

Table 9.1 (continued)

Agents	Important reservoir/carrier	Transmission ^a by			Multipli- cation in food	Examples of some incriminated foods
		water	food	person- to-person		
<i>Staphylococcus aureus</i> (enterotoxins)		-	+	-	+	Ham, poultry and egg salads, cream-filled bakery products, ice cream, cheese
<i>Vibrio cholerae</i> , O1	Man, marine life	+	+	±	+	Salad, shellfish
<i>Vibrio cholerae</i> , non-O1	Man, marine life	+	+	±	+	Shellfish
<i>Vibrio parahaemolyticus</i>	Seawater, marine life	-	+	-	+	Raw fish, crabs, and other shellfish
<i>Vibrio vulnificus</i>	Sea water, marine life	+	+	-	+	Shellfish
<i>Yersinia enterocolitica</i>	Water, wild animals, pigs, dogs, poultry	+	+	-	+	Milk, pork, and poultry
VIRUSES:						
Hepatitis A virus	Man	+	+	+	-	Shellfish, raw fruit and vegetables
Norwalk agents	Man	+	+	-	-	Shellfish, salad
Rotavirus	Man	+	+	+	-	0

Table 9.1 (continued)

Agents	Important reservoir/carrier	Transmission ^a by			Multiplication in food	Examples of some incriminated foods
		water	food	person-to-person		
PROTOZOA:						
<i>Cryptosporidium parvum</i>	Man, animals	+	+	+	-	Raw milk, raw sausage (non-fermented)
<i>Entamoeba histolytica</i>	Man	+	+	+	-	Vegetables and fruits
<i>Giardia lamblia</i>	Man, animals	+	±	+	-	Vegetables and fruits
<i>Toxoplasma gondii</i>	Cats, pigs	0	+	-	-	Undercooked meat, raw vegetables
HELMINTHS:						
<i>Ascaris lumbricoides</i>	Man	+	+	-	-	Soil-contaminated food
<i>Taenia saginata</i> and <i>T. solium</i>	Cattle, swine	-	+	-	-	Undercooked meat
<i>Trichinella spiralis</i>	Swine, carnivora	-	+	-	-	Undercooked meat
<i>Trichuris trichiura</i>	Man	0	+	-	-	Soil-contaminated food

^a Almost all acute enteric infections show increased transmission during the summer and/or wet months, except infections due to Rotavirus and *Yersinia enterocolitica*, which show increased transmission in cooler months.

^b Under certain circumstances, some multiplication has been observed. The epidemiological significance of this observation is not clear.

^c Vertical transmission from pregnant women to their foetus(es) occurs frequently.

+ = Yes; ± = Rare; - = No; 0 = No information. Adapted from: Ref. 10.

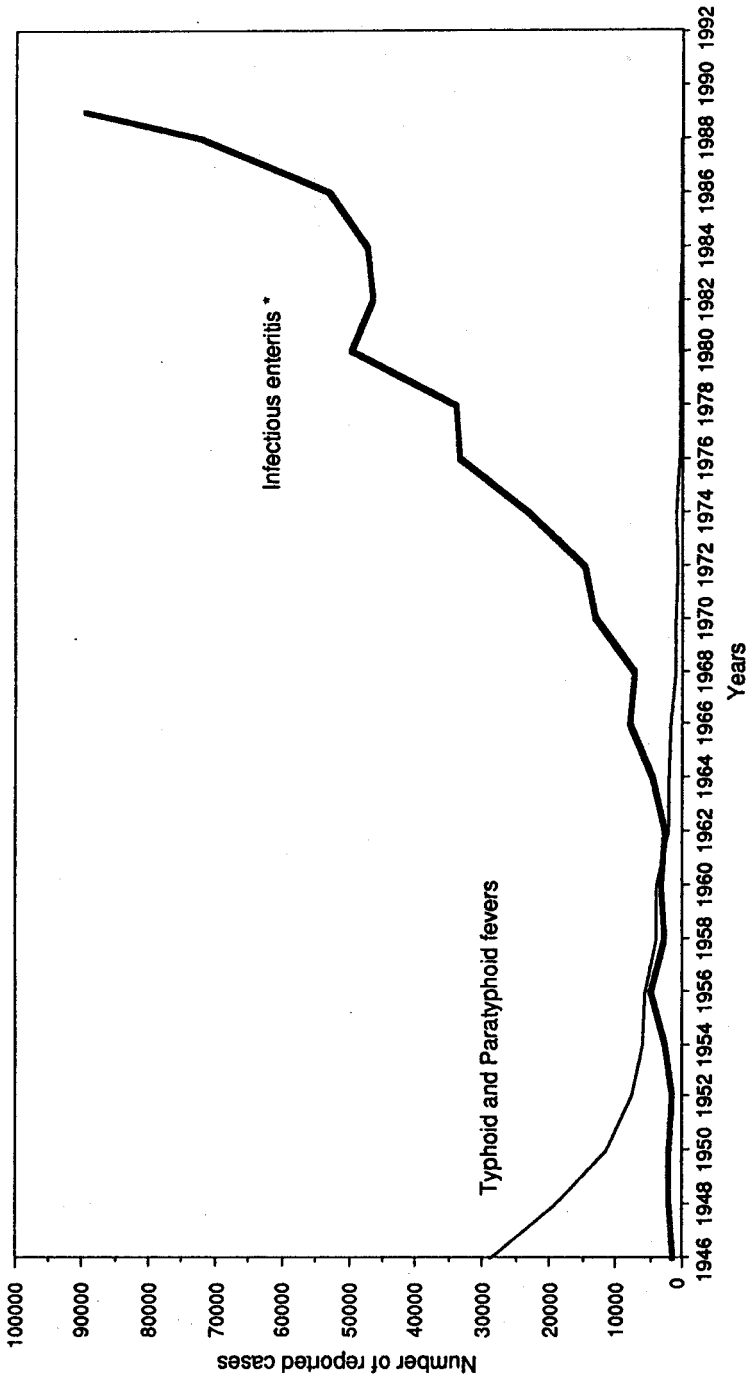
Giardia; and also enteric viruses - rotavirus. Diarrhoea due to pathogenic strains of *Escherichia coli* accounts for about one quarter of all the cases, this microorganism being particularly associated with weaning diarrhoea [4]. Shigellosis accounts for about 10-15% of acute diarrhoea in children under the age of five.

Industrialized countries

Although the situation regarding foodborne diseases is very serious in developing countries, the problem is not limited to these countries and, in recent years, industrialized countries have experienced a succession of major epidemics. In the USA it is estimated there are 6.5 million cases per year, with 9000 fatalities, but according to the Food and Drug Administration of the USA this figure is an underestimate and may be as high as 80 million cases [5,6,7]. The estimate for West Germany was one million cases in 1989 [8]. A study in the Netherlands found that as many as 10% of the population may be affected by foodborne and/or water-borne diseases [9].

With today's improvements in standards of personal hygiene, development of basic sanitation, safe water supplies, effective vaccination programmes (especially for poliomyelitis), food control infrastructure, and the increasing application of technologies such as pasteurization, many foodborne diseases have been either eliminated or considerably reduced in certain industrialized countries (e.g., poliomyelitis, brucellosis, cholera, typhoid and paratyphoid fevers, milk-borne salmonellosis). Nevertheless, most countries are now experiencing an important increase in several other foodborne diseases. The situation in West Germany (1946-89) illustrates this phenomenon (Fig. 9.2).[10]

Salmonellosis, specifically, has increased tremendously on both sides of the Atlantic over the past few years [11]. In many cases it is due to *Salmonella enteritidis*. Fig. 9.3 [12] shows the increase of this microorganism in relation to other *Salmonella* strains in Switzerland. In many countries, poultry meat, eggs and foods containing eggs,



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Fig. 9.2. Infectious enteritis, typhoid, and paratyphoid fevers in West Germany, 1946-1989. From Ref. 10.

* Infectious enteritis includes non-typhoid salmonellosis, campylobacteriosis, yersiniosis, staphylococcal intoxication, *Bacillus cereus* enteritis, and *Clostridium perfringens* enteritis.

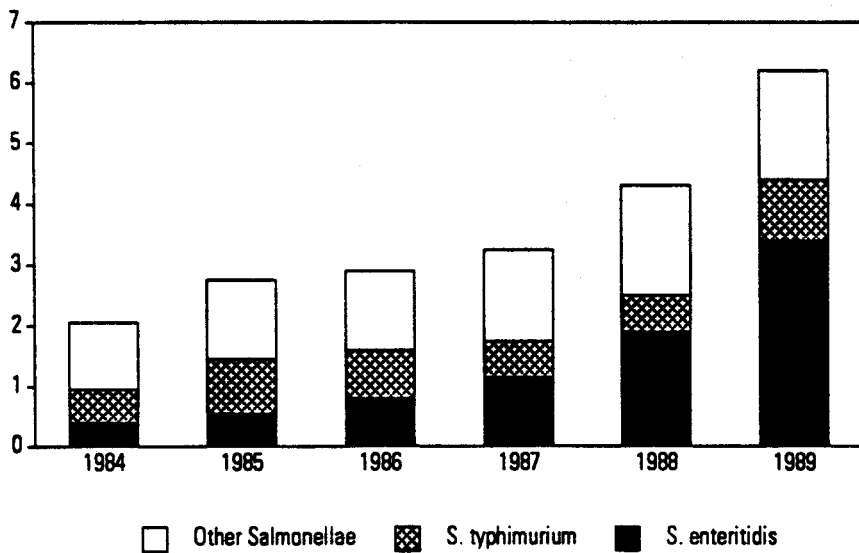


Fig. 9.3. Number of cases of salmonellosis in Switzerland. From: Ref. 12.

have been identified as the predominant sources of this pathogen. In certain countries, 60-100% of poultry meat is contaminated with *Salmonella* spp. and meat, frogs legs, chocolate and milk have also been implicated [13,14]. In 1985, some 170 000 to 200 000 persons were involved in an outbreak of salmonellosis in Chicago which was caused by contaminated pasteurized milk [15].

In addition, many industrialized countries are experiencing outbreaks of diseases due to relatively new types of foodborne pathogens such as *Campylobacter jejuni* and *Listeria monocytogenes*. Campylobacteriosis has increased to such extent that it is now the leading foodborne disease in several industrialized countries, e.g., the United Kingdom (see Fig. 9.4) [16]. As for *Salmonella*, the main vehicles for the transmission of *Campylobacter* are poultry meat and unpasteurized milk. *Listeria monocytogenes* may cause severe foodborne infections with a high fatality rate in susceptible individuals. The fatality rate, especially in neonates and immunocompromized adults, is in the range of 27-30% [17,18]. The microorganism has been implicated in several important outbreaks involving different types of food such as milk, cheese and vegetables. At present there is no clear understanding of its biology, but it is known to be able to grow at refrigeration temperatures, and at a wide range of pH; it is thus of major concern to food industries producing products with extended cold storage, such as cheese.

Hepatitis A is common throughout the world: some 6 000 cases were reported annually from West Germany [19]. In the USA, during the period 1983-89, the number of cases increased from 9.2 to 14.5 per 100 000 population [20]. Shellfish grown in contaminated water have often been recognized as a source of this disease. An epidemic of shellfish-borne hepatitis A in China, in 1988, affected some 292 000 persons (with 32 fatalities), and was related to consumption of contaminated clams [21]. Food infected by food-handlers and not subsequently sufficiently heated may also transmit the disease. Many cases of hepatitis A are known to be restaurant associated [22].

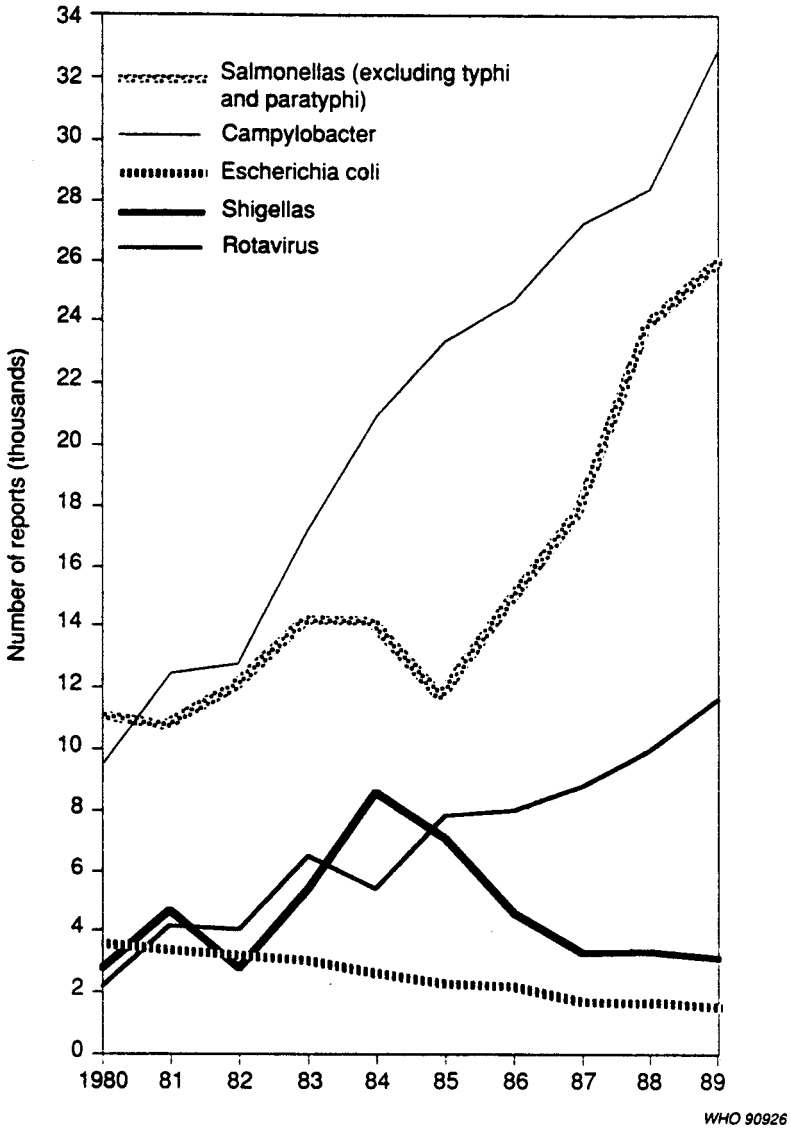


Fig. 9.4. Reported cases of gastrointestinal infections in England, Wales, and Ireland 1980-89. From: Ref. 16.

Parasitic infections have a worldwide prevalence, and in some countries they may even be more important than infections caused by bacteria. For example, *Cryptosporidium* infection is now believed to be more common than *Salmonella* infection in young children (< 5 years) [23]. Helminths also have an important impact on public health. Examples are *Trichinella spiralis*, *Taenia saginata*, and *Taenia solium*, which are acquired through consumption of undercooked or uncooked meat. Ascariasis is one of the most common parasitic infections and is estimated to affect some 1000 million people [3].

Other effects of foodborne diseases

Besides their acute effects, foodborne diseases may also cause other serious health problems. Diarrhoea experienced over a period of time can lead to undernutrition which, in severe cases, may cause impairment of the immune system, thus weakening the body's resistance to further attacks of diarrhoea and other infectious diseases. Some foodborne diseases - listeriosis and toxoplasmosis - are particularly dangerous during pregnancy, as they can be fatal to the fetus, or may cause severe deformation. In the latter case, the child runs a risk of severe congenital cerebral or ocular damage. Estimates from some countries show that in about 3 out of every 1 000 pregnancies, the fetus/infant is affected by toxoplasmosis [3].

Some foodborne infections may lead to chronic conditions such as joint disease, immune system disorders, heart and vascular diseases, disorders of the renal system, and possibly even cancer. In the above-mentioned outbreak of salmonellosis in Chicago, more than 2% of the affected persons suffered from reactive arthritis as a result of their infection [24].

Factors responsible for the high prevalence of foodborne diseases caused by biological contaminants

For the majority of foodborne diseases their etiology and mechanisms for their prevention and control are well known. However, this

knowledge is often not applied in practice, even by the health professions, and large sections of the public remain ignorant that diseases such as diarrhoea, hepatitis A and poliomyelitis are to a great extent foodborne.

In developing countries, food and drinking-water are frequently contaminated with pathogens. Lack of basic sanitation and use of untreated night-soil as fertilizer contribute to the introduction of pathogens into the food-chain.

The problem of food contamination, as well as the growth and survival of foodborne pathogens, is further aggravated by lack of knowledge about basic food safety measures, lack of fuel for cooking, and inappropriate food storage facilities.

Moreover, the rapid increase in the population, combined with a massive migration to urban areas, has led to the formation of urban centres of high population density in many countries. This increase in urban population has occurred at such a pace that it has outstripped the development of the health-related infrastructure, including basic sanitation, and has led inevitably to an increased risk of contamination of the food and water supply.

The situation is somewhat different in the industrialized countries, which benefit from well developed health-related services, including safe drinking-water. The higher standards of hygiene and basic knowledge of health matters have been effective in reducing the prevalence of many diseases (e.g., cholera, shigellosis, typhoid and paratyphoid fevers). Also, with the exception of some raw materials of animal origin (e.g., poultry meat, pork and eggs), the food supply at the retail level is generally safe. The official food control infrastructure (legislation and enforcement mechanisms), as well as the voluntary control measures implemented by the food processing industries, have contributed greatly to the safety of the food supply. Despite this progress, foodborne diseases remain a major public health issue and the following factors may be, at least partly, responsible:

- Improved standards of living have led to an increase in consumption of food of animal origin, which has increased the risk of exposure to meat- and poultry-borne pathogens.
- Extensive demand for food of animal origin has boosted the mass production of animals with the resulting risk that many of these animals are subclinically infected with foodborne pathogens, e.g., *Salmonella* and *Campylobacter*.
- As is also the case in some developing countries, urbanization has changed life-styles. Mothers do not bear the entire responsibility for the preparation of the family meals. Methods of food preparation that in the past ensured the safety of the food have disappeared in recent years. People eat more often in food service establishments (restaurants, canteens, etc.) where the food is prepared in advance in large quantities and where food-handlers are unaware of the special precautions required under such conditions. The lack of education of food-handlers is actually a worldwide problem that concerns both domestic as well as professional food-handlers. Many of the foodborne diseases that occur are due to errors in food preparation or lack of personal hygiene on the part of the food-handlers. Their lack of knowledge, and the use of raw food materials that are already contaminated, increase the risk of cross-contamination and proliferation of microorganisms in food.
- Traditions and beliefs also contribute to the occurrence of foodborne diseases, both in industrialized and developing countries. For example, in some cultures, babies' stools are not considered "dirty", and, in others, raw meat products (chitterlings, steak tartare), raw fish or raw milk are traditional foods, despite the risks that they pose.

- With the increasing number of international travellers, some of the diseases are imported from endemic areas. Fig. 9.5 [25] shows the proportion of imported cases of salmonellosis in relation to the total number of reported cases in Finland.
- Certain outbreaks occur as a result of failures during the food processing, in which case a large number of persons are usually affected.
- Finally, international trade in food and animal feed also plays a major role in the spread of contaminants. Some strains of *Salmonella* have been introduced in North America and Europe through imports of contaminated feeds of animal and vegetable origin from subtropical and tropical regions. Animals given these feeds have in turn contaminated the environment (soil, rivers, surface water and, in turn, insects, rodents and birds) with their faeces. Since then, the microorganisms have established themselves widely in the environment, including domestic and wild animals. Another example is a large outbreak of *Salmonella typhi* infection which occurred in Aberdeen, Scotland, following the importation of canned corned beef [26].

Chemicals and toxicants in food

Considerable efforts have been undertaken at the national and international levels to ensure the chemical safety of food supplies. Two joint FAO/WHO committees have, over a period of three decades, evaluated a large number of food chemicals. The Joint FAO/WHO Expert Committee on Food Additives (JECFA) evaluates food additives, contaminants and veterinary drug residues, and the Joint FAO/WHO Meeting on Pesticide Residues (JMPR) evaluates pesticide residues. Recommendations are made on the Acceptable Daily Intake (ADI), on Maximum Residue Levels (MRLs) and Maximum Levels (MLs). Based on these recommendations the Codex

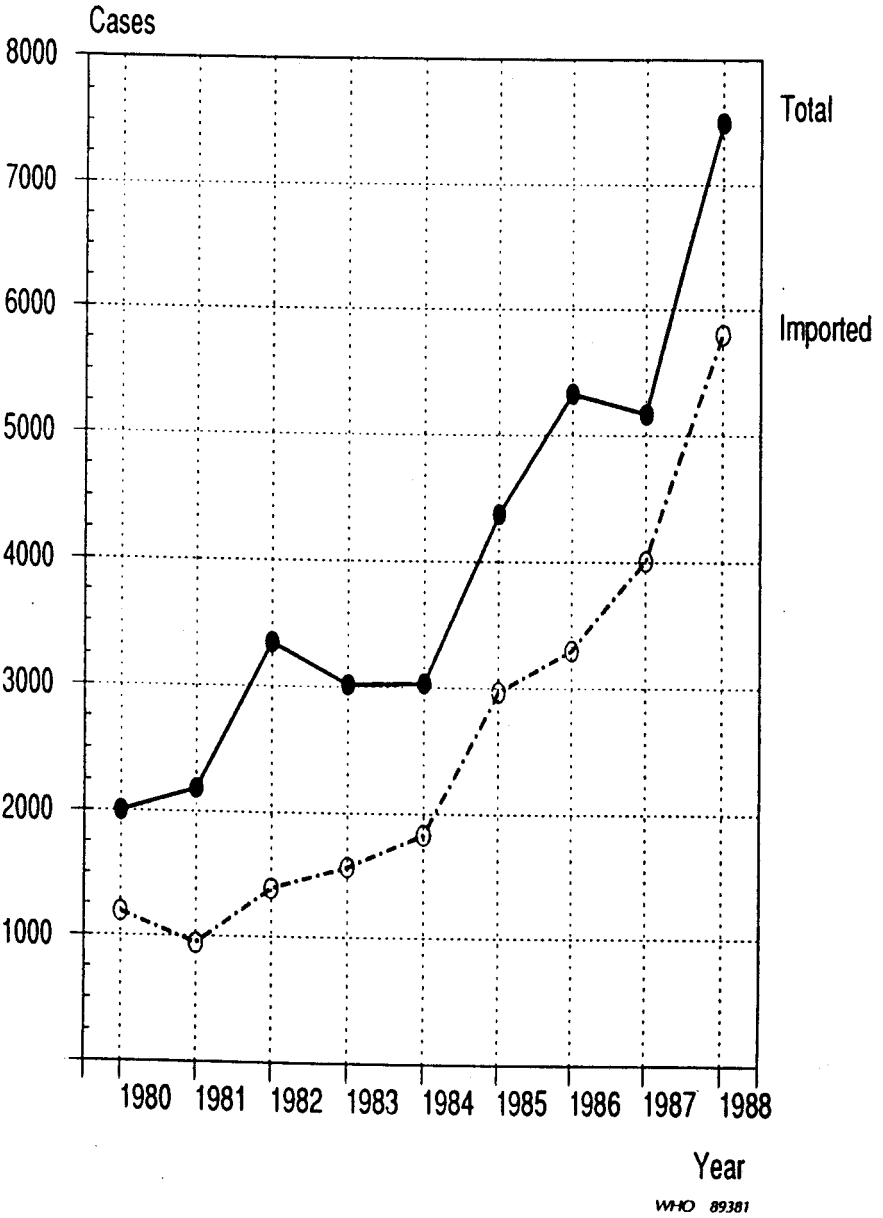


Fig. 9.5 Human *Salmonella* spp. isolations, Finland 1980-1988 all serotypes.
From: Ref. 25.

Alimentarius Commission and governments establish food standards and safe levels for these substances in foodstuffs. Moreover, the Joint UNEP/FAO/WHO Food Contamination Monitoring Programme (GEMS/Food) provides information on the levels of contaminants in food and on time-trends of contamination, enabling preventive and control measures.

Despite these extensive efforts and the fact that, at least in the industrialized countries, a high level of chemical safety has been achieved, the issue of chemicals in food has been the subject of heated debate. A growing number of consumers in industrialized countries are deeply concerned about the eventual health effects of food chemicals. In the developing countries, consumers are more worried that products banned in industrialized countries are being exported to them. As a result, many consumers are turning toward the so-called "health foods" hoping in this way to avoid food chemicals, but ignoring the fact that food itself is a mixture of chemical substances and that many of the substances they fear may occur naturally in food. For instance, a normal diet contains at least 10 000 times more "natural" pesticides than man-made pesticide residues [27]. Similarly, minute quantities of naturally-occurring radionuclides may be found in certain foods, a fact which is often not realized by the public.

While information from most of the developing countries is scarce, surveys made in the industrialized countries suggest that the food supply is largely safe from the chemical viewpoint owing to the extensive food safety infrastructure (i.e., legislation, enforcement mechanisms, surveillance and monitoring systems) and the general level of responsibility of the food industry. However, accidental contamination or adulteration does occur, in which case the health consequences may be grave. For example, in Spain in 1981-82, adulterated cooking oil killed some 600 people and disabled - temporarily or permanently - another 20 000 [28]. The agent responsible for this mass poisoning has not yet been identified in spite of intensive investigations.

Veterinary drug and pesticide residues

Veterinary pharmaceuticals have been a key element in increasing animal productivity. Small quantities of vaccines and therapeutic drugs have been effective in improving the health of cattle in countries such as Argentina, Australia and Uruguay where intensive animal husbandry is not practiced, but they are almost essential in the production of confined animals which are under more stress and are more at risk from communicable diseases. Disease quickly reduces productivity. Drugs are given to animals as preventive measures in the form of vaccines and feed additives and also as therapy to cure disease. Antibacterial drugs are given to animals in less than the normal therapeutic doses to promote weight gain, to prevent disease, and to improve feed efficiency. The use of antibiotics in this way has, however, given rise to serious and widespread problems with antibiotic-resistant organisms.

As a means of intensifying meat production, use is made of growth promoters. Hormonal anabolic agents are widely used in some parts of the world for promoting growth, especially in ruminants. In those countries where such use of anabolics is legalized, only a few active compounds are involved. The application of such anabolics can yield a net increase in muscle meat of 5-10% or more. The effects of anabolics are primarily caused by an improved conversion of feed nitrogen into protein. Under good agricultural and veterinary conditions, possible residues of the anabolic drugs do not present any risk for the consumer. Nevertheless, continued monitoring is necessary to ensure that permitted limits are not exceeded.

The estimation of the risks associated with residues from illegal and uncontrolled treatment of food animals with anabolics is, however, a different matter. In such situations, other hormonal compounds are frequently administered. In practice, these drugs are used as unlabelled mixtures ("cocktails") which are injected into edible as well as non-consumable parts of the animal. Even in this unethical and uncontrolled situation, the health risk for the consumer from residues is very low.

Thyreostats are still in use and primarily cause an increase in water content of the intestines and the muscle meat, which results in fraud with low quality animals and unfair trade. Risks from residues are not well established but are expected to be low.

In the past few years, new hormones have been developed. Made available only recently by modern biotechnology are the species-specific purified protein pharmaceuticals, bovine somatotropin (BST) and porcine somatotropin (PST). Various manufacturers have applied for legal registration of the drug, the residues of which apparently carry no risk for the consumer.

The phenylethanolamines are a group of substances that include drugs which have been found to be very effective growth promoters when used as feed additives. The illegal use of such substances has been widespread in the past few years in Western Europe, especially in veal production, as shown by intensive and effective control activities within the European Economic Community. New members of this group cause a "repartitioning" of feed energy from the growth of fat tissues into the growth of muscle tissues. Bonafide applications, under conditions of good agricultural and veterinary practice, of such new compounds will soon become eligible for legal registration in some parts of the world. Again, under these conditions, risks for the consumer caused by residues will be negligible.

In general, the same applies to situations where other veterinary drugs are used under conditions of good agricultural and veterinary practice. Under such conditions, residue levels will all be below the appropriate maximum residue levels as recommended by the Joint FAO/WHO Expert Committee on Food Additives.

With regard to pesticides, animal laboratory studies and accidental contamination of food, as well as occupational and intentional exposure to pesticides, have provided evidence that these chemicals may cause serious health effects following excessive exposure. The reported effects range from acute fatal poisoning to sensitization, impaired immune function, neurobehavioural disorders, and cancer.

These effects are further aggravated by poor nutrition and dehydration, which lower the toxicity threshold to pesticides [29].

For these reasons, the use of the good agricultural practices is extremely important when these substances are employed. In a number of situations, foods have been found to contain high levels of pesticide residues, for example when the crops are harvested too soon after applications of pesticides, or when fish are caught in treated rice paddies.

However, to the present day, there is no indication that pesticides, occurring in food within the limits established by the Codex Alimentarius, or which are naturally present in food, have caused any harm to human health. In all recorded cases, where food has been implicated in a pesticide poisoning, the chemical substance was found in the food following accidental contamination, either due to negligence or ignorance. For example, in a number of cases, food has been contaminated because of unsafe packing and leakage of pesticide during storage or transport. In other cases, seeds were consumed which had been treated with fungicides and were intended for planting.

Food additives

Food additives comprise a large and varied group of chemicals that are added to food to ensure: its keeping quality (thus preventing losses) and safety; its nutritional quality; its other qualities (taste, appearance, etc.); and certain properties required for processing and/or storage. In recent years, there has been no evidence that any of the food additives evaluated and used in accordance with the Codex recommendations have led to ill health. Some traditional measures such as curing and smoking are, however, considered to be risk factors for certain diseases, for example for hypertension and some cancers. If possible, other methods of preservation should be used [30].

Environmental chemicals

A number of chemical substances may occur in the food supply as a result of environmental contamination. Their effects on health may be extremely serious and have caused great concern in recent years.

Serious consequences have been reported when foods contaminated with heavy metals such as lead, cadmium or mercury have been ingested over extended periods of time. Lead affects the haematopoietic, nervous, and renal systems. When lead pipes or lead-lined water storage tanks are used, the lead exposure from drinking-water is appreciable. Similarly, food in lead-soldered cans may contain significant amounts of lead. During recent years, many countries, especially industrialized ones, have initiated efforts to change to non-lead-soldered cans, and these have led to a significant decrease in the lead content of canned foods [31].

Methylmercury - the most toxic form of mercury - has been shown to have serious effects on the nervous system, which, in severe cases, may be irreversible. Fish are the major dietary source of mercury. It has been demonstrated that the level of mercury in fish may be influenced by industrial pollution of the environment. For instance, in the mid-1960s, it was found in Sweden that the use of organomercury compounds in the paper and pulp industry, as well as other industrial discharges of mercury compounds into the environment, significantly increased the level of mercury in freshwater and coastal fish. Following a series of interventions, including prohibition of the use of phenylmercury acetate in the wood industry and alkylmercury in agriculture, the level of mercury contamination has gradually decreased [32]. The well-known incident of methylmercury intoxication of people in Minamata Bay, Japan, in the late 1950s, was also caused by industrial discharge of mercury-containing compounds.

The Chernobyl accident provoked great concern over the health risks to people exposed to accidental radionuclide emissions. People living in the vicinity of the accident were exposed and this exposure

included radioactive contaminants in food and water. In other parts of Europe and elsewhere, at some distance from the accident, this concern focused on contaminated foods as a source of exposure. In most countries, the estimated average dose acquired from eating contaminated foods only amounted to a very small fraction of the dose normally received from background radiation [33]. However, the deposition was very random, even at a distance from the accident, and local measures were taken to reduce the consumption of some foods produced in some contaminated areas.

At the present time, food monitoring, even in the contaminated regions of the USSR, indicate that the contaminating radionuclides are below the Codex guidelines for food moving in international trade.

Other environmental chemicals of interest are polychlorinated biphenyls. Polychlorinated biphenyls (PCBs) are used in varied industrial applications. Information on the effects of PCBs in man has been obtained from two large-scale incidents which occurred in Japan (1968) and in Taiwan, China (1979), after consumption of contaminated edible oil. In the first case, rice oil was accidentally contaminated with PCBs due to a leaking pipe in a factory plant [34]. Experience from these outbreaks showed that as well as their acute effects, PCBs may also have carcinogenic effects. Drastic restrictions in the production and use of PCBs have been introduced in many countries since the 1970s [31].

DDT was widely used between 1940 and 1960 as an insecticide for agricultural purposes and for the control of vector-borne diseases. It is now banned or restricted in many countries because of its potential risk to the environment. In many tropical countries, DDT is still an important chemical, used for the control of malaria. No confirmed ill effects have been reported due to residues of DDT in food [31].

Mycotoxins

Mycotoxins, the toxic metabolites of certain microscopical fungi (moulds), may cause serious adverse effects in man, as well as in animals. Animal studies have shown that besides acute intoxication, mycotoxins are capable of causing carcinogenic, mutagenic and teratogenic effects. Currently several hundred mycotoxins have been identified. Aflatoxin is the most well known and important mycotoxin from the public health point of view. As fungi producing aflatoxin are prevalent in areas with high humidity and temperatures, crops in tropical and subtropical regions are more subject to contamination. Epidemiological studies show a strong correlation between the high incidence of liver cancer in some African and South-East Asian countries (12-13 per 100 000 annually) and the exposure of the population to aflatoxin. Certain studies suggest that aflatoxins and hepatitis B are co-carcinogens and the probability of liver cancer is higher in areas where both aflatoxins and hepatitis B are prevalent [35]. Aflatoxins are found mostly in oilseeds (e.g., peanuts), cereals, tree nuts, and some fruits such as figs. Besides environmental conditions, and the type of food, post-harvest handling of food plays an important role in the growth of moulds [36,37]. In this respect, compliance with good agricultural practice is of the utmost importance.

Biotoxins

Intoxication by marine biotoxin (also known as "fish poisoning") is another problem of concern. In many areas of the world, this type of poisoning is on the increase. For example, in the South Pacific region, the total number of intoxications due to marine biotoxin increased considerably between 1985 and 1987, with nearly 5 000 cases reported in 1987 (Fig. 9.6) [38]. Examples of such intoxications are ciguatera and various kinds of shellfish poisoning.

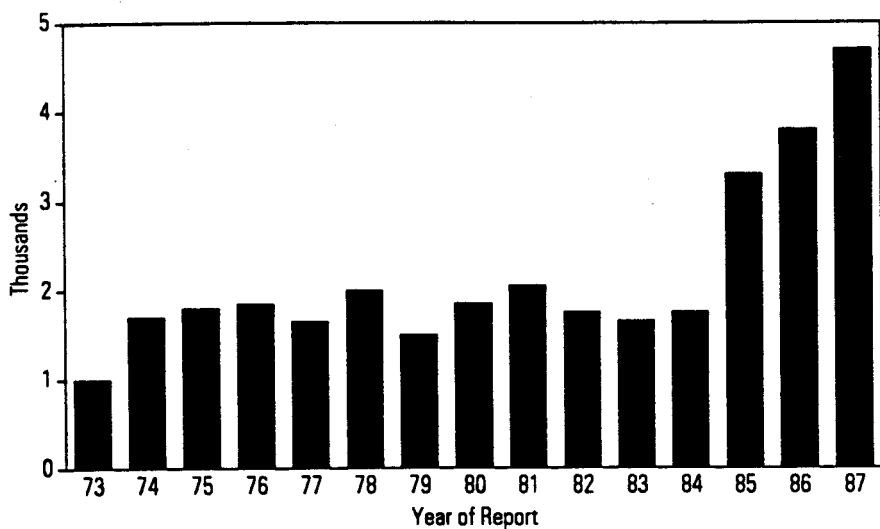


Fig. 9.6. Reported cases of poisoning in the South Pacific Region countries.
From: Ref. 38.

Ciguatera poisoning is a serious intoxication: in severe cases, symptoms may last for several weeks, months or years and the case/fatality rates range from 0.1 to 4.5%. Ciguatera has been associated with the consumption of a variety of tropical and subtropical fish, mainly coral fish or predatory fish consuming coral fish. The toxins causing ciguatera are produced by dinoflagellates which are attached to macro-algae in coral reefs. Man is exposed to the toxin through fishes that feed on dinoflagellates and the detritus of coral reefs, and also larger reef carnivores that prey on these herbivores. A number of studies suggest that ciguatera is associated with naturally-occurring or man-made disturbances of the coral reef ecosystem. During the last two decades, several thousands of cases of ciguatera have been reported from tropical and subtropical regions (e.g., the Caribbean and much of the Pacific area). Intoxications have also occurred in other regions (e.g., France, Canada) due to consumption of fish imported from endemic areas. In a household survey in the Virgin Islands, the annual incidence found was 7.3 per 1 000, and another study suggested that the incidence could be as high as 30 per 1 000 [39].

Acute intoxication after consumption of shellfish has been well known for centuries and it occurs throughout the world. Until the last decade, it was particularly reported as occurring in Europe, Japan and North America, but in recent years developing countries are also reporting it. The toxins causing shellfish poisoning are produced by some species of dinoflagellates which under certain conditions of light, temperature, salinity and nutrient supply may multiply and form dense blooms which discolour the water as in the case of so-called "red tides". Shellfish feeding on these algae accumulate the toxins. The shellfish most often implicated are clams and mussels, and occasionally scallops and oysters. Depending on the symptoms, different types of intoxications may result from consumption of contaminated shellfish. These include paralytic shellfish poisoning (PSP), diarrhoeic shellfish poisoning (DSP), neurotoxic shellfish poisoning (NSP) and amnesic shellfish poisoning (ASP) [39,40].

Plant toxicants

Toxicants in edible plants, and poisonous plants which resemble them (mushrooms, certain wild green plants), are important causes of ill health in many areas of the world. In some places, the poorer sections of the population eat grains known to be potentially toxic (e.g., *Lathyrus sativus*) in order to still their hunger. Pyrrolizidine alkaloids are frequent contaminants of edible millets, and cause liver disease. In many areas of the world, plant toxicants present a troublesome problem for food safety [30].

Economic and social impact of food contamination

The economic and social consequences of food contamination may be of great importance, and for countries with limited resources they may be catastrophic. Foodborne diseases in themselves cause great economic and social problems, such as loss of income, loss of manpower and medical care costs. For instance, just one common foodborne disease - salmonellosis - was estimated to have cost the USA about US\$1 000 million in 1987 [41].

The impact of food losses is considerable. The estimated worldwide loss of grains and legumes is estimated to be at least 10%. With non-grain staples, vegetables and fruits, the loss is believed to be as high as 50% [42]. A considerable proportion of these losses is due to contamination. World food losses due to mycotoxin contamination alone amount to 1 000 million tonnes per year.

Food contamination affects trade in two ways. Firstly, contaminated foodstuffs may be rejected if the level of contaminants is above the limits permitted by the importing country. For example, during a three-month period from January to March 1980, food imports valued at about US\$ 20 million were rejected in the USA alone on account of contamination with moulds and aflatoxins [1]. Secondly, a country's reputation for poor food safety may cause a decrease in trade as well as in tourism.

The epidemic of cholera in Latin America that began in Peru in 1991 is an example of the impact that food contamination may have on the economy of a country. On the one hand, Peru had to sustain medical care costs for the thousands of people affected. On the other hand, the country has had to face a substantial decrease in food exports, as many other countries decided to stop or restrict food imports from Peru. The outbreak has also affected the tourism industry of this country.

Prevention and control

The health problems related to food contamination often differ between countries and regions of the world and depend on factors such as climate, geographical situation, type of crops produced and degree of social and economic development. Nevertheless, the basic principles for prevention and control are similar. For this purpose, three lines of defence are available [43].

The first line of defence is to improve the hygienic quality of raw foodstuffs at the agricultural level. Although the production of pathogen-free food of animal origin has been shown to be possible experimentally, its application on a large scale is not yet feasible. However, by applying the principles of good agricultural practice and animal husbandry and improving the environmental conditions under which animals are raised, the hygienic quality of raw food products can be improved, and efforts have to be undertaken in this regard.

The second line of defence is the application of food processing technologies. For example, pasteurization, sterilization, fermentation or irradiation not only increase the availability of foods by extending their shelf-life, but also contribute to their safety by reducing or eliminating the pathogenic microorganisms. In countries where milk pasteurization is a common or compulsory practice, it has been possible to prevent many diseases transmitted through milk. For example, in Scotland, prior to 1983, when legislation was drawn up for the compulsory pasteurization of milk for sale, milk-borne salmonellosis was a particular problem. During the period 1970-82,

some 3 500 people fell ill and 12 died. Following the introduction of the legislation, no more problems were observed with regard to milk [44]. Poultry remains, though, a source of salmonellosis. It is possible that, in future, irradiation of meat and poultry products will play a similar role to that of pasteurization of milk.

The third and last line of defence is the most critical and will protect the health of consumers when the other two fail. This concerns the education of food-handlers on the principles of safe food preparation. The term "food-handlers" includes professional cooks, persons handling food in food service establishments (including street vending stands and mass catering services), as well as those in charge of the preparation of food at home. The education of food-handlers is of special importance because in most cases the occurrence of foodborne disease is attributable to only a few causes, the most frequent being:

- insufficient cooking or reheating of food;
- preparation of food several hours prior to consumption, combined with inadequate storage conditions;
- use of contaminated raw food material;
- cross-contamination in the food preparation premises; and
- infected or colonized persons in charge of the preparation of meals.

As cases of foodborne disease are frequently due to mishandling of food in homes, as a result of negligence, ignorance or ingrained traditions/habits, special efforts should be made to educate those responsible for the preparation of the family food. In this context, particular attention should be given to women, since they are usually responsible for the care of infants and young children, in which groups the rates of morbidity and mortality caused by diarrhoea are high. The education of children in schools should also be regarded as an effective means of communicating to parents the concept of

food safety and implanting the principles of safe food preparation in the mind of future adults.

With regard to chemicals in food, the first line of defence is the production of food in which the quantities of added chemicals lie within the limits permitted by current legislation. For this purpose the primary industry (producers of the agricultural, animal and fishery products) and processing industries have to comply with laws and regulations and observe the principles of good agricultural, animal husbandry and manufacturing practices.

The second line of defence is the application of technologies which can prevent or reduce the use of chemicals in food; for example, by drying crops to prevent mould growth and the production of mycotoxins in food during storage. Biotechnology can be used for the selection of plants resistant to diseases, and in this way decrease the need for pesticide use. Food irradiation can replace the use of potentially harmful chemicals used for insect disinfection and inhibition of sprouting.

The third line of defence is the rigorous control and monitoring of levels of chemicals in food, the responsibility for which is laid on governments and their food control agencies. The work of the food control agencies has to be supported by up-to-date food legislation.

Consumers have a major role to play in the prevention of foodborne disease due to biological contaminants. However, in the prevention of intoxication due to food additives, veterinary drugs, pesticide residues and environmental chemicals, this role is more limited.

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10. DISEASES RELATED TO WATER AND WATER RESOURCES DEVELOPMENT

Water so profoundly influences all aspects of human well-being that many fail to realize how much human disease is directly or indirectly related to the availability and use of water supplies and the development of water resources. Such diseases are mainly, though not exclusively, communicable, and are so numerous that it is helpful to classify them by the way in which they are related to water.

- (a) Scarcity and inaccessibility of water make washing and personal cleanliness difficult and infrequent, and in such areas some diarrhoeal diseases and contagious skin and eye infections are prevalent. They diminish once an adequate supply of water for washing is made available and used. These are the **water-washed** diseases.
- (b) Contamination of water by human or animal faeces or urine infected by pathogenic viruses or bacteria may result in direct transmission when such water is drunk or used in the preparation of food - cholera and typhoid being the classical examples. Other diseases, e.g., leptospirosis, may be acquired through contact of abraded skin with infected water. Such diseases are **water-borne**.
- (c) Another large group - the **water-based** diseases - comprises the various helminthic diseases in which the parasites pass part of their life-cycle in intermediate host organisms (e.g., snails) living in freshwater. Their infective larval forms find their way back to man by boring through wet skin (schistosomiasis), being eaten on water plants (liver flukes), infecting crustaceans or fish which are eaten inadequately cooked (liver and lung flukes), or by infecting a minute water crustacean (*Cyclops* water fleas) and being swallowed (guinea-worm infection or dracontiasis).

- (d) Water may also affect communicable diseases by providing a habitat for **water-related** insect vectors of disease. Mosquitos breed in water; their eggs are laid on it; and their larvae and pupae live and grow in it. The adult mosquitos emerge from it and may transmit malaria, filariasis, yellow fever and other arthropod-borne virus infections such as dengue and Japanese encephalitis. Different mosquitos vary in their preference for different water bodies, but are usually very specific in their requirements. Most malaria vectors require relatively clean water, whereas the culicine mosquitos, which spread filariasis efficiently, prefer to breed in flooded pit latrines and other highly polluted water.

The *Simulium* blackflies that spread river blindness breed in moving water, and the *Chrysops* horseflies conveying eye worms prefer muddy swamps. But the tsetse flies that spread Gambian sleeping sickness, although breeding on land, bite near watercourses and can be effectively prevented by clearing the woodland that fringes the water for a distance of a few metres.

- (e) The above four categories of water-related diseases are primarily problems of developing countries, though some can also occur in industrialized countries as a result of indigenous transmission or introduction by immigrants and travellers. A fifth category is emerging in developed countries, which may be called, for convenience, the **water-dispersed** infections. These are infections whose agents can proliferate in freshwaters and which enter the human body through the nose and nasal passages. Some freshwater amoebae, that are usually not pathogenic, can proliferate in warm waters and if they enter the nose in large numbers can enter the body along the olfactory tracts and cause a fatal meningitis. Bacteria of the genus *Legionella* have demonstrated a capacity to proliferate in the water of complex air-conditioning systems from which they may be dispersed as aerosols to infect substantial numbers of people through their respiratory tracts. It is

likely that other opportunistic pathogens may appear that find a suitable habitat in new technological devices involving water, while other water-related infections such as the water-borne *Cryptosporidium* may achieve increased clinical importance as the numbers of immuno-depressed people increase as a result of AIDS infection or chemotherapy associated with organ or tissue transplants.

Public health impact of diseases related to water

Water-related disease, with its manifold causes, imposes a massive burden of ill-health on the peoples of the developing countries, notably in the tropics and subtropics where climatic conditions favour the survival of pathogens and vectors alike.

Without attempting any sort of global overview, clearly beyond the scope of this report, it is useful and revealing to illustrate this statement by reference to the situation in sub-Saharan countries where, on average, safe water is estimated to be available to 44% of the population and adequate sanitary facilities to 36%; but these are only averages and there are wide variations between countries, with coverage in some as low as 16% for safe water and 9% for sanitary facilities. Figures for rural areas are almost invariably worse than national averages (Fig. 10.1).

Communicable diseases, many of them water-related, are the main causes of mortality and morbidity in sub-Saharan Africa, accounting for 47% of all deaths. Most of them can be prevented or controlled.

Malaria heads the list: tropical Africa has only 16% of the world population at risk from malaria, but accounts for 85% of malaria cases in the world. For 30-40% of patients seeking health care in rural dispensaries, malaria is the underlying cause. An estimated 126 million people are infected with schistosomiasis in the endemic countries.

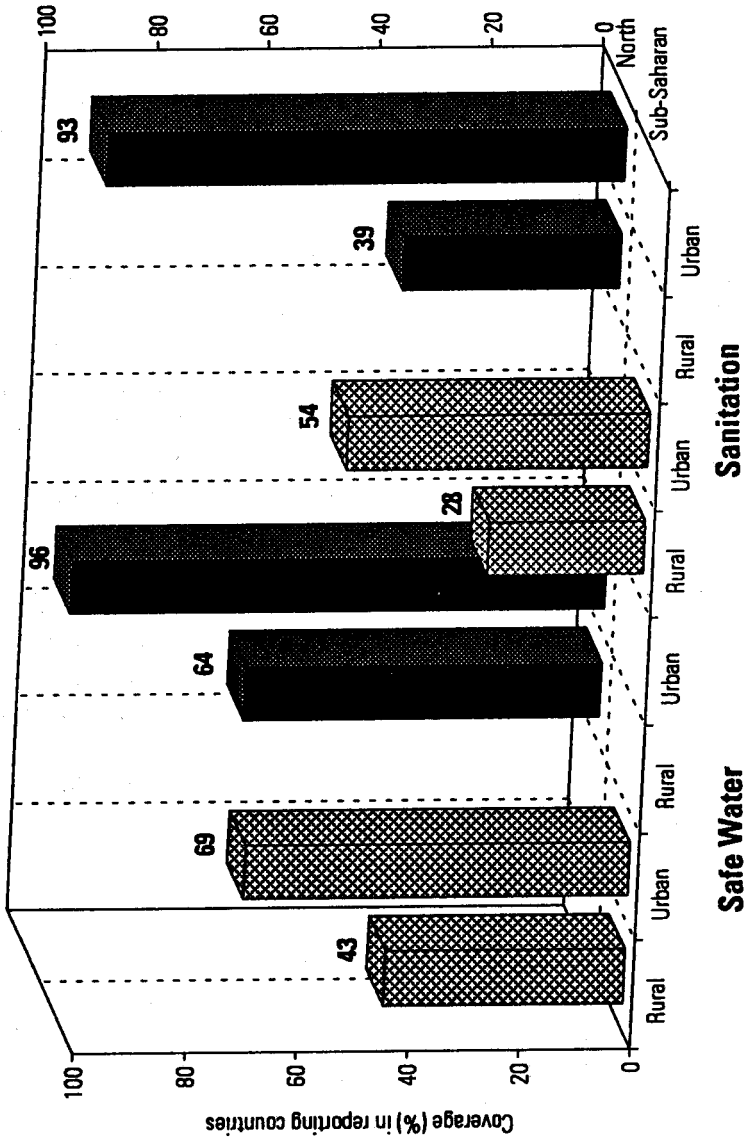


Fig. 10.1. Safe water and sanitation, Africa: urban-rural coverage.

Reflecting the contamination of water and food and the lack of sanitation, water-related diarrhoeal disease is responsible for some 38% of deaths in children under five years of age. This represents a large number of deaths for, despite significant progress in the past 20 years or so, death rates in this age group remain appallingly high. In two sub-Saharan countries, nearly 300 children per 1 000 die before they reach the age of five, and in 14 countries the rate exceeds 200 (Fig. 10.2).

For many of these sub-Saharan countries, the outlook is grave, with a falling gross national product, the effects of inflation, further cut-backs in already inadequate health services, the poverty that goes with underdevelopment, and rapid population increase.

But the situation is not unique and in many respects may be repeated, albeit on a smaller scale, in other countries and especially in the sprawling slums and squatter settlements of the ever-expanding urban agglomerations, where deficient and highly polluted domestic supplies are the rule.

However, the 1990 report of the United Nations Development Programme on Human Development clearly shows that despite a low *per capita* GNP some countries have achieved a low under-five mortality rate and greater life expectancy through placing a high priority on resource allocation for human development. This illustrates the critical role of public policy in rescuing millions of children, women and men from sub-human living conditions.

Urban areas

Water supply, and wastewater and excreta disposal are grossly inadequate for many of the world's people, but water supply tends to run ahead of facilities for its disposal so that waterlogging and puddles around domestic water sources are common, providing breeding-sites for vectors, which can be avoided by good drainage. Where water-borne sewerage is installed, an increasing problem with

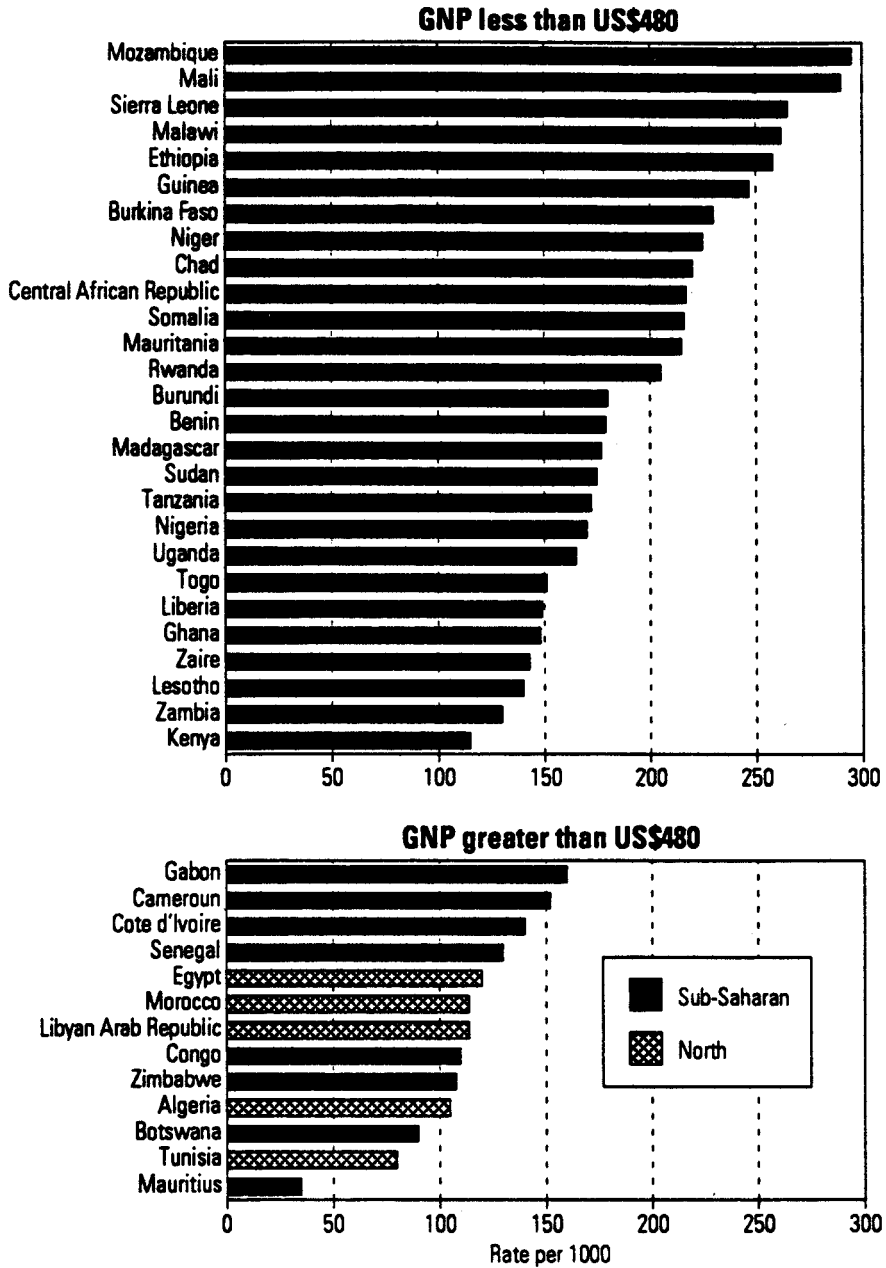


Fig. 10.2. Under-5 child mortality, Africa, 40 countries, 1968.

the massive growth of cities in developing countries is sewage treatment and disposal. This can be achieved, where space is not at a premium, more readily in warm than temperate climates by means of sewage stabilization pond systems. But where water is scarce, reuse of urban sewage and wastewater for irrigated agriculture is taking place on an increasing scale. Often the sewage is incompletely pre-treated, as is the case in Mexico City. This necessitates firm limits on the crops grown, and even then there is an increased health risk for the operatives and farmers. Proper treatment is needed. In East and South-East Asia, raw excreta is often used to fertilize ponds used for aquaculture. The main health hazards are when water is used for other domestic purposes, or when fish infected with human pathogens from the faeces are eaten in an inadequately cooked or raw form. Similar problems result from virus contamination of marine shellfish through contact with sewage. The most effective prevention is by proper cooking or adequate fermentation of the fish. In the future, reuse of sewage will increase, but methods for reducing its infectivity are already available. More severe practical problems will result from heavy metal ions in urban sewage.

The uncontrolled disposal of excreta at an individual level will continue to pose major health hazards, and the economic consequences of increasing human populations in poor countries suggest that the scale of this will remain vast. Uncontrolled dumping of collected sewage from communities is indefensible, and improvement in this, particularly in developed countries, must surely occur. It is now realized that, unlike the approach in industrialized countries where prevention of water-borne infection is wholly directed to water and food supply, in developing countries it is both necessary and feasible (because the warm climate favours stabilization ponds) to concentrate on pathogen removal in the treatment of excreta.

Changes in the use of surface water, apart from agricultural use, have also had a substantial effect on health. Chief among these have been the increase in urban water container breeding of clear water mosquitos, chiefly *Aedes aegypti*, and in the dirty water breeding of

Culex quinquefasciatus in ditches, sullage water and flooded pit latrines in Africa and Asia. *Aedes* was formerly controlled in cities of the American continent by rigorous domestic inspection and removal of containers, to control yellow fever. This disease is now very rare and is, in any case, effectively prevented by immunization, but *Aedes* has returned, to transmit massive epidemics of dengue fever. Where several strains of dengue are being intensively transmitted, as in many cities of South-East Asia, a severe and often lethal haemorrhagic shock syndrome occurs, and can be a major cause of child mortality, for example, in Bangkok. The increasing *Culex* populations of urban Asia and East Africa are not only a massive biting nuisance but also transmit lymphatic filariasis which is on the increase as a silent epidemic in tropical cities. The causes of and solutions to the *Aedes* and *Culex* problems are primarily environmental. Insecticides may assist in water cisterns with *Aedes*, whilst long-acting impregnated floating polystyrene spheres can prevent *Culex* breeding in flooded pit latrines.

Water resources development

Although, in principle, water for domestic use, water for livestock and agriculture, and surface waters that either are present naturally or have been created for power generation are separate issues, it is common for water resources to be developed for multiple uses and for there to be much in common in the health hazards.

The health problems of large surface catchments are similar, regardless of whether primary water use is for hydroelectric power, irrigation or flood control. Dam construction is associated with an unstable immigrant work force, often susceptible to locally endemic diseases, such as malaria or onchocerciasis, and with a high incidence of trauma, alcoholism in many areas, and sexually transmitted diseases. Filling of the reservoir creates a large area of still water. If vegetation has not been cleared prior to inundation, there may be a phase of eutrophication, destruction of submerged trees, proliferation of fish and of aquatic macrophytes, that may last a decade or even more.

Intermediate hosts of human schistosomiasis thrive on such vegetation and will tend to colonize the periphery of most tropical reservoirs. A schistosomiasis epidemic of variable size may affect immigrant fishermen and other users of the lake. Conversely, the flooding of previously fast-flowing influent streams by the rising water level tends to remove the breeding sites of *Simulium* vectors of river blindness, though new habitats for them can arise on the dam spillways. Schistosomiasis will be most prevalent where the reservoir shores are gently sloping, where there is much human-water contact, and where waterweed is abundant. However, it increases still more in any irrigation systems fed from the reservoir.

In irrigation schemes, particularly in Africa, Western Asia and the Philippines, schistosomiasis is the predominant health problem. The intermediate host snails flourish in the slower moving water of minor canals and particularly in the ditches of the drainage systems needed to remove excess water from the fields and to avoid salinization. Whether urinary or intestinal schistosomiasis predominates depends on locality, duration of canal filling and temperature, and it is not always possible to predict which species will predominate, except in the Far East where *Schistosoma japonicum*, whose hosts are amphibious snails, is found. A somewhat similar parasite, *S. mekongi* has been found in the river valley of that name, and although it is currently of little public health importance, it could increase if the proposed dam system along the Mekong develops.

Malaria is also strongly, but locally, associated with water impoundments, particularly in Asia and Latin America where vectors may breed at the margins of reservoirs. In much of sub-Saharan Africa, however, the level of transmission is already so high that, even if anopheline mosquitos become more abundant, there is little scope for worsening of the human malaria situation.

In South-East Asia there are reservoirs with a major problem of *Opisthorchis* infections. This human liver fluke is acquired by eating uncooked and inadequately fermented freshwater fish which have in turn been infected by fluke larvae emerging from freshwater snails.

Not only does the parasite damage the human bile duct; it is also unequivocally carcinogenic and leads to significant mortality from bile duct carcinoma.

Health consequences of cultivation and deforestation

Agricultural change tends primarily to involve alterations in the basic environment, domestic plants and animals, and farming methods. The two main types of environmental modification are the provision of increased, or more controlled, water for vegetation growth and the opening up of additional land.

The trend towards multiple cropping which depends on both irrigation and appropriate crop varieties can, in the case of rice, increase three-fold the period when the rice-fields provide breeding habitats, in the absence of measures to restrict mosquito larval survival. However, selection of crop rotations within the year can reduce the time when free surface water is present.

Asian rice cultivation is always associated with malaria, schistosomiasis and Japanese encephalitis, with smaller risks of gastrointestinal and hepatic flukes. But all these diseases are patchily distributed and in many areas malaria is prevalent but unrelated to agricultural activity. Similar problems occur with irrigated rice elsewhere, though different arboviruses will replace the Japanese encephalitis, especially in the Americas, and the filariases will play a variable role.

Changes in livestock may affect vector-borne disease patterns in a complex manner. Increased animal populations may direct mosquito biting activity away from man, especially if the livestock pens are located between the breeding sites and human settlements. On the other hand, the stock may act as amplifier populations, allowing the great proliferation of arboviruses normally transmitted at a lower level among wild birds or mammals. Subsequently the infection may spill over into the human population, as may occur with Japanese encephalitis virus, amplified in domestic pig populations. Livestock

populations, by increasing food supplies for mosquitos and tsetse flies, may also encourage larger vector populations than otherwise would be the case, but few quantitative data are available. In the case of schistosomiasis in East Asia, domestic animals are susceptible and may also play a role in maintaining the parasite life-cycle in the Philippines and elsewhere.

The process of deforestation creates a moving boundary zone, or ecotone, between the forest and cultivation. In South America, malaria may be most intense in the arable areas, while mucocutaneous leishmaniasis is more a feature of the jungle itself with transmission to the intruding loggers and other people. Large tracts of South and South-East Asia have their most intense malaria transmission along the forest fringes of the hilly areas which often coincide with national borders. Not only is *Anopheles dirus*, which breeds in sunlit pools in the partly cleared forests, an extremely effective vector of falciparum malaria, but the effects of population movements, often accompanied by such illicit activities as smuggling and gem mining, facilitate transmission and diminish enthusiasm for government control activities.

Such areas are often politically restive and inhabited by ethnic minorities. Gem mining creates many pools to act as mosquito larval habitats. These areas appear likely to create some of the most intractable foci of Asian malaria for several decades. Much of it is multi-drug resistant and prospects for control are poor, even if vaccines are eventually developed, except for immigrant groups. In these areas, political and environmental issues are intermixed to an extreme degree.

Increased mechanization may affect the transmission of water-related diseases. For example, it may cause a decrease in snail populations by better clearing of vegetation from canals; or, indirectly, may lead to larger fields, better levelling, drainage of marshy areas, and a sharper separation of land and water, which will generally tend to decrease vectors of disease.

Most forms of mechanical equipment will also tend to reduce personal contact of farm workers and the aquatic environment. Thus, schistosomiasis transmission will be reduced, and so will leptospirosis, with its rodent reservoirs but no invertebrate vector. Where mechanical means are used to harvest crops or cut sugarcane there will be a decreased risk of snake-bite (a substantial hazard in some parts of Asia). Improvement of agricultural methods, short of mechanization, may also reduce schistosomiasis in those working in water, while better clothing will reduce leech bites and insect bites among plantation workers such as tea-pickers.

As agricultural activity and culture methods become more sophisticated and higher yields are systematically sought, a more evenly cultivated landscape will result. The ecotones, patches of waste land and water will be reduced and many disease vectors will decrease. There may, however, be larger populations of a few vectors whose ecological preferences happen to coincide with the spreading pattern of agriculture.

Effects of climatic change on water-related disease

In much of the world, vector-borne and other water-related disease transmission shows marked seasonal variation. The transmission season may be very short, or may show seasonal rises from a lower perennial level. Both climatic change and irrigation may change this regime, to perennial surface water in the case of irrigation. The latter will tend to prolong disease transmission, but sometimes the relationship is complex and an increase in anopheline mosquitos due to irrigation may not be accompanied by increased malaria.

Climatic change, though the subject of much speculation, will affect water-related diseases to an uncertain degree. Indirect effects would include increased *Culex* breeding in coastal cities due to rises in ground water levels, and greater flooding in those areas, together with changes in the inland rural water regime. Desertification seems to be occurring in the western Sahel resulting in a marked shortening of the malaria transmission season in The Gambia (for which long-

term records exist). Since the stages outside man in the life-history of protozoal and helminthic parasites depend on the ambient temperature, global warming would be expected to increase the distribution and intensity of vector-borne disease. The main changes might affect malaria and schistosomiasis. Already there are suggestions that malaria is spreading beyond previous altitudinal and latitudinal limits in Africa, but the causes could be due to population pressures and migration as well as, or instead of, climatic change.

Malaria is likely to spread from adjacent uncontrolled endemic areas rather than to re-invade more distant places where eradication has been successful. Often the changes may be specific to the locality. Some Asian vectors favour brackish water; in Africa the freshwater vectors are usually more effective; some vectors flourish in drying-up streams, others will proliferate in transient puddles. If precipitation, and hence water supplies, become more erratic as a result of global climatic change, diarrhoeal diseases resulting from lack of water for hygiene and from contamination of supplies will increase and the multiple health problems secondary to flooding and drought will increase in frequency. Secondary effects from nutritional deprivation resulting from disruption of agricultural production by drought and floods may be even greater.

Future prospects

What changes are likely in the future? Preventive measures are being incorporated to a greater degree in the planning and construction of large dams, and fewer are being built than before. However, small dams not requiring external capital or formal assessment are being constructed in vast numbers (thousands in Nigeria alone, recently) and without regard to health issues. Irrigation continues to increase steadily, and with a tendency towards small farmer-managed systems the very tight discipline previously needed to enforce environmental control of water-related infections has lapsed and not yet been replaced by adequate cooperative efforts.

The relative importance of diseases is gradually changing. Schistosomiasis has the same endemic potential as in the past, but better and safe chemotherapy has led to extensive control of infection in man. If resistance of the worms to the drugs praziquantel and metrifonate should arise, the problem would immediately re-intensify, but this has not yet happened. The importance of Japanese encephalitis, transmitted by the rice-field mosquito, *Culex tritaeniorhynchus*, has risen throughout Asia, and as long as immunization remains expensive will pose an increasing threat. Although few of those infected become ill, if they do show clinical symptoms, half of the victims die and another quarter are permanently mentally disabled.

New pathogenic organisms may infect man: new in the sense that they were previously unknown in the locality. This may be because of the environmental changes in agricultural practices, introduction by immigrant farm workers, or amplification of zoonotic viruses by introduced livestock. Infections already present may become more prevalent, and in the case of helminthic infections the parasite burden may be increased, with a resulting rise in overt disease. Thus, the transition from annual flood irrigation to perennial irrigation in the Nile valley has led to a changed balance between schistosome species and a greater intensity of infection. Vector populations may increase in numbers, or in a few cases decrease, have an extended season of activity, and undergo many complex changes.

Malaria, whether related to irrigation in Asia or to other water bodies throughout the tropics, is an increasing problem. Partly this is due to its continuing resurgence from the days of attempted eradication, though some sort of new steady state has now been reached in many places, but more often the hazard is due to the spread of multi-drug resistant strains of the parasite, which make chemoprophylaxis and treatment much more difficult and expensive. Hopes have been placed on a vaccine, but this may be several years away and has so far proved a receding target. The alternative approach of insecticidal control becomes less applicable as major vector mosquitoes become resistant to the available substances, and replacements become much

more expensive. The rise in insecticide resistance is due both to deliberate vector control activities and to some extent to the use of insecticides against agricultural pests. Both schistosomiasis and malaria illustrate the interactions of environmental change and chemotherapy/insecticides on transmission and in determining the public health importance of these conditions, with schistosomiasis currently receding somewhat and malaria increasing in importance.

How can the adverse health effects of adverse environmental effects be minimized? Medical advances in chemotherapy and vaccine development may reduce the public health importance of some diseases, while acquired resistance of pathogens to drugs and of vectors to insecticides can make them worse. Adequate attention to health issues at the design stage of water resource developments is reducing the problems from some large developments, but is still often ignored. It is essential first to raise public and political awareness of the issues involved, and to ensure that professionals have a sufficiently multidisciplinary training so that they are aware of the problems. Health impact and opportunity assessments at the pre-feasibility stage are needed, leading to modifications of agricultural and other water resource developments at the planning stage, when it is often possible to design for the reduction of health problems. This requires a proper policy framework and appropriately drafted terms of reference for resource development consultants. At the operation and maintenance stage, irrigated agriculture can often be made both more efficient economically and safer for health. Domestic water supplies require similar attention, and with increasing water scarcity for both urban and rural use, there will be opportunities to try to combine economical use with reduced health hazards.

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11. OCCUPATIONAL DISEASES RELATED TO FOOD AND AGRICULTURE

A number of occupations are represented in agriculture, and in food processing and distribution. These fall into three groups, according to their relationship with the environment. Farmers and foresters are engaged entirely in a form of environmental management. Fishermen and hunters follow occupations that may influence the ecological balance. Together, these two groups constitute the primary producers. Slaughtermen, butchers, tanners, and furriers work in secondary industries that are more readily controllable, but have considerable potential for environmental pollution. While each occupation has its own occupational hazards, the first and second groups have the most hazards specifically determined by environmental factors, such as climate, close contact with animals, dead and alive, and the need to augment soil fertility and control pests.

The population at risk

Epidemiological studies of the occupational health of primary producers present great problems to those who design surveys. Although this is the largest single occupational group in the world, it is difficult to define numerically. In the least developed countries, the agricultural populations form a much higher percentage of the total population than in economically more developed societies, exceeding 80% in 11 countries, 10 of which are in the African region, and Bhutan. In the USA, the figure is 2% [1]. The agricultural labour force as a percentage of the agricultural population varies much less, with a mean of 40.4% (range 23-61%) in 163 countries.

Many members of a rural family may participate, to some extent, in agricultural activities, and thus are exposed to occupational hazards. Particularly in developing countries, the boundaries become blurred between diseases that are strictly occupational and those that are endemic in rural communities, but may be aggravated by specific occupational factors. Even though conditions, such as chemical

exposure, may seem at first to be occupational, uncertainties arise in classifying these because of the variety of different chemicals, natural and synthetic, to which a worker might be exposed, and the simultaneous use or misuse of the same chemicals in households.

Relative risks

Relative risks between occupations can be indicated roughly by standardized mortality ratios (SMR), which are calculated around an average value of 100 for all occupations in the age and sex group. These have been particularly studied in the United Kingdom [2], and in the years 1979-80 and 1982-83, men aged 20-64 engaged in farming, fishing, and related occupations did not show any significant excess of mortality from all causes (SMR 105), including infectious diseases (SMR 108) or cancer (SMR 104). There were significant excesses in diseases of the respiratory system (SMR 114), and especially from accidental causes (SMR 144). Mortality is only one measure of conditions with a serious outcome. Morbidity is more important because it affects ability to work, but there are very few reliable figures that can be used to compare hazards in different occupations.

Zoonoses and vector-borne diseases

The close association of farming and related occupations with animals makes their workers more prone to be affected by zoonoses, i.e., infectious diseases naturally transmissible between animals and man. Over 120 conditions have been described, and their incidence in humans depends very much on the prevalence of the disease in animals in a particular area, and on the environmental mode of contact. Some with severe effects include anthrax, rabies, tuberculosis, toxoplasmosis, tularaemia, Lassa fever, and various forms of encephalitis. Other conditions are debilitating and may become chronic, such as brucellosis, some forms of leishmaniasis, echinococcosis, and salmonellosis. Infections, such as cowpox, foot and mouth disease, orf, and vesicular stomatitis, are self-limiting in humans, but may provide problems in differential diagnosis.

Some zoonoses are transmitted by intermediate hosts, such as mosquitos and ticks. Other vector-borne diseases, especially malaria, filariasis, and schistosomiasis, figure prominently in the morbidity pattern of most rural areas in the tropics, and farmers and other workers in irrigated or naturally wet areas are groups with a high risk of infection.

Respiratory disease

The high incidence of respiratory disease among primary producers depends on two main factors. The first is climate, since most workers are exposed to extreme climatic conditions. It is not surprising that chronic bronchitis is a very common occupational disease, exacerbated by smoking. The second factor is exposure to various natural organic dusts during the handling of agricultural products, which causes either hypersensitivity leading to pneumonitis, or sensitization resulting in asthma.

Hypersensitivity is mainly due to moulds of various species or organic dusts. Farmer's lung is caused by mouldy hay and some types of grain dust, sugar cane workers suffer from bagassosis, maltsters are affected by sprouting barley, foresters by felling trees and handling logs, and sawyers by redwood and other sawdust. Mouldy cork dust can cause suberosis, and mushroom workers are affected by moulds other than those that they are growing. In addition, bird breeders can suffer from hypersensitivity to droppings and feathers, and animal handlers may be affected by faecal dust and particles of hair, conditions that are more likely to occur where birds or animals are closely confined. The prevalence of these diseases is difficult to measure. Farmer's lung is probably the most common condition and has been reported in up to 57 per 1 000 farmers in the United Kingdom, but only 2-7 per 1 000 in the USA [3]. Workers who suffer from hypersensitivity may have to change their occupations to prevent the condition worsening. Mortality statistics record the occupation at the time of death, and thus may underestimate the importance of these diseases.

The prevalence of asthma or related lung diseases due to sensitization is unknown, but the conditions have been caused by a wide variety of agents, including some that also cause hypersensitivity. An important condition in this category is byssinosis, which is associated with the early processing of cotton, flax, jute, and hemp. Sensitization can also occur to remains of insects and mites, especially in grain storage, and to some agricultural chemicals or their solvents. Desensitization may be successful in some cases, but in others repeated attacks of asthma may force a change of occupation.

Accidents

Accidents are the most important group of hazards for primary producers, and include both physical accidents in the usual sense, and poisoning from chemical exposure. While farmers have a higher accident rate than the general population, fishermen, foresters, and hunters still have higher rates. These differences are clearly environmentally determined. For farmers, most major accidents are caused by farm vehicles or unguarded machinery; most of the former are due to overturning of a tractor on hilly terrain or into ditches. Unguarded machinery takes a toll of life, limbs, and eyes. Animals can cause injury, both in the handling of domesticated animals, and from snake and poisonous spider bites. Hunters are at risk from wild animals and from their own firearms and knives. Forestry workers are liable to injury from saws, ropes, cables, and falling objects. At sea, falls and machinery are the commonest causes of injury.

Chemicals and pesticides

Exposure to chemicals is most common among the farming group. There are a large number of potential sources of exposure, including the application of fertilizers, pesticides (insecticides, herbicides, rodenticides, fumigants, soil and seed treatments), and plant growth regulators, the dipping and drenching of animals, working in proximity to exhaust fumes, and using disinfectants and veterinary drugs, including the administration of antibiotics to animals. Of

these, pesticides are the chemicals that cause most health concern. The main hazard is acute poisoning, and mortality rates vary from 1 to 9% of cases presenting for treatment [4,5], depending on the availability of antidotes and the quality of medical services. Although the global number of cases each year has been estimated at 1-3 million, the latter figure may be the most appropriate estimate [6]. Most countries that have studied their own cases have found that pesticide poisonings account for about 5% of all accidental acute poisoning cases, but the picture is sometimes confused by difficulty in separating intentional poisonings from truly accidental cases. Except in countries such as Sri Lanka [7], where pesticides are the preferred agent in suicide attempts, occupational cases account for about half of all accidental cases; the remainder are mostly children who gain access to opened pesticide packs, or victims of ill-advised practices, such as the decanting of a pesticide into an unlabelled container.

Cases of acute poisoning occur singly, or in outbreaks which are usually due to the accidental contamination of food, frequently during transportation. Statistics only record cases that come to medical attention, and it is clear that many of the pesticide users have been affected to some degree by pesticides after applying them without taking the recommended precautions. Some pesticides can cause permanent damage to health, notably arsenic, organic mercurial compounds, thallium, and some fumigants. Several hundred compounds from other chemical groups are registered by countries for use, less than half of which are sufficiently toxic to cause accidental poisoning. Where this does occur, and is survived, it is normally followed by complete recovery, as far as can be objectively measured. Although there have been allegations that chronic effects, including cancer, may result from acute exposure to some of these compounds, no confirmation of this has been found in any series of surveys in different environments. Pesticides have now been in very wide use globally for several decades, and it seems likely that any serious or consistent chronic effects of pesticides registered for use during this period would have been described by now.

Pesticides vary in toxicity, from those that are very highly hazardous, to those that present no hazard in ordinary use. Cases of intoxication arise from misuse, and are eminently preventable. With this objective, WHO has developed the *Recommended classification of pesticides by hazard, and guidelines for classification* [8], and FAO, in consultation with WHO and other UN agencies, has obtained widespread acceptance of the *International code of conduct on the distribution and use of pesticides* [9]. A general account of the public health impact of pesticides used in agriculture has been published by WHO and UNEP [10].

Physical hazards

Apart from the conditions described above, physical conditions also present some hazards for workers in these occupations. Rural areas are often considered quiet and tranquil, but machinery, especially generators, tractors, and saws, may produce levels of noise loud enough (in excess of 85 dB) to cause high-frequency hearing loss in those exposed for considerable periods of time. Since this loss is additive to that associated with age, many farmers and foresters suffer significant hearing loss in their later years. Hunters show similar loss due to firearm noise.

In addition to noise, vibrating tools and machinery are hazards for many workers. Whole body vibration can cause fatigue, impaired balance, and chest pain, while chronic effects include back pain and degenerative changes in the spinal column and other joints. These are exacerbated or can also be caused by the lifting of heavy objects. Local vibration, especially in the hands, may result in neuro-vascular conditions such as Raynaud's phenomenon, particularly in cold climates, and in damage to sensory and motor nerves.

Prevention and control

There are several ways in which the occupational health of primary producers can be improved: by the use of certain techniques; by medical preventive measures; by education in the safe handling of

machinery and chemicals; and by regulation, where this seems appropriate and enforceable.

Four types of techniques can reduce accidents and chemical exposures. The first is adherence to what is generally known as good agricultural practice. This includes such measures as crop rotations, the avoidance of excessive treatment with fertilizers, the use of correct dosages of chemicals for essential pest control, and the correct use of agricultural tools and machinery.

Integrated pest control is a methodology that has slowly developed in recent years. It is essentially a combination and development of traditional environmental, biological, and chemical pest control methods to reduce reliance on chemicals, and to lessen the real risk that the pest may become resistant to the pesticide. At the same time, the hazard of exposure of those who apply the chemicals is diminished.

These two techniques play a part in the prevention of accidents, but personal protection is often needed. Priority areas are the use of goggles or visors to prevent eye injuries, the use of respirators in dusty atmospheres, the use of gloves to protect the hands, the use of steel-reinforced footwear whenever working with heavy objects, and the use of ear defenders or plugs in noisy environments to protect the hearing. Personal protection also includes the use of washable working clothing suited to the climate, and the provision of water for washing exposed skin whenever working with chemicals, both of which may be difficult to achieve in the tropics.

The last preventive technique really depends on designers of equipment rather than individual workers. This is to reduce noise, vibration, and dust hazards, and to ensure that moving parts of machinery are properly guarded, whenever this is practicable.

Medical preventive measures are within the scope of primary health and veterinary services, and chiefly consist of vaccination of man and/or animals against some diseases, such as tetanus, yellow fever,

and rabies, and early treatment of other conditions before they become established in the individual or are transmitted to others. This applies particularly to anthrax, tuberculosis, brucellosis, and salmonella infections. Intestinal parasitic infections also need more attention, as they reduce energy and lessen productivity. The importance of adequate water supplies and sanitation as preventive measures cannot be overemphasized.

The education of workers at all levels is needed with regard to the hazards faced and the use of techniques to avoid them. Every opportunity should be taken to extend this to other members of the rural family. Farmers are notorious for their independence, and therefore all education has to show a positive advantage in improvement of crops or livestock. It is more likely to be effective if delivered informally, and agricultural extension officers are key personnel in this regard. Illiteracy can be a problem in all educational techniques, but is no excuse for the neglect of any chance to reinforce the teaching of techniques. This applies especially to the distributors of chemicals, who must be in a position to advise farmers on the proper use of their product and the precautions to be followed, especially when they know that the farmer cannot read the label.

Regulation is the last resort, but plays a necessary role in prevention. Factory and workshop situations for workers such as tanners, furriers, and slaughtermen should be covered by the usual legislation governing working conditions. In addition, nationally adopted, health-related standards are needed for temperature, dusts, and noise. Finally, the packing and distribution of agricultural chemicals should be controlled by registration procedures and all that these imply, as set out in the *FAO International code of conduct on the distribution and use of pesticides* [8].

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12. FOOD, NUTRITION, AND DISEASE^a

Deficiency diseases

After the Second World War, protein-energy malnutrition was recognized as a widespread and important public health problem in all regions of the developing world. In the same areas, communicable diseases were the principal causes of sickness and death, and it came to be realized that the resistance of children and adults to infectious diseases often depends on their nutritional state, which may have a profound impact on the development of immunity. Although acute childhood malnutrition is, in general, a receding problem, large populations of children and adults, especially in Africa, remain chronically undernourished and particularly vulnerable to any further deterioration in their food supplies. Other, more specific, forms of nutritional deficiency remain widespread.

Iodine deficiency disorders

Iodine deficiency disorders are a major scourge and their prevention or amelioration depends on the ready availability of iodine in the water consumed by the population, or in the types of food eaten. The Andes, Alps, Great Lakes basin of North America, and the Himalayas are particularly iodine-deficient mountainous areas, but coastal areas and plains may also be deficient. Excessive intakes of goitrogens (for example from consumption of cassava in central Africa, or of waterborne goitrogens in Latin America) interfere with the normal uptake and metabolism of iodine and can thus amplify the effects of iodine deficiency.

In addition to the clinically obvious and easily recognizable effects of iodine deficiency (i.e., goitre and cretinism), the more pervasive effects of milder iodine deficiency on the survival and the physical and mental development of children, and also on the intellectual

^a A comprehensive review of current knowledge on diet, nutrition, and the prevention of chronic diseases is to be found in the report of a WHO Study Group [1], from which most of the material in this Chapter has been drawn.

ability and work capacity of adults are now being recognized. Iodine deficiency disorders are of sufficient importance to warrant urgent government action and monitoring, since about 1 000 million people are affected in more than 80 countries.

Iodination of salt is one of the very few effective ways of controlling endemic goitre, and there is some indication that the problem is increasing in some sections of Europe as people voluntarily reduce salt usage. In areas where iodine intakes from other sources are low, there is a clear need for the coordination of policies relating to the control of goitre by the iodination of salt and to the control of hypertension risk by limiting salt intake. There may be a need to adjust the iodination levels of salt as salt intake changes or, in industrialized countries, to add iodine to all salt rather than only to table salt. Another approach in goitre endemic areas may be to use injectable iodized oil.

Vitamin A deficiency

Vitamin A deficiency, leading to xerophthalmia and sometimes blindness, continues to be a widespread problem among children [2]. Deficiency of vitamin A also decreases resistance to infections and increases mortality. There is some evidence that administration of vitamin A supplements to deficient populations can reduce both mortality and blindness. Supplements of vitamin A in such populations may reduce the under-five mortality rate, even where xerophthalmia is not present. Analyses of food supplies from different regions show that the availability of vitamin A is limited; this problem is exacerbated by any tendency to withhold vegetables from children for cultural or other reasons. In Asia, there is a particular problem, because the estimated overall average availability of vitamin A is less than that required by the population. Any maldistribution of foods high in vitamin A within the population would further exacerbate the problem. Although, in most countries, there is a slow, but steady, improvement in the availability of foods rich in vitamin A, xerophthalmia continues to be a major problem in about 40 countries.

The desirability of low-fat diets for the prevention of cardiovascular disease and cancer is discussed in later sections; very low fat intakes will interfere with the absorption of vitamin A and provitamin A. However, at the levels of fat advocated, i.e., 15-30% of energy, no detrimental effects on absorption would be expected.

Iron deficiency

A further example of a continuing deficiency disease of widespread importance is anaemia. Table 12.1 [3] shows the startling difference in the prevalence of anaemia at all ages in developing compared with developed countries. Africa and southern Asia have a particular problem, the dominant cause being iron deficiency. In many areas of the tropics and subtropics, existing dietary iron deficiency, due to low intake of iron and/or its poor absorption, may be complicated by hookworm infection, which causes intestinal blood loss and may lead to profound iron deficiency anaemia.

In Africa, Asia, and South America, the trend in iron availability has been deteriorating rather than improving, so it is not surprising that iron deficiency anaemia continues to be a massive public health problem in the world.

The availability of dietary iron for absorption is affected by both the form of iron and the nature of the foods concurrently ingested. Two major forms of iron exist in diets - haem iron and "inorganic" iron. The former, found only in animal sources, is readily available and absorption is not influenced by other constituents of the diet. Absorption of inorganic iron is strongly influenced by factors present in foods ingested at the same time. Two widely recognized promoters of absorption are animal foods and ascorbic acid (vitamin C). Even though diets based primarily on cereals and legumes may contain much iron, without co-existent factors, such as vitamin C, they may actually provide only a low level of available iron.

Table 12.1 Estimated prevalence of anaemia and number affected, by geographical region and age/sex category, around 1980 (population data in millions)^{a,b}

Region	Children										Men				Women						
	0-4 years					5-12 years					16-59 years				15-49 years						
	%		No.		%	%		No.		%	%		No.		%		No.		%	%	
Africa	56	48.0	49	47.3	20	23.4	63	44	46.8												
North America	8	1.6	13	3.6	4	3.1	-	8	5.1												
Latin America	26	13.7	26	18.1	13	12.8	30	17	14.7												
Eastern Asia ^c	20	3.2	22	5.6	11	6.1	20	18	8												
Southern Asia	56	118.7	50	139.2	32	123.6	65	58	191.0												
Europe	14	4.7	5	2.7	2	3.0	14	12	14.1												
Oceania	18	0.4	15	0.5	7	0.5	25	19	1.0												
Developed regions	12	10.2	7	9.1	3	12.0	14	11	32.7												
Developing regions	51	183.2	46	208.3	26	162.2	59	47	255.7												
World	43	193.5	37	217.4	18	174.2	51	35	288.4												

^a Adapted from Ref. 3.

^b Anaemia is defined as a haemoglobin concentration below WHO reference values for age, sex, and pregnancy status (see WHO Technical Report Series, No. 405, 1968).

^c Excluding China.

Concern about iron deficiency is one nutritional reason for recommending the consumption of at least some meat, or foods providing a substantial amount of ascorbic acid. Where hookworm infection is prevalent, appropriate public health measures must form part of any programme for the control of iron deficiency anaemia.

Fluoride deficiency

There is clear, clinical, epidemiological and experimental evidence that fluoride significantly reduces the incidence of dental caries. Until about 10 years ago, it was believed that fluorides worked principally by increasing the resistance of enamel to acids produced in dental plaque from sugars. More recent research shows that fluoride acts principally by remineralizing the early carious lesion and by an effect on the bacteria in dental plaque. Fluoride intake may be increased to optimum levels by fluoridation of community water supplies, by adding fluoride to salt, milk, or toothpaste, by taking fluoride supplements, or by the topical application of fluoride.

The combined effect of fluoride sufficiency and a lowered intake of free sugars (including sucrose) is beneficial in terms of the development of caries. The consumption of a limited amount of free sugars is acceptable, only if the population is using fluoridated toothpaste and/or drinking fluoridated water.

Other nutrient deficiencies

Only the major deficiencies have been mentioned. Other significant disorders include:

- rickets, which is still widespread in parts of northern Africa and the Eastern Mediterranean, and is reported to be increasing in Mexico; this condition is attributable to insufficient exposure to sunlight and lack of vitamin D in the diet;

- ascorbic acid deficiency, particularly in some drought-affected populations, e.g., in Africa;
- deficiencies of other trace elements, e.g., zinc; and,
- vitamin B₁₂ deficiency, which causes anaemia and, if severe, neurological disorders: it may occur in those consuming exclusively vegetarian diets containing no foods of animal origin.

Diseases related to dietary and behavioural patterns

It is only over recent decades that it has been realized that socio-economic improvement, food sufficiency, urbanization, and industrialization are all associated with dietary and behavioural changes that have profound effects on the pattern of disease, morbidity, and mortality.

The type of diet prevailing in the industrialized countries is characterized by an excess of energy-dense foods rich in fat and free sugars, but a deficiency of complex carbohydrate foods (the main source of dietary fibre). Epidemiological research has demonstrated a close and consistent relationship between the establishment of this type of diet and the emergence of a range of chronic noncommunicable diseases, including, particularly, coronary heart disease, cerebrovascular disease, various cancers, diabetes mellitus, gallstones, dental caries, gastrointestinal disorders, and various bone and joint diseases.

Coronary heart disease

Coronary heart disease as a public health problem became evident in Europe and North America early in this century. By the 1950s, it had become the single major cause of adult death, and suspicions then began to emerge as to its likely causes. The approximately five-fold difference in rates among various developed countries (e.g., Finland compared with Japan) and the intrapopulation variation

in rates, according to socioeconomic class, ethnicity, and geographical location emphasized the environmental basis of the condition. Further evidence for environmental determinants comes from the marked shifts in rates seen in migrant populations following changes in their life-style and diet.

Epidemiological studies carried out on middle-aged men provide clear evidence that the risk of coronary heart disease in individuals is increased by three major factors: high serum total cholesterol, high blood pressure, and cigarette smoking [4]. The presence of several risk factors, simultaneously, increases the risk of the disease more than would be expected from the sum of the individual risk factors. The fundamental importance of diet in the development of coronary heart disease is mediated through its effects on the development of hypercholesterolaemia and hypertension. Body-weight changes induced by changes in diet and physical activity are strongly related to changes in serum total cholesterol and blood pressure, and obesity is strongly related to diabetes, which is a further risk factor for coronary heart disease.

A low intake of saturated fatty acids is the preferred option for preventing coronary heart disease and is the strategy that is still accepted by numerous international committees. In most developed countries, a high total fat intake coincides with a high saturated fat intake - diets with 40% of energy from total fat often provide 15-20% of the energy from saturated fat. Reducing total fat intake to 30% of energy will therefore have a substantial effect on saturated fatty acid intake in these populations, but should still allow the different unsaturated fatty acids to contribute up to 20% of energy.

High blood pressure and cerebrovascular disease

The risk of both coronary heart disease and stroke increases as blood pressure rises. A recent large-scale multinational study (the Intersalt Study), involving 52 centres in 32 countries around the world, assessed the role of obesity, alcohol, and mineral intake in determining the progressive rise in blood pressure seen with age in

most countries. A high body-mass index (body-mass index = body mass in kg/(height in metres) and high alcohol intake had strong, independent effects on blood pressure. Salt (sodium chloride) intake had a weaker, but significant, effect on the rise in blood pressure with age. In the four populations with a particularly low salt intake of below 3 g/day, no increase in blood pressure with age was observed, but a salt intake of 6 g/day may be a more reasonable estimate of a safe upper limit. Epidemiological studies consistently suggest lower blood pressures among vegetarians than non-vegetarians independent of age, weight and pulse rate. Although it is not easy to determine the precise reasons for these findings, the studies suggest that some component of animal products, possibly protein or fat, may influence blood pressure in well-nourished populations.

Increased physical activity may reduce blood pressure independently of its effect on weight change, and an increase in total dietary fat may also have an effect in promoting hypertension as well as obesity. Further research is needed, but the evidence for marked environmental effects on blood pressure is clear. A recommendation to maintain normal weight with a diet low in fat and high in complex carbohydrates, and minimize the intake of alcohol, is relevant to the avoidance of both obesity and hypertension; a low salt intake may also be beneficial in preventing the rise in blood pressure that is apparent in developed countries from early childhood.

Cancer

The relationships between specific dietary components and cancer are much less well established than those between diet and cardiovascular diseases. However, the overall impact of diet on cancer rates throughout the world appears to be significant. For populations in developed countries, where cancer rates are highest and account for approximately one-quarter of all deaths, some epidemiologists estimate that 30-40% of cancers in men and up to 60% of cancers in women are attributable to diet [5].

The evidence for the influence of diet on cancer risk is derived from several sources. Correlations between national and regional food consumption data and cancer rates, and studies of the changing rates of cancer in populations as they migrate from a region or country of one dietary culture to another, have led to many important hypotheses. Case-control studies of the dietary habits of cancer patients and comparison subjects, and prospective studies of populations with known dietary habits, provide stronger evidence for the effects of diet in relation to major cancers. Many of these observations from human populations have been supported by experimental animal data.

Studies of diet in relation to some cancers have been confined to relatively homogeneous populations and have not been replicated across a range of cultural and dietary settings; for other cancers, the research has been pursued over a wider range of dietary intakes. Included among the cancers that have been linked repeatedly to dietary factors in different populations are cancers of the oral cavity, pharynx, larynx, oesophagus, stomach, large bowel, liver, pancreas, lung, breast, endometrium, and prostate.

Cancers of the oral cavity, pharynx, larynx, and oesophagus

In developed countries, the results of epidemiological studies clearly indicate that drinking alcoholic beverages is causally related to cancers of the mouth, pharynx, oesophagus, and upper part of the larynx [6]. There is no indication that the effect is related to the type of beverage. Smoking also causes cancers at these sites. There is also some evidence that cancers of the mouth and throat are increased by poor oral and dental hygiene.

In correlation studies conducted in different parts of the world, investigators have found positive associations between oesophageal cancer and several dietary factors, including: low intakes of lentils, green vegetables, fresh fruits, animal protein, vitamins A and C, riboflavin, nicotinic acid, magnesium, calcium, zinc, and molyb-

denum; high intakes of pickles, including salt-pickled vegetables, and mouldy foods containing *N*-nitroso compounds; and consumption of foods and beverages at very high temperatures. The reported associations are consistent with the general hypothesis that certain nutrient deficiencies, such as are found in many high-risk populations, including heavy alcohol drinkers, might increase the susceptibility of the oesophageal epithelium to neoplastic transformation.

Case-control studies of oral and laryngeal cancers have also shown an increased risk associated with infrequent ingestion of fruit and vegetables.

Stomach cancer

A high incidence of stomach cancer is found in Japan and other parts of Asia and in South America, but not in North America or Western Europe where the rates are low and still decreasing. In the USA, stomach cancer rates are now among the lowest in the world, whereas, in 1930, this was the leading cause of cancer death for men and the second leading cause in women. Gastric cancer incidence is decreasing in Japan, and a gradual decline in incidence over several generations has been noted among Japanese migrants to Hawaii. It seems most likely that these trends are related to changes in food consumption patterns, since several dietary factors have been implicated in gastric cancer risk. Stomach cancer is associated with diets comprising large amounts of smoked and salt-preserved foods (which may contain precursors of nitrosamines) and low levels of fresh fruits and vegetables (acting as possible inhibitors of nitrosamine formation). Dietary shifts away from this pattern could explain the declines in stomach cancer mortality in industrialized nations over the past 50 years, but the evidence is not conclusive.

Colorectal cancer

International comparisons indicate that diets low in fibre-containing foods and high in fat increase the risk of colon cancer. The initial

suggestion that a lack of dietary fibre might increase the occurrence of large bowel cancer came from observations of the virtual absence of this cancer in southern Africa. The indigenous populations were known to eat a lot of plant foods, and to have much higher faecal weights than populations from industrialized countries.

Several studies also demonstrate positive associations between the risk for colorectal (primarily colon) cancer and dietary fat. In general, the data suggest that saturated rather than unsaturated fatty acids may be responsible for this effect. In other studies, positive associations have been found between meat consumption and this cancer, but many studies have also shown no relationship between fat or meat intake and colorectal cancer. Several case-control and cohort studies provide suggestive, but inconclusive, evidence that drinking alcoholic beverages, in particular beer, has a causal role in the development of rectal cancer.

Liver cancer

Primary liver cancer is relatively rare in North America and most developed countries, but it is common in sub-Saharan Africa and South-East Asia, where it is associated mainly with exposure to hepatitis B virus infection. Liver cancer incidence and mortality, by geographical area, or among different subpopulations, have been correlated with aflatoxin contamination of foodstuffs in Africa. On the basis of evidence in developed countries, consumption of alcoholic beverages is causally related to liver cancer.

Lung cancer

In most industrialized countries, lung cancer is the leading cause of cancer deaths among men, and it is rapidly approaching this status among women. The most important causal factor is cigarette smoking. Lung cancer risk in males is increased by certain occupational exposures (e.g., to asbestos, nickel, chromate, or gamma-radiation), several of which have been shown to interact synergistically with smoking.

Studies in different populations have shown an interactive effect between smoking and a low frequency of intake of green and yellow vegetables rich in beta-carotene. These findings are consistent with experimental data showing tumour inhibition by vitamin A and synthetic analogues. Dietary fats and dietary cholesterol have also been positively associated with lung cancer risk.

Female breast cancer

Several lines of evidence support the importance of dietary factors in the causation of breast cancer. A role for fat and other dietary factors is supported by descriptive epidemiological studies, correlation studies, case-control and cohort studies, and evaluations of nutrition-mediated biological risk factors.

Correlation studies provide evidence of a direct association between breast cancer mortality and the intake of energy (high kJ diet), fats, and specific sources of dietary fats, such as milk and beef. Several case-control studies have associated breast cancer risk with dietary constituents, especially fats. However, not all studies show these relationships.

There is epidemiological evidence - not fully consistent - relating alcohol consumption to the risk of breast cancer in women. It is unclear whether this association is causal.

Endometrial cancer

A strong association between endometrial cancer risk and excess weight has been reported, and a hormonal mechanism has been postulated for this association. Specific dietary factors, other than obesity, have not been identified for this disease.

Prostate cancer

International incidence and mortality data generally show a positive correlation of prostate cancer with the incidence of other diet-related

cancers, including cancers of the breast, corpus uteri, and colon. Intercountry and intracountry analyses show positive correlations between mortality from prostate cancer and intake of total fat. These findings have been supported in analytical studies showing an association of prostate cancer with the intake of high-fat foods.

Major associations between diet and cancer

Table 12.2 [7] summarizes the strength of association between dietary components and cancers at various sites. A review of the evidence indicates that a high intake of total fat (and in some case studies also saturated fat) is associated with an increased risk of cancers of the colon, prostate, and breast. The evidence is strongest for cancer of the colon, and weakest for breast cancer.

In conclusion, though several lines of evidence indicate that dietary factors are important in the causation of cancer at many sites and that dietary modifications may reduce cancer risk, the contribution of diet to total cancer incidence and mortality cannot be quantified on the basis of present knowledge. Nevertheless, evidence indicates that a diet that is low in total and saturated fats, high in plant foods, especially green and yellow vegetables and citrus fruits, and low in alcohol, salt-pickled, smoked, and salt-preserved foods is consistent with a low risk of many of the current, major cancers, including cancer of the colon, prostate, breast, stomach, lung, and oesophagus.

Obesity

There is little evidence that some populations are more susceptible to obesity for genetic reasons, and the differences in the prevalence of obesity in different populations are largely attributable to "environmental" factors (especially diet and physical activity). Within a single population, those who become obese usually come from overweight families and there is evidence of heritability for obesity. Thus, from a public health point of view, the challenge is to modify the population's environmental circumstances so that the

Table 12.2. Associations between selected dietary components and cancer^a

Site of cancer	Fat	Body weight	Fibre	Fruits and vegetables	Alcohol	Smoked, salted, and pickled foods
Lung						
Breast	+	+			+/-	
Colon	++		-			
Prostate	++					
Bladder						
Rectum	+				+	
Endometrium		++				
Oral cavity					+ ^b	
Stomach						++
Cervix						
Oesophagus					+ + ^b	+

^a Adapted and extended from Ref. 7.

^b Synergistic with smoking

+ = Positive association; increased intake with increased cancer.

- = Negative association; increased intake with decreased cancer.

susceptible individual members of the population are less liable to become obese.

As societies become more affluent and mechanized, the demand for physical activity declines. This is apparent in many societies and affects both young and old. The fall in physical activity demands that energy intakes should also be reduced, if excess energy is not to be stored as excess fat. Therefore, changes in the environment that affect the level of energy expenditure of children and adults may influence the development of obesity. National and international analyses are in keeping with the concept that, as the proportion of energy derived from fat increases, so does the problem of obesity, particularly in susceptible individuals. A diet with modest amounts of fat, e.g., 15-20% of energy, may avoid problems of energy deficiency without unduly enhancing the hazards of obesity and other chronic diseases that tend to occur in societies with an average dietary fat content above 30% of energy.

The treatment of obesity is notoriously difficult, because of the prolonged nature of the treatment, the need to readjust dietary energy intakes and/or physical activity permanently to maintain a reduced weight, and the changes in metabolism and in appetite that tend to minimize weight loss. Thus, a preventive policy seems the only long-term solution to the problem of obesity, with a high-risk group within a society being identified as those with a family history of obesity, diabetes, hypertension, or hyperlipidaemia. These people have a far greater risk of putting on weight or of developing complications with only modest gains in weight.

Non-insulin-dependent diabetes mellitus

This disease, the onset of which usually occurs in middle adult life, is strongly associated with an increased risk of coronary heart disease [4], with a range of renal, neurological, and ocular disorders, and, during pregnancy, with adverse effects on the fetus.

Obesity is a major risk factor for the occurrence of non-insulin-dependent diabetes, the risk being related to both the duration and the degree of obesity. Approximately 80% of patients with this form of diabetes are obese. The incidence rate of diabetes is almost doubled when moderate overweight is present and can be more than three times as high as normal in the presence of frank obesity. The occurrence of diabetes within a community appears to be triggered by a number of environmental factors, such as sedentary life-style, dietary factors, stress, urbanization, and socioeconomic factors.

The most rational and promising approach to preventing non-insulin-dependent diabetes is to prevent obesity. Weight control is of fundamental importance in both the population strategy for the primary prevention of this disorder and the strategy for prevention in high-risk individuals (i.e., persons with impaired glucose tolerance or with a genetic predisposition to diabetes). Physical activity not only improves glucose tolerance by reducing overweight, but also acts independently, by having a beneficial effect on insulin metabolism.

Osteoporosis

As the number of elderly in the population increases, problems of old age can be expected to become a greater burden on health services. Already, in the developed world, many people die following fracture of the femur, which occurs particularly in older women with fragile bones, after a relatively minor fall. Increasing fragility of bone is one major reason for hip fractures, although instability of gait, deteriorating eyesight, and poor neuromuscular reflex coordination also account for the rising incidence of hip fracture with age.

Known determinants of bone density have been classified under five headings [8]: lack of oestrogen, immobility, smoking, alcohol and drug therapy, and calcium intake. Oestrogen lack in public health terms relates to the decline in oestrogen activity in women after the menopause.

Populations in developing countries appear to be less at risk from fracture than those in developed countries, despite their lower body weights and calcium intakes, possibly because they smoke less, drink less alcohol, do more physical work (which promotes bone formation), and consume less protein and salt (both of which increase obligatory calcium loss from the body).

Dental caries, sugars, and fluoride

Dental caries is a very common health problem affecting a large proportion of people in developed and rapidly developing countries. It causes considerable suffering and impairs the quality of life. In addition, caries places a heavy financial burden on public health services, and the problem cannot be controlled by treatment alone.

The prevalence of caries in many developing countries is currently increasing rapidly in response to dietary changes associated with the growing use of products containing sugar. This trend is in striking contrast to that in the industrialized nations, where dental caries has been decreasing over the past 20 years, in response to various preventive measures.

Numerous epidemiological studies conducted at the population level suggest that there is a direct relationship between the quantity and frequency of sucrose consumption and the development of caries. In general, very little caries occurs in children when the national consumption of sugar is below 10 kg/person per year (about 30 g/day), but a steep increase may occur from 15 kg upwards. As a result of the rising consumption of sugar and other cariogenic substances in developing countries and the absence of adequate fluoride intake, the prevalence of caries is now higher in some developing countries than in many industrialized countries [9].

The introduction of new sugar-containing products in developing countries, in particular for eating or drinking between meals, will lead to increased caries incidence, if not immediately met by effective caries-prevention programmes. There is an obvious dilemma in that

the preventive programmes have to be established first, at a stage when the disease level may still be low and, consequently, the interest in prevention minimal. Nevertheless, if such programmes are not established while the shift in dietary patterns is still taking place, caries will become a major health problem.

When ingested in excess, fluoride has toxic effects on teeth and bone. Dental fluorosis and skeletal fluorosis are well-known effects of fluoride excess. The margin of safety between the range for deficiency and toxicity is narrow. A sufficient daily ingestion of fluoride is needed to prevent dental caries, though there is no consensus regarding the exact amount of fluoride needed (figures of 0.7-1.5 mg of fluoride per day from all sources have been discussed in the scientific literature). In most countries, drinking-water supplies about 75% of daily fluoride intake. Many communities, particularly in temperate climates, have water supplies fluoridated to a level of around 1 mg/litre. Keeping in mind the toxic effects of fluoride, and the high daily intake of water in the tropics, there is a need to prescribe both lower and upper limits in terms of total daily intake. A concentration of 0.6 mg/litre in drinking-water has been proposed for tropical countries. The presence of dental fluorosis within a community is an indication that the total intake of fluoride is too high. Countries with a problem of excess environmental fluoride must try to defluoridate their water supplies. Countries with low water fluoride levels may plan strategies to increase the fluoride intake of the population to the appropriate level by adopting known methods of fluoride supplementation.

Non-cancer conditions of the large bowel, and gallstones

Certain chronic disorders of the large bowel are thought to occur more frequently in association with the typical "affluent" diet. These include diverticular disease of the colon, haemorrhoids, and constipation. Low intake of dietary fibre is considered to be a major cause of these disorders.

In gallbladder disease, gallstones (predominantly cholesterol gallstones) form within the gallbladder. Gallstones occur much more commonly in developed countries than in developing countries. Within affluent societies, the prevalence is higher in non-vegetarians than in vegetarians. In women, the prevalence increases steadily from around 5% in young adult life to around 30% in old age; in men, the prevalence rates at every age are approximately one-half of those in women. In symptomatic cases (i.e., approximately one-quarter of all cases), surgical removal of the gallbladder, or physical or chemical dissolution of the gallstones, is often required. A starchy diet, rich in fibre, may therefore be protective, particularly if it helps to limit the problem of overweight.

Chronic liver and brain diseases, and other effects of alcohol

Alcohol consumption has many adverse health effects, many of which are strongly associated with the age of exposure and with the amount consumed. In middle and older age, alcohol consumption influences the risks of a range of chronic disease processes, particularly of the liver and brain.

Liver cirrhosis is the major chronic disease caused by alcohol consumption. The liver's capacity to metabolize alcohol is surpassed when consumption is excessive; toxicity results and liver cells are destroyed, to be replaced by scar tissue. In developed countries, at least 40% of fatal liver damage is due to alcohol. There is evidence that women are more susceptible to this cirrhogenic effect of alcohol than are men. Long-term excessive consumption of alcohol has a variety of other adverse effects on the gastrointestinal tract and pancreas [6].

Another important chronic effect of alcohol consumption is brain damage, entailing mood disorder, with confabulation, or a state of delirium and cranial nerve palsies. It takes about 10 years of heavy drinking to produce these brain damage syndromes; alcohol appears to accelerate aging processes that interfere with the capacity to reason and solve the problems of everyday living.

Alcohol consumption influences the occurrence of coronary heart disease and hypertension. While people who consume low-to-moderate amounts of alcohol are at a slightly lower risk of coronary heart disease than abstainers, many epidemiological studies have shown that moderate or heavy consumption of alcohol is associated with increased blood pressure, and abstinence from alcohol is followed by a fall in blood pressure. Hypertension contributes to an increased risk of coronary heart disease and stroke.

Alcohol is a causal factor in various cancers, including cancers of the liver, larynx, mouth, throat, and oesophagus, perhaps, cancer of the rectum and, in women, cancer of the breast.

Alcohol also causes serious health problems at younger ages. There is a characteristic pattern of abnormalities, recognized over the past two decades, in newborn babies of mothers who drink alcohol heavily during pregnancy, i.e., the "fetal alcohol syndrome". The fully developed form of the syndrome occurs predominantly in the children of women consuming more than eight alcoholic drinks per day. However, other effects on the fetus, such as low birth weight and an increased risk of stillbirth, occur at levels of intake greater than two drinks (or 20 g of alcohol) per day. Estimates from North America and Europe indicate an incidence of fetal alcohol syndrome of 1-3 per 1 000 live births and of some adverse effects in a further 3-5 per 1 000 live births. Alcohol is therefore one of the most common causes of birth abnormalities in developed countries.

In adults, particularly young adults, the importance of alcohol in motoring accidents, is well established. In developed countries, between one-third and one-half of deaths on the road have alcohol as a significant causal factor. Alcohol is also a major factor in other accidents such as drownings and boating accidents, and in industrial accidents and absenteeism.

The population perspective

Within a population, the medical care system can sometimes develop approaches to reducing the risk of disease in certain individuals, particularly those at high risk. But from the population perspective, it may be that the entire population's risk profile is "high" relative to that of other populations. Thus, the public health approach to disease prevention requires health-oriented food and nutrition policies for whole populations.

In developing countries, the aim should be to avoid the diseases and premature deaths related to the "affluent" diet that characterize the populations of many developed countries. In the developed countries, the aim should be to moderate or remove the excesses in the present diet that contribute to the high incidence of these diseases.

Developing countries can benefit by learning from the experience of dietary change and adverse health effects in many developed countries. If they act now, the governments of developing countries can gain for their people the health benefits of avoiding nutritional deficiencies, without encouraging the development of the chronic diet-related diseases that usually accompany economic and technological development. Thus, as well as reduced childhood mortality, increased life expectancy should be sought by means of nutrition policies that minimize diet-related chronic disease, thereby avoiding the social and economic costs of premature death during the period of highest economic activity, in middle age. These nutritional policies will also improve the quality of life in the elderly.

Achieving population-based dietary change

If such a socially and economically desirable goal is to be achieved, then national governments in both developing and developed countries must:

- Be aware of the relationship between the changes in a population's diet that tend to accompany economic

development and the consequent changes in the health of the population;

- Recognize that it is both possible and desirable to seek an optimum national diet, in association with economic development, that both maximizes health benefits and minimizes health hazards;

- Develop nutrition-based health policies that are intersectoral. These policies should involve many government departments, and be supported by the activities of nongovernmental organizations, health care workers, and the community at large. Such widespread involvement is needed in order to influence favourably the production, processing, and marketing of foods conducive to health, and to increase public awareness of the relationship between food and health. The mix of integrated policies will constitute a progressive, health-oriented, national food and nutrition policy. From the individual's point of view, such a policy will make healthy choices the easy choices when purchasing food,

Intersectoral public policies are difficult to develop. The links between diet, nutrition, and health have often been poorly specified, and it has therefore been difficult to bring the issues into focus as a coherent public policy. The priority traditionally given in national budgets to food production, without regard to the effects on consumers' nutrition and health, needs to be reconsidered. Short-term policies that seek to maximize local economic activity and foreign exchange earnings, while neglecting health considerations, may incur substantial health care costs and loss of productivity in economically important groups of the community.

Economic development is normally accompanied by improvements in a country's food supply with regard to both quantity and quality (i.e., less spoilage and less contamination of food). Provision of a nutritionally adequate and hygienic diet, in a socially equitable fashion, confers major health benefits, including:

- elimination of dietary deficiency diseases;
- reduction of acute and chronic foodborne diseases;
- improvement in overall nutritional status, including increased childhood growth rates; and
- increased resistance to bacterial and parasitic infectious diseases.

A major consequence of improvements in the food supply has been an increase in life expectancy. However, further economic development has entailed qualitative changes in the production, processing, distribution, and marketing of food. With these changes have come the problems of diet-related chronic diseases, which typically occur in middle and later adult life, and counteract the gains in life expectancy attributable to an improved food supply. These chronic diseases are, in part, manifestations of nutrient excesses and imbalances in the "affluent" diet, so, in principle, they are largely preventable.

In developed countries, the enormous cost of the high-technology, tertiary health care needed for the diagnosis and management of these high-incidence chronic diseases is already apparent. Similar demands in developing countries will impose a huge burden on the human and economic resources of the country and are liable to disturb priorities in the health care sector.

In many developed countries, there is growing evidence of social and political acceptance of the need for prevention-oriented health policies and behaviour to reduce the incidence of diet-related chronic diseases. Some developed countries have been active in public education, using national dietary guidelines as a stimulus. Changes in consumer preferences (e.g., to foods lower in salt, free sugars, and saturated fat, but higher in dietary fibre) are leading to modification of systems for food production and processing. Progress in changing consumer preferences is intrinsically slow, and,

so far, has occurred largely without any support from public policies in any but the health sectors.

Despite this limited support, mortality from coronary heart disease (the leading cause of death in developed countries) has begun to decline and there has been a reduction in the prevalence of hypertension in many developed countries. The downturns have been particularly strong with, for example, a fall of 40-50% in deaths due to coronary heart disease over the past 20 years in North America and Australia. These recent reductions in death rate reflect changes in population life-style, e.g., in dietary habits, such as decreases in the consumption of saturated fats.

The process of changing unsatisfactory dietary practices and promoting health in developed countries can prove socially and politically difficult, but must be tackled, if the suffering and economic impact of cardiovascular diseases, cancers, and other diet-related chronic diseases are to be avoided.

In some developing countries, the first priority must remain the attainment of an adequate food supply for the whole population and the elimination of various forms of nutritional deficiency among vulnerable groups (e.g., protein-energy, vitamin and mineral deficiencies). However, as in the developed countries, efforts are also required to forestall or arrest a population shift towards a high intake of saturated fat, sugar, and salt. This shift is now occurring almost everywhere, even if only in some sectors of society. The challenge is how best to formulate national policies for food that can provide the usual health gains associated with economic development, while minimizing the future social and economic costs of the diet-related, chronic diseases of adult life, which will emerge if developing countries follow the previous experience of many countries in the developed world.

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13. NUTRITION POLICIES FOR THE PREVENTION OF DIET-RELATED DISEASE

The immediate goal of a nutrition policy is the integration of nutritional objectives into different sectoral strategies of national and international organizations. The policies relate directly to the specific nutrient intakes of the populations as a whole, and of subsections of those populations. The immediate goal of a food-production policy is to make food available to meet the demands of the population, as well as to provide foreign exchange. At the household level, food security aims to guarantee all families access to their minimum food requirements, and this implies that both the availability of foods and the purchasing capacity of the population must be assured. A food policy that relates only to the provision of foods does not necessarily also ensure nutritional security for the population.

The objective of preventing chronic disease has introduced a new urgency to the need to link the wider range of demands in a nutritional policy with food-production policies. In addition to making food available, the food suppliers need to match supplies to the nutritional requirements of the community. This means that food policy should be geared to the provision and consumption of foods of the quality and in the quantities that are necessary to promote and sustain nutritional health and to reduce the risk of developing the diseases discussed earlier.

There has been a widespread tendency to oversimplify nutrition policies and to assume that many nutritional problems can be solved by an expansion of animal production. The need to reconsider agricultural and food priorities is not helped by the fact that economic, marketing, and farming practices were established in accordance with the old food policies. There are entrenched farming and industrial interests that will not welcome the reduced emphasis on milk and meat production and a policy specifying the wisdom of consuming only modest amounts of meat and milk, low in fat content. Many farming policies have also been developed to

encourage the cultivation of sugar beet and sugar cane as a method of supporting farm incomes. Sugar as a commodity has the advantage of being readily transported and non-perishable. It is not surprising, therefore, that large industrial interests in affluent societies are now involved in maintaining or promoting sugar consumption.

The dilemma for those in the field of public health is that, though the nutritional thinking of 50 years ago led to a sense of urgency with regard to the improvement of agriculture, the priorities set then have been incorporated into routine government policy making, without specific concern for nutritional objectives. The relatively new philosophy concerned with the prevention of chronic diseases is only now beginning to emerge as an issue in agricultural policy in developed countries, and has not been considered before by agricultural economists and planners in the developing world. Since the new nutritional objectives of preventing both the deficiency diseases and the chronic diseases of the developed world may have immense implications for the economics of farming, government, industrial and social policies, and international trade, it will inevitably take time for coherent policies and programmes to emerge, and for entrenched attitudes to change.

Food strategies in developing countries

Food and nutrition policies in the developing world have focused primarily on food production, the control of communicable diseases, and education. In disaster-prone areas especially, the main focus has been on maintaining national food availability. It is only in countries where sufficient food is available for all that other strategies have been designed for equitable distribution. Table 13.1 shows the emphasis given in formulating food policies in 21 developing countries. It is noteworthy that none of the policies had a specific nutritional objective, and most policies were dominated by issues of producer welfare and self-sufficiency.

Table 13.1. Government food policy objectives for 21 developing countries^a

Country or area	Consumer welfare	Producer welfare	Government revenue	Foreign exchange	Self-sufficiency	Stable prices	Food security	Specific nutrition objective ^b
Africa								
Botswana		x			x		x	
Kenya		x		x	x		x	
Mali		x			x	x		
Morocco					x			
Nigeria		x			x			
Senegal		x			x			
Sudan		x		x	x			
United Republic of Tanzania					x			
Asia								
Bangladesh	x	x		x	x	x	x	
India	x	x			x	x	x	
Indonesia	x	x			x	x	x	
Philippines		x			x	x	x	

Table 13.1 (continued)

Country or area	Consumer welfare	Producer welfare	Government revenue	Foreign exchange	Self-sufficiency	Stable prices	Food security	Specific nutrition objective ^b
Asia (continued)								
Sri Lanka	x	x		x	x	x		
Thailand	x	x	x	x		x		
Latin America								
Brazil	x			x	x			
Dominican Republic	x			x	x			
Guatemala	x	x	x	x	x	x		
Haiti		x				x		
Jamaica		x						
Paraguay		x		x				
Peru	x	x					x	

x indicates that this type of objective is specified.

^a Adapted by FAO from Ref. 1. reproduced by kind permission of the Food and Agriculture Organization of the United Nations.

^b No specific nutrition objectives were identified.

However, implicit and explicit food and nutrition policies have been developed in several countries. Implicit policies were formulated, for example, in Costa Rica, Cuba, and Panama, and explicit food policy statements and food planning initiatives were made in Brazil, the Caribbean countries, Colombia, Honduras, the Philippines and Thailand, among others. Food production policies have also been made explicit in a number of African and Asian countries. In recent years, increased emphasis has been given to developing regional strategies for food security, i.e., the ability to withstand temporary food shortages [2]. Although there have been many failures, a number of countries have benefited greatly from these policies.

Food policies have to move away from short-term crisis management to plans for sustainable improvements in food availability. These plans of action may include: interventions in taxation, credit, trade, and exchange rates; agricultural prices and controls; and measures to distribute benefits and incentives, and to ensure food security and improve diet and nutritional status. Nutritional interventions are normally implemented separately, and usually seek to identify vulnerable subgroups within society.

Promoting healthy nutrition in a modern context

Is it possible to discern a set of key principles for action? The economic policies of governments vary widely and the health care systems are very different. The traditions for tackling public health problems related to nutrition range from an almost exclusive concentration on public education to recognition that the availability, price, and nutrient composition of foods are a major responsibility of the national government and will have a profound effect on food and nutrient consumption. This last view was held by many governments during the Second World War and remains an accepted principle in many countries. Nevertheless, several conclusions clearly emerge from national experiences since this time:

- Government economic policies affecting food production, processing, distribution, and sales, if specifically organized to promote food production, are often based on outmoded ideas about what constitutes a healthy diet. As such, they may be an impediment to dietary change and health promotion.
- Once a public health problem has been identified by a government, or by medical research workers, major changes in dietary behaviour are rarely promoted by the medical profession. Indeed, the medical profession often lags behind public demand for health-promoting measures. Nevertheless, its knowledge, understanding, and promotion of new concepts in healthy nutrition could provide an important stimulation to community change.
- The greater the consumers' sense of responsibility for their own health, the greater the speed of behavioural change, e.g., in diet, smoking, and exercise. Populations with access to a free health care system that is effective and widely available for treating disease may be more inclined to rely on medical advice and less likely to initiate behavioural changes themselves.
- Despite the apparent confusion in dietary messages in many developed countries, and the advertising of foods high in fat, sugar, and salt, a reasonably well educated public seems able to distinguish between these contradictory messages and information on prevention given by health promoters and unbiased sections of the media. Nevertheless, the slower rate of change in life-style, seen among the less affluent and less well educated, may reflect the impact of these contradictory promotional efforts. The initiation and maintenance of successful health promotion campaigns often seem to depend on voluntary organizations or on small groups of activists.

- Preventive measures have not been given high priority by any government. Few health departments have the effective working relationships with other departments involved in food production, e.g., agriculture, trade, and finance, that will be needed when an integrated food and nutrition policy is introduced.
- Following health promotion initiatives at the national level, there seems to be a delay of at least five years before appreciable changes are observed in national statistics on health and disease, even though special studies show that definite dietary changes can lead to rapid effects. Most European initiatives have only begun within the last five years and initiatives in many regions of the world have not yet started.
- In developing countries, the need to develop a food and nutrition policy, appropriate to the prevention of the chronic diseases observed in affluent societies, is a high priority, because the current economic planning (including agricultural policies, subsidies, etc.) may adversely affect the health of the community over the next 5-10 years.

Factors needed for successful food and nutrition policies

Many non-nutritional factors can lead to the success or failure of food and nutrition policies. Consequently, in addition to being physiologically sound, they must be politically viable, economically feasible, and culturally acceptable. To achieve this, food and nutrition policies must have the credibility provided by scientific and epidemiological evidence, as well as political and technical support, and must be regarded as necessary and convenient by the consumer. All this indicates that the development and implementation of food and nutrition policies require multisectoral government actions. These need to be coordinated to be effective; they should involve the whole food chain, from the production or importation of food through to its consumption.

Sustained determination over many years is needed to implement a nutrition policy. It must also be recognized that the prevention of diet-related chronic diseases requires a broad approach that goes beyond the food production-consumption chain. It involves government action on smoking, and policies to encourage leisure-time physical activity, to combat poverty, to provide a hygienic environment, and to combat communicable diseases.

The multisectoral and multidisciplinary approach

The development and implementation of food and nutrition policies in a country require the participation of government sectors involved in health, agriculture, economics, education, social welfare, planning, and development, all with support from the highest levels of decision-making. Technical or operational assistance should be provided by health and other workers involved with nutrition, universities, and nongovernmental organizations interested in health and social development, and, in many cases, also by the food industry, farmers' organizations, the catering industry, and others.

Cultural and social acceptance of the policy by the population is crucial. Community leaders, educators, communicators, marketing specialists, anthropologists and other social scientists may be needed to ensure that the implementation of the policy is made in a way that benefits the consumer. In most countries, consumers are aware of the relationship between good nutrition and health, and this awareness must be stimulated and developed, whenever possible. The importance of involving consumer organizations and voluntary organizations based within the community cannot be over-emphasized.

Nutrition policy objectives and nutrient targets

To guide the implementation of food and nutrition policies, governments will have to formulate clear policy objectives. These may be given at a general level, or specifically, as in the case of nutrient targets that can be achieved within a defined period of time.

Intermediate nutrient intake targets should be developed by ministries of health after consultations with other government departments. Depending on the structure of the administration, this decision may be incorporated into the government's general policy making, but it is important that experts in medicine, epidemiology, nutrition, and agricultural economics are all involved in making an analysis of the costs and benefits of setting an intermediate target. It should also be recognized that the implications of working towards an intermediate target may be quite different from those of achieving the ultimate nutrient goals. For example, if the levels of total fat or saturated fatty acid intake were very high, then the food industry in that country could be asked to produce food products with a lower fat content and this would lead to a considerable reduction in the importation of fats and oils. Achievement of the ultimate goal might require a programme of fundamental agricultural change, which might take several decades to carry out.

National nutrient goals

The first thing that most national authorities will wish to know is whether current national food supplies and intakes are adequate, both overall and for individual sectors of the population. The most immediate goal is an assurance that energy intakes are adequate for the needs of adults and for the growth and activity of children. Recently, a procedure for the estimation of *per caput* energy needs has been described [3]. All of the recommended population nutrient goals presented below are based on the assumption that, at the national level, the first priority is, and will remain, the adequacy of the total food supply (measured as energy) and equity of distribution of that supply in accordance with individual needs.

The population nutrient goals proposed are designed to address the situation in which the total intake of energy is reasonably appropriate, but where the balance of macronutrients (protein, fat, carbohydrate) is inappropriate and is a major contributing cause of chronic disease. The goals proposed are appropriate for developed and developing countries alike. Population approaches to the control of chronic

diseases should be introduced as a part of nutritional policy in all countries. The definition of population nutrient goals is based upon this concept.

The fundamental focus of the population approach is the population as an entity. It is assumed that certain problems require an approach that considers the population as a whole, if the health problems of individuals within that population are to be addressed effectively. The concept used is one of a safe range of intakes, sufficiently high to avoid dietary inadequacies and sufficiently low to avoid the detrimental effects of excess; the present report follows this lead, but focuses on the maintenance of low population risk rather than low individual risk. The approach is to identify the level of population intakes that, for the population as a whole, will lead to a low risk of inadequacy and a low risk of excess. It is the entire distribution of intakes, characterized by the average intake, that is of interest, not the intakes of particular individuals.

The population nutrient goal represents the population average intake that is judged to be consistent with maintenance of health in a population. Health in the population is, in this context, marked by a low prevalence of diet-related diseases in the population. Seldom is there a single best value for such a goal. Instead, consistent with the concept of a safe range of nutrient intakes for individuals, there is often a range of population averages that would be consistent with the maintenance of health. If existing population averages fall outside this range, or trends in intake suggest that the population average will move outside the range, health concerns are likely to arise. Sometimes there is no lower limit. This implies that there is no evidence that the nutrient is required in the diet and hence low intakes should not give rise to concern.

The population nutrient goals recommended for use in all parts of the world are presented in Table 13.2. They are expressed in numerical terms, rather than as increases or decreases in intakes of specific nutrients, because the desirable change will depend upon existing

Table 13.2. Population nutrient goals

	Limits for population average intakes	
	Lower	Upper
Total energy	See important footnote ^a	
Total fat (% total energy)	15	30 ^b
Saturated fatty acids (% total energy)	0	10
Polyunsaturated fatty acids (% of total energy)	3	7
Dietary cholesterol (mg/day)	0	300
Total carbohydrate (% total energy)	55	75
Complex carbohydrate ^c (% total energy)	50	70
Dietary fibre ^d (g/day)		
As non-starch polysaccharides (NSP)	16	24
As total dietary fibre	27	40
Free sugars ^e (% total energy)	0	10
Protein (% total energy)	10	15
Salt (g/day)	- ^f	6

- ^a Energy intake needs to be sufficient to allow for normal childhood growth, for the needs of pregnancy and lactation, and for work and desirable physical activities, and to maintain appropriate body reserves of energy in children and adults. Adult populations on average should have a body-mass index (BMI) of 20-22 (BMI - body mass in kg/(height in metres)²).
- ^b An interim goal for nations with high fat intakes; further benefits would be expected by reducing fat intake towards 15% of total energy.
- ^c A daily minimum intake of 400 g/head of vegetables and fruits, including at least 30 g of pulses, nuts, and seeds, should contribute to this component.
- ^d Dietary fibre includes the non-starch polysaccharides (NSP), the goals for which are based on NSP obtained from mixed food sources. Since the definition and measurement of dietary fibre remain uncertain, the goals for total dietary fibre have been estimated from the NSP values.
- ^e These sugars include monosaccharides, disaccharides, and other short-chain sugars produced by refining carbohydrates.
- ^f Not defined.

intakes in the particular population, and could be in either direction. Thus, for example, in some developing countries the population nutrient goal for fat intake (lower limit) might suggest that it would be desirable to increase average intakes slightly. Conversely, for most of the industrialized countries, a reduction in fat intake is seen as desirable. These recommendations are intended to complement, not replace, the existing series of FAO/WHO reports on energy and nutrient requirements [4,5,6]. In formulating policy, requirements for micronutrients as well as population nutrient goals must be taken into account.

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14. CHALLENGES AHEAD

Nutritional and ecological security

Ninety per cent of the world population increase expected over the next 20 years will be in the developing countries which, according to a United Nations projection, will contain 82% of the global population by the year 2010. How can their food needs be met without placing an insupportable burden on the environment?

Some of these countries will not be self-sufficient in food, and great efforts will be needed to achieve and maintain nutritional security for their populations. This involves physical and economic access to a balanced diet and safe drinking-water for all people at all times. Nutritional security is essential to allow children the opportunity for the full expression of their innate genetic potential for physical and mental development. Moreover, the undernutrition- malnutrition-infection complex remains the principal health problem in the developing world, and nutrition security is fundamental to improvement in any nation's health.

By the year 2000, an annual production of at least 3 000 million tonnes of food grains and 200 million tonnes of aquatic products, besides larger quantities of vegetables and fruits, may be needed to provide balanced diets for the world's population, many of whom will have enhanced purchasing power. In addition, considerable additional quantities of fuel wood, fodder, fibre, and other agricultural commodities will be needed. Even now, fuel wood occupies the second position in relation to the gross value of production in developing countries.

Globally, UNEP estimates that 90% of the annual deforestation of about 15 million hectares is due to the spread of agriculture. FAO places the estimate even higher, at 17 million hectares a year. Thus, the ecological necessity for improving production through higher productivity rather than through area expansion is obvious.

But, just as agriculture transforms the environment for health (sometimes beneficially, sometimes not), so also intensive production brings its own health risks, whether through pollution by pesticides and fertilizers, or by the spread of parasitic disease and infections. Much closer collaboration will be needed between agricultural and health authorities.

The needs of land-saving agriculture and grain-saving animal husbandry can be met only by further improvements in technology. At the same time, persistent environmental degradation, which is threatening the natural resource base underpinning sustainable advances in biological productivity, will have to be arrested. This will call for intensification of efforts in the blending of traditional and frontier technologies in such a manner that the ecological and economic strengths of both are combined. The frontier technologies of particular interest are biotechnology, space technology, such as weather satellites, and remote sensing, information technology including computer-aided instruction and extension, and management technology, which helps to introduce a systems approach to all aspects of production, processing, storage, and marketing.

Nearly half the world's population live in coastal areas. Both the ecological security of coastal regions and the livelihood security of coastal communities need great attention. There is a need for coastal systems research programmes designed to promote the linked development of capture and culture fisheries, and of coastal forestry and agro-forestry, including the protection of mangroves, coral reefs, sea grasses, and associated flora and fauna. Also needed are methodologies for an ocean productivity classification on the model of land capability studies. As much carbon is fixed in the ocean as on land and greater benefit from such aquatic carbon fixation must be derived.

Which instruments should be used in handling such a situation? First, use should be made of untapped technologies through appropriate social engineering, extension and training programmes, and public policies in land ownership, input and output pricing, and

rural infrastructure development. Second, agricultural research must be intensified, making effective use of the emerging scientific opportunities provided by biotechnology as well as space, information and management technologies. Third, it must be ensured that ecological sustainability becomes the foundation for all efforts in the development and dissemination of technologies.

New technologies

The significance of biotechnology for a better future of the developing countries can be illustrated by taking the example of Asian agriculture. Asia has over 50% of the global population, over 70% of the world's farming families, but only 25% of the world's arable land. At the beginning of the 21st century, the *per capita* land availability will be 0.1 hectare in China and 0.14 hectare in India.

The only pathway open to countries like China and India for feeding their growing human populations is continuous improvement in yield. This involves research to raise the maximum yield further. For this purpose, China has gone into the large-scale exploitation of hybrid vigour in rice. The tools of biotechnology can help in raising the productivity of major crops, thus increasing their economic value.

Europe, Japan, and the USA, as well as some developing countries, such as Brazil and India, are investing substantial amounts of money in genetic modification, tissue culture, embryo transfer, monoclonal antibodies, and other techniques that make up the new biotechnology. The impact of this new biotechnology will be felt first in animal production in the developed countries. A few genetically modified products are already on the market in the USA. Embryo transfer is being used extensively and greatly increases the reproductive performance of superior cattle. Despite considerable opposition, the use of bovine growth hormone will probably be approved by some national regulatory authorities in 1991. It could increase the productivity of dairy cattle by 10-20%, while adding no extra burden on the environment.

The application of new technologies to the needs of developing countries is a special problem. Industrialized countries can apply an extensive infrastructure of technological and economic resources to the solution of food problems, thus assuring their people a continually growing, varied, healthy, and economically attainable food supply; but this is not true of the developing world. The problem is compounded by the fact that, in almost all developing countries, two worlds exist side by side; the modern with the traditional, well-nourished people living side by side with the hungry, and high technology and living standards contrasting with primitive tools and poverty. If the benefits of biotechnology are great, the products are more expensive and not all can afford them, though in time they will become more easily affordable.

Modern technologies related to the level of sophistication and economic standard of the user will have to be developed and implemented. In most developing countries, it is common to have losses of more than 50% of food as it proceeds from farm to consumer. After all the effort spent in labour, equipment, fertilizers, chemicals, and energy to produce food crops, it is not tolerable that such a large part is wasted, because of the lack of proper technology for handling, transportation, processing, distribution, and storage. It is clear that a major role for food science in the next several decades is the development of processing and distribution technologies directly related to the capacity of countries, communities, and cultures to use them.

Scientific principles are universally transferable, but many technologies are not. Technologies based on biological principles relating to the transformation, preservation, and distribution of food are significantly influenced by the physical, social, cultural, and economic environment. As a result, it is often impossible to transfer new technologies without adapting them to the climates and economic conditions in which they are to be used. Developing countries are mostly located in tropical, subtropical, or semi-arid areas and suffer from economic deprivation. Many modern products are built upon the concept of minimal processing and refrigerated distribution and

storage. It should be possible to adapt such technology for tropical countries but, in addition to the cost of refrigeration systems, there are other economic issues to consider. Many commodities are currently too low in unit price to bear the cost of mechanically refrigerated storage. Moreover, many developing countries do not have a sufficiently well organized distribution system, even in their cities, to ensure the integrity of such products.

Developing human resources

It is now widely accepted that chronic hunger today is more due to the lack of purchasing power than to the non-availability of food in the market. In other words, to win the battle against hunger, we have to fight the "famine" of jobs. An integrated programme of work, wage (i.e., the enforcement of a minimum wage), and welfare measures in the fields of public health, sanitation, drinking-water, and education, are essential for this purpose.

A major factor having a bearing on the development and dissemination of new technologies is the nature of the demographic profile of countries, in terms of age composition as well as dependance on the primary farm sector for livelihood security. In most developing countries, the population is predominantly young. For example, over 50% of India's current population of about 850 million is below the age of 21 years. Also, nearly 70% of the population derive their livelihood from agriculture and other rural occupations. The future of agriculture in such countries will therefore depend on their ability to attract and retain youth in farming and other rural occupations. Otherwise, urban slums will multiply and social tensions will grow.

For educated youth to be attracted to work in rural areas, farming and allied rural work must become both economically rewarding and intellectually satisfying. In other words, agriculture should become an occupation that requires brain as much as brawn. Land ownership and tenancy rights, and input and output pricing policies should be such that farmers feel encouraged to save and invest surplus funds in

strengthening the ecological infrastructure essential for sustainable advances in biological productivity. Since capital is scarce, knowledge must become, as far as possible, a substitute for capital. Fortunately, most ecologically sound technologies, like integrated pest management and integrated nutrient supply, are also knowledge-intensive.

Biotechnology can make a useful contribution for integrating brain and brawn in rural professions. For example, Kerala State in India is planning to develop the district of Ernakulam as a "biotechnology district" to take advantage of its wealth of educated human resources, particularly educated women, who often tend to be inappropriately employed. The programme will include extensive tissue culture propagation of forest tree species, banana, cardamom, and ornamental and medical plants, genetic improvement of cattle and poultry, and the establishment of biomass refineries. The cause of educated unemployment is often not the lack of employment opportunities *per se*, but the paucity of employable skills in educated youth. The prevailing mismatch between the skills needed for the sustainable conversion of natural endowments into economic wealth should be ended through a carefully planned learning revolution.

Technology and trade have been prime movers in bringing economic prosperity to the countryside in industrial countries. Non-farm and off-farm employment opportunities grow when post-harvest technologies and trade opportunities improve. The primary, secondary, and tertiary sectors of the economy get symbiotically interlinked. To achieve this goal, a faster rate of agricultural growth is needed.

Sharing the benefits of research

The basic research on which the techniques of biotechnology are based has largely been carried out in universities and public-funded laboratories. However, the work on the conversion of scientific information into economically viable technologies has mainly been undertaken in the private sector. This has led to the question whether

the fruits of such research will be available only to those who can afford to pay adequately for them. For example, in agriculture, some experts have stated that, while the "green revolution" technologies arising from research funded by philanthropic foundations, like the Rockefeller and Ford Foundations, and by the governments of developing and industrialized countries, were available to all farmers who could derive benefit from them, the "gene revolution" technologies associated with biotechnological research may not be so available, since they owe their origin mainly to investments made by private companies and may be protected by patent right. Where should the line be drawn between private profit and public good, particularly in a world characterized by glaring economic inequities?

The dilemma arises from the fact that, although developing nations often represent centres of biological diversity and have rich endowments of biological wealth, the capacity to convert biological diversity into biological productivity through science and technology resides predominantly in industrialized countries, where such conversion work is increasingly in the hands of private industry.

International cooperation

International cooperation needs considerable strengthening, in trade and trade-related matters, in the sharing of environmentally friendly technologies, and in long-term commitments of development assistance to meet the infrastructure and institutional investments required for a more sustainable and equitable agriculture. All this will call for a revolution, in both patterns of international cooperation and information systems. Such information systems should be capable of integrating and analysing the interactions between biophysical, environmental, economic, social, and demographic trends of rural livelihood systems. Unless the substrate requirements for new technologies to strike roots and confer economic and social benefits are clearly understood and attended to, the availability of useful technologies and stagnant production conditions will continue to co-exist.

National policies

Policy formulation at the national level for any individual sector is difficult enough, but the development of intersectoral policies is infinitely more complex. And yet, in the area of food and agriculture, this is one of the primary needs for the global effort to promote health and protect the environment. Without such intersectoral policies at the national level, matching agricultural and food production to population and health needs is unlikely to be optimal. Thus, sound policies are as important as technology in ensuring food supplies, and involving health authorities in the planning of agricultural developments may reduce or prevent outbreaks of disease.

In the fields of food and agriculture, national intersectoral policies are needed in the following priority areas:

- food production and equitable distribution;
- food safety in all its aspects;
- appropriate application of scientific and technological developments;
- water and land resource development for agriculture.

ANNEX I

Panel on Food and Agriculture

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