they have developed they tend to track in that individual throughout life. On the more positive side, there is evidence that they can be corrected. Overweight and obesity are, however, notoriously difficult to correct after becoming established, and there is an established risk of overweight during childhood persisting into adolescence and adulthood (*89*). Recent analyses (*90, 91*) have shown that the later the weight gain in childhood and adolescence, the greater the persistence. More than 60% of overweight children have at least one additional risk factor for cardiovascular disease, such as raised blood pressure, hyperlipidaemia or hyperinsulinaemia, and more than 20% have two or more risk factors (*89*).

Habits leading to noncommunicable disease development during adolescence

It seems increasingly likely that there are widespread effects of early diet on later body composition, physiology and cognition (*45*). Such observations "provide strong support for the recent shift away from defining nutritional needs for prevention of acute deficiency symptoms towards long-term prevention of morbidity and mortality" (*45*).

Increased birth weight increases the risk of obesity later, but children with low birth weight tend to remain small into adulthood (*89, 92*). In industrialized countries there have been only modest increases in birth weight so the increased levels of obesity described earlier must reflect environmental changes (*89*).

The "obesogenic" environment appears to be largely directed at the adolescent market, making healthy choices that much more difficult. At the same time, exercise patterns have changed and considerable parts of the day are spent sitting at school, in a factory, or in front of a television or computer. Raised blood pressure, impaired glucose tolerance and dyslipidaemia are associated in children and adolescents with unhealthy lifestyles, such as diets containing excessive intakes of fats (especially saturated), cholesterol and salt, an inadequate intake of fibre and potassium, a lack of exercise, and increased television viewing (*10*). Physical inactivity and smoking have been found independently to predict CHD and stroke in later life.

It is increasingly recognized that unhealthy lifestyles do not just appear in adulthood but drive the early development of obesity, dyslipidaemia, high blood pressure, impaired glucose tolerance and associated disease risk. In many countries, perhaps most typified by the United States, changes in family eating patterns, including the increased consumption of fast foods, pre-prepared meals and carbonated drinks, have taken place over the past 30 years (*89*). At the same time, the amount of physical activity has been greatly reduced both at home and in school, as well as by increasing use of mechanized transport.

4.2.4 *Adulthood*

The three critical questions relating to adulthood were identified as: (i) to what extent do risk factors continue to be important in the development of chronic diseases; (ii) to what extent will modifying such risk factors make a difference to the emergence of disease; and (iii) what is the role of risk factor reduction and modification in secondary prevention and the treatment of those with disease? Reviewing the evidence within the framework of a life-course approach highlights the importance of the adult phase of life, it being both the period during which most chronic diseases are expressed, as well as a critical time for the preventive reduction of risk factors and for increasing effective treatment (*93*).

The most firmly established associations between cardiovascular disease or diabetes and factors in the lifespan are the ones between those diseases and the major known "adult" risk factors, such as tobacco use, obesity, physical inactivity, cholesterol, high blood pressure and alcohol consumption (*94*). The factors that have been confirmed to lead to an increased risk of CHD, stroke and diabetes are: high blood pressure for CHD or stroke (*95, 96*); high cholesterol (diet) for CHD (*97, 98*), and tobacco use for CHD (*99*). Other associations are robust and consistent, although they have not necessarily been shown to be reversible (*10*): obesity and physical inactivity for CHD, diabetes and

stroke (*100–102*); and heavy or binge drinking for CHD and stroke (*99, 103*). Most of the studies are from developed countries, but supporting evidence from developing countries is beginning to emerge, for example, from India (*104*).

In developed countries, low socioeconomic status is associated with higher risk of cardiovascular disease and diabetes (*105*). As in the affluent industrialized countries, there appears to be an initial preponderance of cardiovascular disease among the higher socioeconomic groups, for example, as has been found in China (*98*). It is presumed that the disease will progressively shift to the more disadvantaged sectors of society (*10*). There is some evidence that this is already happening, especially among women in low-income groups, for example in Brazil (*106*) and South Africa (*107*), as well as in countries in economic transition such as Morocco (*108*).

Other risk factors are continually being recognized or proposed. These include the role of high levels of homocysteine, the related factor of low folate, and the role of iron (*109*). From a social sciences perspective, Losier (*110*) has suggested that socioeconomic level is less important than a certain stability in the physical and social environment. In other words, an individual's sense of understanding of his or her environment, coupled with control over the course and setting of his or her own life appears to be the most important determinant of health. Marmot (*111*), among others, has demonstrated the impact of the wider environment and societal and individual stress on the development of chronic disease.

4.2.5 *Ageing and older people*

There are three critical aspects relating to chronic diseases in the later part of the life-cycle: (i) most chronic diseases will be manifested in this later stage of life; (ii) there is an absolute benefit for ageing individuals and populations in changing risk factors and adopting health-promoting behaviours such as exercise and healthy diets; and (iii) the need to maximize health by avoiding or delaying preventable disability. Along with the societal and disease transitions, there has been a major demographic shift. Although older people are currently defined as those aged 60 years and above (*112*), this definition of older people has a very different meaning from the middle of the last century, when 60 years of age and above often exceeded the average life expectancy, especially in industrialized countries. It is worth remembering, however, that the majority of elderly people will, in fact, be living in the developing world.

Most chronic diseases are present at this period of life — the result of interactions between multiple disease processes as well as more general

losses in physiological functions (*113, 114*). Cardiovascular disease peaks at this period, as does type 2 diabetes and some cancers. The main burden of chronic diseases is observed at this stage of life and, therefore, needs to be addressed.

Changing behaviours in older people

In the 1970s, it was thought that risks were not significantly increased after certain late ages and that there would be no benefit in changing habits, such as dietary habits, after 80 years old (*115*) as there was no epidemiological evidence that changing habits would affect mortality or even health conditions among older people. There was also a feeling that people "earned" some unhealthy behaviours simply because of reaching "old age". Then there was a more active intervention phase, when older people were encouraged to change their diets in ways that were probably overly rigorous for the expected benefit. More recently, older people have been encouraged to eat a healthy diet – as large and as varied as possible while maintaining their weight – and particularly to continue exercise (*113, 116*). Liu et al. (*117*) have reported an observed risk of atherosclerotic disease among older women that was approximately 30% less in women who ate 5–10 servings of fruits and vegetables per day than in those who ate 2–5 servings per day. It seems that, as elderly patients have a higher cardiovascular risk, they are more likely to gain from risk factor modification (*118*).

Although this age group has received relatively little attention as regards primary prevention, the acceleration in decline caused by external factors is generally believed to be reversible at any age (*119*). Interventions aimed at supporting the individual and promoting healthier environments will often lead to increased independence in older age.

4.3 Interactions between early and later factors throughout the life course

Low birth weight, followed by subsequent adult obesity, has been shown to impart a particularly high risk of CHD (*120, 121*), as well as diabetes (*18*). Risk of impaired glucose tolerance has been found to be highest in those who had low birth weight, but who subsequently became obese as adults (*18*). A number of recent studies (*12, 13, 25, 59–61, 120*) have demonstrated that there is an increased risk of adult disease when IUGR is followed by rapid catch-up growth in weight and height. Conversely, there is also fairly consistent evidence of higher risk of CHD, stroke, and probably adult onset diabetes with shorter stature (*122, 123*). Further research is needed to define optimal growth in infancy in terms of prevention of chronic disease. A WHO multicentre growth reference study (*124*) currently under way may serve to generate much needed information on this matter.

4.3.1 *Clustering of risk factors*

Impaired glucose tolerance and an adverse lipid profile are seen as early as childhood and adolescence, where they typically appear clustered together with higher blood pressure and relate strongly to obesity, in particular central obesity (*76, 78, 125, 126*). Raised blood pressure, impaired glucose tolerance and dyslipidaemia also tend to be clustered in children and adolescents with unhealthy lifestyles and diets, such as those with excessive intakes of saturated fats, cholesterol and salt, and inadequate intake of fibre. Lack of exercise and increased television viewing add to the risk (*10*). In older children and adolescents, habitual alcohol and tobacco use also contribute to raised blood pressure and to the development of other risk factors in early adulthood. Many of the same factors continue to act throughout the life course. Such clustering represents an opportunity to address more than one risk at a time. The clustering of health-related behaviours is also a well described phenomenon (*127*).

4.3.2 *Intergenerational effects*

Young girls who grow poorly become stunted women and are more likely to give birth to low-birth-weight babies who are then likely to continue the cycle by being stunted in adulthood, and so on (*128*). Maternal birth size is a significant predictor of a child's birth size after controlling for gestational age, sex of the child, socioeconomic status, and maternal age, height and pre-pregnant weight (*129*). There are clear indications of intergenerational factors in obesity, such as parental obesity, maternal gestational diabetes and maternal birth weight. Low maternal birth weight is associated with higher blood pressure levels in the offspring, independent of the relation between the offspring's own birth weight and blood pressure (*7*). Unhealthy lifestyles can also have a direct effect on the health of the next generation, for example, smoking during pregnancy (*9, 130*).

4.4 Gene–nutrient interactions and genetic susceptibility

There is good evidence that nutrients and physical activity influence gene expression and have shaped the genome over several million years of human evolution. Genes define opportunities for health and susceptibility to disease, while environmental factors determine which susceptible individuals will develop illness. In view of changing socioeconomic conditions in developing countries, such added stress may result in exposure of underlying genetic predisposition to chronic diseases. Gene–nutrient interactions also involve the environment. The dynamics of the relationships are becoming better understood but there is still a long way to go in this area, and also in other aspects, such as

disease prevention and control. Studies continue on the role of nutrients in gene expression; for example, researchers are currently trying to understand why omega-3 fatty acids suppress or decrease the mRNA of interleukin, which is elevated in atherosclerosis, arthritis and other autoimmune diseases, whereas the omega-6 fatty acids do not (*131*). Studies on genetic variability to dietary response indicate that specific genotypes raise cholesterol levels more than others. The need for targeted diets for individuals and subgroups to prevent chronic diseases was acknowledged as being part of an overall approach to prevention at the population level. However, the practical implications of this issue

for public health policy have only begun to be addressed. For example, a recent study of the relationship between folate and cardiovascular disease revealed that a common single gene mutation that reduces the activity of an enzyme involved in folate metabolism (MTHFR) is associated with a moderate (20%) increase in serum homocysteine and higher risk of both ischaemic heart disease and deep vein thrombosis (*132*).

Although humans have evolved being able to feed on a variety of foods and to adapt to them, certain genetic adaptations and limitations have occurred in relation to diet. Understanding the evolutionary aspects of diet and its composition might suggest a diet that would be consistent with the diet to which our genes were programmed to respond. However, the early diet was presumably one which gave evolutionary advantage to reproduction in the early part of life, and so may be less indicative of guidance for healthy eating, in terms of lifelong health and prevention of chronic disease after reproduction has been achieved. Because there are genetic variations among individuals, changes in dietary patterns have a differential impact on a genetically heterogeneous population, although populations with a similar evolutionary background have more similar genotypes. While targeted dietary advice for susceptible populations, subgroups or individuals is desirable, it is not feasible at present for the important chronic diseases considered in this report. Most are polygenic in nature and rapidly escalating rates suggest the importance of environmental change rather than change in genetic susceptibility.

4.5 Intervening throughout life

There is a vast volume of scientific evidence highlighting the importance of applying a life-course approach to the prevention and control of chronic disease. The picture is, however, still not complete, and the evidence sometimes contradictory. From the available evidence, it is possible to state the following:

- Unhealthy diets, physical inactivity and smoking are confirmed risk behaviours for chronic diseases.

- The biological risk factors of hypertension, obesity and lipidaemia are firmly established as risk factors for coronary heart disease, stroke and diabetes.
- Nutrients and physical activity influence gene expression and may define susceptibility.
- The major biological and behavioural risk factors emerge and act in early life, and continue to have a negative impact throughout the life course.
- The major biological risk factors can continue to affect the health of the next generation.
- An adequate and appropriate postnatal nutritional environment is important.
- Globally, trends in the prevalence of many risk factors are upwards, especially those for obesity, physical inactivity and, in the developing world particularly, smoking.
- Selected interventions are effective but must extend beyond individual risk factors and continue throughout the life course.
- Some preventive interventions early in the life course offer lifelong benefits.
- Improving diets and increasing levels of physical activity in adults and older people will reduce chronic disease risks for death and disability.
- Secondary prevention through diet and physical activity is a complementary strategy in retarding the progression of existing chronic diseases and decreasing mortality and the disease burden from such diseases.

From the above, it is clear that risk factors must be addressed throughout the life course. As well as preventing chronic diseases, there are clearly many other reasons to improve the quality of life of people throughout their lifespan. The intention of primary prevention interventions is to move the profile of the whole population in a healthier direction. Small changes in risk factors in the majority who are at moderate risk can have an enormous impact in terms of population-attributable risk of death and disability. By preventing disease in large populations, small reductions in blood pressure, blood cholesterol and so on can dramatically reduce health costs. For example, it has been demonstrated that improved lifestyles can reduce the risk of progression to diabetes by a striking 58% over 4 years (*133, 134*). Other population studies have shown that up to 80% of cases of coronary heart disease, and up to 90% of cases of type 2 diabetes, could potentially be avoided through changing lifestyle factors, and about one-third of cancers could be

avoided by eating healthily, maintaining normal weight and exercising throughout life (*135–137*).

For interventions to have a lasting effect on the risk factor prevalence and the health of societies, it is also essential to change or modify the environment in which these diseases develop. Changes in dietary patterns, the influence of advertising and the globalization of diets, and widespread reduction in physical activity have generally had negative impacts in terms of risk factors, and presumably also in terms of subsequent disease (*138, 139*). Reversing current trends will require a multifaceted public health policy approach.

While it is important to avoid inappropriately applying nutritional guidelines to populations that may differ genetically from those for whom the dietary and risk data were originally determined, to date the information regarding genes or gene combinations is insufficient to define specific dietary recommendations based on a population distribution of specific genetic polymorphisms. Guidelines should try to ensure that the overall benefit of recommendations to the majority of the population substantially outweighs any potential adverse effects on selected subgroups of the population. For example, population-wide efforts to prevent weight gain may trigger a fear of fatness and, therefore, undernutrition in adolescent girls.

The population nutrient goals recommended by the Joint WHO/FAO Expert Consultation at the present meeting are based on current scientific knowledge and evidence, and are intended to be further adapted and tailored to local or national diets and populations, where diet has evolved to be appropriate for the culture and local environment.

The goals are intended to reverse or reduce the impact of unfavourable dietary changes that have occurred over the past century in the industrialized world and more recently in many developing countries. Present nutrient intake goals also need to take into account the effects of long-term environmental changes, i.e. those that have occurred over time-scales of hundreds of years. For example, the metabolic response to periodic famine and chronic food shortage may no longer represent a selective advantage but instead may increase susceptibility to chronic diseases. An abundant stable food supply is a recent phenomenon; it was not a factor until the advent of the industrial revolution (or the equivalent process in more recently industrialized countries).

A combination of physical activity, food variety and extensive social interaction is the most likely lifestyle profile to optimize health, as reflected in increased longevity and healthy ageing. Some available evidence suggests that, within the time frame of a week, at least 20 and

probably as many as 30 biologically distinct types of foods, with the emphasis on plant foods, are required for healthy diets.

The recommendations given in this report consider the wider environment, of which the food supply is a major part (see Chapter 3). The implications of the recommendations would be to increase the consumption of fruits and vegetables, to increase the consumption of fish, and to alter the types of fats and oils, as well as the amount of sugars and starch consumed, especially in developed countries. The current move towards increasing animal protein in diets in countries in economic transition is unlikely to be reversed in those countries where there are increased consumer resources, but is unlikely to be conducive to adult health, at least in terms of preventing chronic diseases.

Finally, what success can be expected by developing and updating the scientific basis for national guidelines? The percentage of British adults complying with national dietary guidelines is discouraging; for example, only 2–4% of the population are currently consuming the recommended level of saturated fat, and 5–25% are achieving the recommended levels of fibre. The figures would not be dissimilar in many other developed countries, where the majority of people are not aware of what exactly the dietary guidelines suggest. In using the updated and evidence-based recommendations in this report, national governments should aim to produce dietary guidelines that are simple, realistic and food-based. There is an increasing need, recognized at all levels, for the wider implications to be specifically addressed; these include the implications for agriculture and fisheries, the role of international trade in a globalized world, the impact on countries dependent on primary produce, the effect of macroeconomic policies, and the need for sustainability. The greatest burden of disease will be in the developing world and, in the transitional and industrialized world, amongst the most disadvantaged socioeconomically.

In conclusion, it may be necessary to have three mutually reinforcing strategies that will have different magnitudes of impact over differing time frames. First, with the greatest and most immediate impact, there is the need to address risk factors in adulthood and, increasingly, among older people. Risk-factor behaviours can be modified in these groups and benefits seen within 3–5 years. With all populations ageing, the sheer numbers and potential cost savings are enormous and realizable. Secondly, societal changes towards health-promoting environments need to be greatly expanded as an integral part of any intervention. Ways to reduce the intake of sugars-sweetened drinks (particularly by children) and of high-energy density foods that are micronutrient poor, as well as efforts to curb cigarette smoking and to increase physical activity will have an impact

throughout society. Such changes need the active participation of communities, politicians, health systems, town planners and municipalities, as well as the food and leisure industries. Thirdly, the health environment, in which those who are most at risk grow up, needs to change. This is a more targeted and potentially costly approach, but one that has the potential for cost-effective returns even though they are longer term.

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