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WORLD HEALTH ORGANIZATION
TECHNICAL REPORT SERIES
No. 477

FAO NUTRITION MEETINGS REPORT SERIES
No. 49

JOINT FAO/WHO EXPERT COMMITTEE ON NUTRITION

Eighth Report

Food Fortification
Protein-calorie Malnutrition

Geneva, Switzerland, 9–18 November 1970

Published by
FAO and WHO

WORLD HEALTH ORGANIZATION
GENEVA
1971

PRINTED IN SWITZERLAND

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Geneva, 9–18 November 1970

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JOINT FAO/WHO EXPERT COMMITTEE ON NUTRITION

Eighth Report

GENERAL INTRODUCTION

The Joint FAO/WHO Expert Committee on Nutrition met in Geneva from 9 to 18 November 1970. The meeting was opened, on behalf of the Directors-General of FAO and WHO, by Dr P. Dorolle, Deputy Director-General of WHO. In his introductory remarks, Dr Dorolle mentioned that the meeting should concentrate its attention on two main subjects of international importance: (1) food fortification programmes within the context of overall national food and nutrition policies; (2) protein-calorie malnutrition, one of the most serious public health problems confronting the developing countries today.

Dr Dorolle added that FAO and WHO would welcome suggestions from the Committee on other nutritional topics that it considered of particular importance for future programmes.

PART I. FOOD FORTIFICATION

1. INTRODUCTION

1.1 General considerations

Depending upon the causative factors of malnutrition and the resources available, different approaches to the improvement of nutrition may be adopted. It is always important to consider the costs and effectiveness, both short-term and long-term, of a particular approach or group of approaches. The first requisite is a supply of nutritionally adequate food. Owing to inequalities in distribution, the required supply is always greater than a simple sum of individual requirements.

Food fortification is only one of the measures affecting the quality of food supply that are worthy of consideration in the design of programmes intended to improve the health of the population. Thus, at the level of the food producer, the long-term possibilities of improved agricultural practices should be considered. Such measures as selective plant breeding may produce crops with higher nutritive value as well as higher yield, while improved animal feeding practices coupled with a programme of genetic improvement may provide an increased supply of foods of animal origin.

Between their leaving the producer and their reaching the consumer, foods may be treated in many ways, several of which may affect their nutritional quality. Adequate storage facilities not only prevent total loss of food but may reduce nutritional deterioration of some foods. Similarly, care in the selection of processing methods can ensure retention of nutrients, obvious examples being the parboiling of rice and the under-milling of wheat, both of which increase the retention of vitamins of the B group. Another example is high-temperature short-time sterilization resulting in decreased loss of nutrients. Other processing methods may lead to the destruction of antimetabolites or toxic materials or to the release of such bound nutrients as niacin, as well as improving the digestibility of the food. A further approach to the improvement of quality can be described as " biological ennoblement " — the improvement that takes place following sprouting and fermentation procedures.

At the level of the consumer, the way in which food is prepared can alter nutrient intake and bad practices can be corrected through education. Cooking losses can be minimized and parboiling or fermentation processes can be encouraged. Suitable mixtures of available foods to improve the quality of dietary protein can be prepared in the home. Education on how to choose foods for maximum nutrient value should be part of any nutrition programme.

The educational approaches mentioned above must be regarded as long-term measures. However, it is also possible to improve the quality of the food supply immediately, without necessarily changing food habits, by adding nutrients directly to food. The guidelines given below for consideration in implementing a programme of this type are based on the wide experience already gained in the use of this procedure.

1.2 Definition

Of the names in current use in various parts of the world, the Committee considered the term *fortification* to be the most appropriate to describe the process whereby nutrients are added to foods to maintain or improve the quality of the diet of a group, a community, or a population.

The nutrients may be added as extracts or concentrates of materials of biological origin, or as products of chemical or biochemical synthesis. Although it is not possible to draw a sharp line of demarcation between fortified products and some kitchen or factory formulations of food mixtures, the term " fortification " is intended to apply principally to the use of relatively small quantities of additives.

The Committee did not discuss the fortification of salt with iodine nor the fluoridation of water, since these subjects have already been extensively considered in WHO publications.[1]

1.3 Objectives

Fortification is a public health measure aimed at improving and maintaining the health of individuals in the population through the provision of adequate levels of nutrient intake. Although fortification programmes will often cover the entire population, they may also be designed to meet the needs of people in particular geographic areas, of particular socio-economic groups, or of particular age and sex groups. Some fortification programmes may have still more limited objectives, such as those concerned with the specification of quality standards for the foods used in special feeding programmes (e.g., school lunch programmes).

For the purposes of the present report, it is assumed that a fortification programme will usually be intended to meet a demonstrable need in the population, apparent from either dietary, biochemical, or clinical evidence, and that the severity of the nutritional deficiency and its prevalence will be factors influencing the priority to be assigned to such a programme. It is recognized, however, that while the basic purpose of fortification, i.e., the improvement or maintenance of health, remains unaltered, the approach

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[1] *Endemic goitre*, by various authors, Geneva, World Health Organization, 1960 (*Monograph Series*, No. 44); *Fluorides and human health*, by various authors, Geneva, World Health Organization, 1970 (*Monograph Series*, No. 59).

to fortification may change as the technological capabilities and economic resources of a country increase. The different approaches have been reviewed by various authors ;[1] here it need only be stated that, in countries that have highly developed food industries and where food fortification is customary, less emphasis may be placed on the use of this process to meet demonstrated needs than on its use as a method of maintaining the quality of foods consumed by the population. For example, nutrients may be added to foods to replace those lost in processing ; they may be added to " imitation foods " to provide nutritive value equivalent to the foods that they imitate ; or they may be added to " ready to eat " meals or similar preparations. Foods may also be classified into groups and fortified to provide the nutrients expected in members of that group. Finally, nutrients may have to be added to food mixtures compounded for special dietary needs, e.g., infant foods, weaning foods, or emergency rations.

Some of these considerations were recently discussed by the Committee on Food Standards of the International Union of Nutritional Sciences.[2]

The Joint FAO/WHO Committee on Nutrition noted that at present there is no unanimity among nutritionists about the role to be assigned to food fortification in solving the nutrition problems of a country. Whereas there would appear to be close agreement on the potential value of fortification in a community where nutritional diseases are prevalent, there is a divergence of views on the action to be taken in situations where nutrient intakes are low but there is little or no evidence of actual nutritional disease, or where there is concern that new trends in food processing and food usage may lead to nutritional problems, again without specific evidence of ill health for the time being. In these situations, it may be very difficult to choose between various approaches, which might include not only conventional nutrition education and programmes for improving agricultural production but also national policies relating to the whole food processing industry and the extent to which the processing of foods is deemed desirable. Clearly, all these aspects of the problem must be considered before a decision can be reached on the value of a fortification programme. Attention is drawn to the following specific points that have led to differences in opinion about the relative merits of fortification and it is suggested that these should be considered before implementing a programme.

(1) Knowledge of human nutrient requirements remains incomplete, particularly as it is very difficult to obtain precise information about actual

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[1] Causeret, J. (1946) *Bull. Soc. Sci. Hyg. Aliment. rat.*, **34**, 122 ; Causeret, J. (1957) *Enrichissement des aliments.* In : *Nutrition et alimentation tropicales*, Rome, Food and Agriculture Organization of the United Nations (Réunions de la FAO sur la Nutrition, Rapport No. 20), p. 709 ; Harris, R. S. (1968) *J. agric. Food Chem.*, **16**, 149 ; Bigwood, E. J. & Gérard, A. (1968) *Objectifs et principes fondamentaux d'un droit comparé de l'alimentation.* Vol. 2 : *Eléments de motivation et éléments de qualification*, Basle, Karger.

[2] Unpublished report.

nutrient intakes and to interpret the data correctly (see section 3.1). Serious doubts may remain about the actual benefits to be gained when there is no definite evidence of a nutritional disease problem in the population. Introduction of fortification programmes may divert limited resources and efforts from more important approaches.

(2) In most cases, fortification is carried out with a small number of nutrients and it may be forgotten that other nutrients lost during processing or reduced in supply with the introduction of new types of foods have not been replaced. For example, in the usual fortification of white bread only a few nutrients are added while many are partially removed.

(3) Since, with a multiplicity of fortified foods, it would be very difficult to maintain the nutrient ratios found in a usual mixed diet, the possibility remains that widespread fortification could lead to nutrient imbalances perhaps unrecognized at present.

(4) Experience in some countries has suggested that the introduction of fortified foods, unless undertaken for specific reasons and carefully controlled, may lead to a much broader range of such foods than had been originally envisaged and, in some instances, to unwarranted claims for their health advantages. This might, in turn, lead to confusion in the minds of the public and thwart the efforts of other nutrition programmes. As pointed out elsewhere (see section 4.2, p. 27), such a situation may give rise to special problems, particularly in the case of potentially harmful nutrients.

(5) There is always a danger that the apparent simplicity and early effectiveness of fortification may lead to a slackening of efforts directed towards the maintenance of the basic quality of food products and the development of nutrition education programmes. Thus, a balanced approach to a sound food and nutrition policy may be difficult to maintain.

In view of the above considerations, the Committee stressed that the final decision on food fortification must be made at the national level, as a part of the national food and nutrition policy. It urged, however, that in formulating a national policy on food fortification appropriate to a particular situation due attention should be paid to the arguments set forth in this report.

2. FOOD FORTIFICATION IN PRACTICE

2.1 A review of past programmes

Some 50 years ago, the fortification of salt with iodine compounds was recommended for the prevention of goitre. Since then, many countries have adopted programmes of this kind.[1]

The next major development in this field came with the identification of vitamins A and D and their availability as fish liver oils or concentrates and later as pure vitamins. The serious consequences of the replacement of dietary milk fat with certain substitutes were dramatically demonstrated in Denmark between 1909 and 1920, when the substitution of unfortified margarine for butter produced eye lesions in children.[2] As a result, the fortification of margarine, first with concentrates and later with purified or synthetic forms of vitamin A or provitamin A, was introduced in many countries.

The third nutrient that was added to foods to prevent a clearly defined nutritional deficiency disease was vitamin D. In the 1920s it became feasible to prevent rickets by providing vitamin D in the diet through the irradiation of sterol-containing foods. Later the addition of purified vitamin D to milk and such foods as cereals and margarine was widely adopted, but this practice has recently been reconsidered (see section 4.2, p. 27).

Between 1920 and 1940 rich sources of the B-vitamins, such as yeast, wheat germ, and liver extract, were used to fortify various food products. The fortification of bread, pasta, and other cereal products with purified and synthetic B-vitamins — particularly thiamine, niacin, and riboflavin — together with iron and calcium was first introduced in Newfoundland in the 1940s. The USA followed a few years later when it passed federal regulations permitting the fortification of wheat and maize products.

Rice fortification also received considerable attention, particularly in the 1940s. Processes were being developed for impregnating foods with nutrients through a parboiling process, for adding nutrients to the surface of rice kernels in a protective coating, and for making vitamin-mineral concentrates in the form of simulated rice kernels. Rice-enrichment programmes were started in Japan, the Philippines, Taiwan, and the Territory

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[1] *Endemic goitre*, by various authors, Geneva, World Health Organization, 1960 (Monograph Series, No. 44); *Seminario sobre yodización de la sal para prevención del bocio endemico, Salta, Argentina, 21-26 de Junio de 1965 — Informe final*, Washington, Pan American Health Organization, 1965; *Report of a Seminar on Goitre Control, New Delhi, 30 October – 4 November 1967*, New Delhi, WHO Regional Office for South-East Asia, 1967 (unpublished document SEA/Nut/22).

[2] Vitamins: a survey of recent knowledge (1932) *Spec. Rep. Ser. med. Res. Coun. (Lond.)*, **167**, 231.

of Papua and New Guinea. In the last of these, comprehensive programmes are still being implemented, while in Japan and the Philippines enrichment is mostly being continued on a small scale on a voluntary basis. In some countries of eastern Asia, the implementation of rice fortification programmes has been hampered by such factors as dispersion of milling facilities and unsatisfactory economic arrangements from the point of view of the millers, the government, or the consumer.

During the Second World War, when an undermilled flour was introduced in the United Kingdom to increase the nutrient content of bread, it was also enriched by the addition of calcium in anticipation of a possible deficiency. In the same period, Canada introduced the addition of vitamin C to canned apple juice in anticipation of a decreased supply of citrus fruits. Vitamin C has now been added to a wide range of fruit drinks and juices as well as to canned milk and other products.

The discovery of vitamin B_{12} and its ready availability in pure form removed one of the chief barriers to the development of complete vegetarian formulations.

Fortification of bread with protein concentrates from soybean, milk, or other sources is practised in various countries. Only in Japan has the addition of lysine to cereal products been practised on a wide scale. In India it is still in the experimental stage.

During the years since the first introduction of fortification programmes, considerable experience has been gained in the technology of fortification.[1] Some idea of the variety of procedures that have been used can be obtained by reference to Table 1 (p. 14).

2.2 Evaluation of some past programmes

In considering the history of fortification programmes, the following should be borne in mind. These programmes have been evolved gradually over the past 40 years as suitable sources of nutrients became available. At the time that many of the programmes were instituted, techniques for the evaluation of nutritional status were relatively crude and background data for evaluating the specific effects of the programmes were fragmentary. Most of these programmes were implemented in developed countries where the prevalence of many of the deficiency diseases was not very high. Furthermore, their implementation often coincided with a variety of social, economic, agricultural, educational, and public health developments—

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[1] Harris, R. S. *Mineral fortification of foods and food products.* In : *Proceedings of the Third International Congress of Food Science and Technology, Washington, August 9–14, 1970* (in press) ; Aylward, F. & Morton, I. D. *Vitamin fortification of foods.* In : *Proceedings of the Third International Congress of Food Science and Technology, Washington, August 9–14, 1970* (in press).

TABLE 1. SOME TYPES OF FOOD USED IN FORTIFICATION PROGRAMMES *

Nutrient	Type of food	Comments
Ascorbic acid	Canned, frozen, and dried fruit drinks, canned and dried milk products, dry cereal products	Must be protected from air if in neutral solution
Thiamine, riboflavin, niacin	Dry cereals, flour, bread, pasta, milk products	With materials like rice, may be impregnated into or coated on the kernel; riboflavin may colour the food; nicotinamide is usually preferred to nicotinic acid
Vitamin A (or β-carotene)	Dry cereal products, flour, bread, pasta, milk products, margarine, vegetable oils	Must be protected from air and must be added in water-miscible form to non-fat products — may be added in gelatin beadlets together with stabilizer coated on product or mixed in simulated kernel (e.g., rice); carotene may colour product; heat losses in cooking oils may be great
Vitamin D	Milk products, margarines, dry cereal products, vegetable oils, fruit drinks	See comments for vitamin A; multiple sources may be undesirable (see section 4.2, p. 27)
Calcium	Cereal products, bread	The quantity to be added usually limits the scope of vehicles
Iron	Cereal products, bread, canned and dried milks	Availability varies with form used (see section 4.1, p. 25); may cause colour or flavour changes
Iodine	Salt	Iodine usually used; iodate more stable in crude salt
Proteins	Cereal products, bread, cassava flour	Protein concentrates of various types used; the amount to be added usually limits the scope of vehicles
Amino acids	Cereals, bread, meat substitutes	Other vehicles have been proposed but not yet used; lysine or methionine now authorized in some areas

* In addition a wide range of nutrients have been added to infant foods and prepared formulas.

for example, in Newfoundland,[1] where one of the early trials of fortification was carried out. Under such conditions, it is not surprising that the specific effects of the fortification programmes can rarely be identified. Nevertheless,

[1] Adamson, J. D. et al. (1945) Medical survey of nutrition in Newfoundland. *Canad. med. Ass. J.*, **52**, 227; Metcoff, J. et al. (1945) Nutritional survey in Norris Point, Newfoundland. *J. lab. clin. Med.*, **30**, 475; Aykroyd, W. R. et al. (1949) Medical resurvey of nutrition in Newfoundland 1948. *Canad. med. Ass. J.*, **60**, 329.

improvements in nutritional status did occur. The prevalence of the classical deficiency diseases fell to very low levels, and several were practically eliminated. Many public health and nutritional authorities concluded that these fortification programmes provided a safeguard against shortcomings in the national diet and should therefore be continued.

In this brief review it is convenient to consider the evidence available with regard to each specific nutrient, although it is realized that fortification will be effective only if the vehicle delivers the nutrient to the target group in adequate amounts. It must also be remembered that single deficiency diseases are rare.

Thiamine

The Philippine experiments in the 1940s [1] provided some indication of the effectiveness of thiamine fortification in reducing the prevalence of beriberi and improving tissue thiamine levels. This work has not been followed up by a programme of rice fortification in the Philippines. Such programmes have been implemented, however, in Japan, Korea, and Taiwan.

Riboflavin

It is difficult to assess the efficiency of riboflavin fortification programmes because clinical signs of the deficiency lack specificity. However, in a study carried out in the Chinese Army in Taiwan in the 1950s, 12 companies were examined before and after the implementation of a fortification programme in 6 of the companies. At the beginning of the study many of the men had a severe form of the " orogenital syndrome " and were presumed to be severely deficient in riboflavin. Improvements were noted and were probably attributable to the increased riboflavin intake, although the effect of other changes that were made in the diet is not completely clear.

Niacin

Epidemiological studies of the effects of niacin fortification in pellagrous areas do not appear to be available. The virtual disappearance of pellagra in the USA in the 1930s and 1940s clearly began before the implementation of widespread fortification programmes. Although the role of the fortification is not discounted, such other factors as economic improvements, nutrition education, and improved medical care undoubtedly played a major role.

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[1] *Rice enrichment in the Philippines*, Rome, Food and Agriculture Organization of the United Nations, 1954 (FAO Nutritional Study No. 12).

Vitamin C

Although ascorbic acid has been added to many products in some countries and there is no reason to doubt the effectiveness of such products in the control of scurvy, data do not appear to be available from areas where special health benefits would have been expected.

Vitamin D

See section 4.2, p. 27.

Vitamin A

The addition of vitamin A and/or carotene to margarines has long been practised in many countries. In the Newfoundland surveys,[1] clinical evidence of vitamin A deficiency was reported. A programme for the fortification of white bread with B vitamins, iron, and calcium, and of margarine with vitamin A, was begun. A repeat survey in 1948 [2] indicated a reduced incidence of symptoms suggestive of nutritional deficiency. Mean serum vitamin A levels had risen from 20 µg/100 ml in 1944 to 45 µg/100 ml in 1948. However, there were rather large economic improvements during these years. These were associated with increased supplies of various foods — milk, fruits, vegetables, etc. — nutrition education programmes, free distribution of skim milk to schools, and free cod liver oil to expectant mothers and infants. These changes undoubtedly obscure the direct effect of the vitamin A fortification programme.

Calcium

Since neither clinical nor biochemical methods for the evaluation of dietary calcium deficiency are available, there is no evidence on the effect of calcium fortification upon the health of populations.

Iron

See section 4.1, p. 25.

Protein and amino acids

See section 4.3, p. 29.

2.3 Fortified food formulations for infants

Up to fifty years ago, it was common paediatric practice in many industrialized countries to feed infants on diets composed of cow's milk

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[1] For references, see p. 14.

[2] Aykroyd, W. R. et al. (1949) Medical resurvey of nutrition in Newfoundland 1948. *Canad. med. Ass. J.*, **60**, 329.

diluted with corn syrup or a similar source of carbohydrate to give approximately the same composition as breast milk. Later, various milk preparations became available in powder form.

From 1920 onward, with the discovery and identification of the vitamins and increased knowledge of the role of vitamins, minerals, and proteins in nutrition, improved methods of processing and more adequate formulations were developed, under the guidance of paediatricians, in many industrialized countries. Studies in major hospital paediatric clinics, orphanages, and other centres, involving co-operation between the paediatrician and the nutritionist-biochemist, demonstrated that the newer knowledge of nutrition could be successfully applied in practice, both in the hospital and later in the home.

The addition of nutrients to infant foods was among the first successful examples of food fortification. In more recent years, both infant foods and weaning foods based wholly or partly on foods from plant sources have been formulated and have been fortified with nutrients. These formulations have been tested and used extensively with success.

The earlier work on formulated infant and weaning foods has provided a background for the large number of formulations developed in many different countries, e.g., Incaparina and Superamine. These preparations are fortified foods designed for specific purposes.

3. DESIGN OF A FORTIFICATION PROGRAMME

In designing a fortification programme it is first necessary to decide (*a*) what nutrients to add and (*b*) what food to use as the vehicle. To answer these questions, nutrient needs and food usage in the population must be determined as precisely as possible. It is then necessary to consider several subsidiary points concerning the technological, legislative, control, and economic aspects before assessing the potentialities of the programme and reaching a final decision on its design. Provision should also be made for the evaluation and monitoring of programmes after implementation.

3.1 Definition of nutrient needs and target groups

If estimates indicate gross inadequacy in the availability of a particular nutrient, this may be sufficient indication of the need for action. However, it must be recognized that national food balance sheet data provide no information about the distribution of nutrients within the population. Since the portion of the population with low intakes constitutes the target group, the intake distribution must be known. Data may be available from food consumption surveys, but their usefulness will depend both on the reliability

of the information and on the basic unit of investigation. Unfortunately for the present purpose, many such studies examine food usage at the family level, thus leaving unanswered the question of distribution within the family and making precise definition of the risk group impossible. In spite of these limitations, such data do permit a rough identification of target groups.

There are three overlapping situations in which improvements in the nutrients of the diet must be considered:

(*a*) when there is clinical evidence of deficiency diseases;

(*b*) when estimates indicate low availability of nutrients;

(*c*) when deficiencies are thought likely to develop because of changes taking place in food habits.

The immediate objective of a fortification programme is the maintenance or improvement of the nutrient intake of a population or a segment of it (the target group) to meet an established or anticipated need. To make sure that the programme is directed at those most in need, it is important to define the target group in terms of age, sex, socio-economic status, geographical location, and other significant variables.

Where a fortification programme has been decided on because of the known prevalence of a deficiency disease, the presence of the disease itself will serve to describe the primary target group. It is then only necessary to establish that the disease will respond to the nutrient in question (i.e., that it is attributable to a dietary deficiency) and to determine whether other segments of the population have low intakes of the nutrient (i.e., to define the extent of the target group).

Sometimes, however, the dietary intakes may be low but not low enough for there to be clear evidence of a significant prevalence of identifiable disease. In such circumstances, the dietary information must be critically examined and should be reinforced whenever possible by biochemical and other studies. As has already been noted (section 1.3) there is a divergence of opinion about the action that might be taken in such situations. Before taking a decision on food fortification, therefore, its relationship to other programmes designed to improve nutrient intakes should be thoroughly assessed.

If fortification is accepted as a possible solution, the costs must be examined carefully. Should the programme prove to be relatively inexpensive, there may be no justification for spending additional money in order to define the target group precisely; it may be more economical to aim at a rather wide group of the population.

It is well to remember that the cost of adding a second or third nutrient may be relatively low, once the initial programme is established. In reviewing the dietary information, therefore, a search might be directed toward

other nutrients possibly in short supply. Before deciding on the addition of a second nutrient, it is important to be sure that persons with low intakes of the second nutrient fall within the primary target group or that it is economic to expand the target group.

3.2 Selection of a vehicle and level of fortification

Once the target group is known, it is possible to consider possible vehicles for fortification. It is obvious that the food selected must be one consumed by members of the target group. For maximum efficiency it is desirable to select a food used preferentially by the target group ; in addition, the intake should be similar for all members of the target group and should be expected to remain stable. While these conditions cannot always be met, their significance can be assessed by examination of data on the intakes of various foods believed to reach the population group in question. Only those foods that pass through central, regional, or communal processing points, and hence might be fortified, need to be considered for this purpose. While a staple food, consumed in relatively large amounts, is often chosen as a vehicle, it is always wise to consider other perhaps unusual foods that reach the target group and might be suitable. It is again stressed that knowledge of the distribution of individual intakes is essential, since the level of nutrients to be added is a function both of the estimated individual need for the nutrient — which may be affected by environmental conditions — and of the lowest intakes of the chosen food by individuals in the target group.

It should be noted that in practice it will be impossible to ensure that those with the lowest intakes of the vehicle food receive adequate quantities of the nutrient. The decision on how complete a coverage should be attempted will probably be based on the considerations of cost-effectiveness. The use of multiple vehicles for the nutrient(s) may increase the effectiveness of coverage but necessitates careful consideration of the level of nutrient to be added to each food in order to minimize waste. Such estimates can be made, but only with detailed information about the range of intakes of vehicle foods by the individuals in the target group and the costs of multiple fortification.

In the case of potentially toxic nutrients (see section 4.2, p. 27) it is also important to have information about the upper range of intake of the vehicle food in all segments of the population. This information is needed to ascertain the safe upper limit of fortification.

Special mention should be made of sugar, soft drinks, and alcoholic beverages as potential vehicles. One or the other of these may meet the specifications described above. Special problems are raised when foods whose excessive consumption is discouraged by nutritionists are selected as potential vehicles for fortification. Fortification of these products with

properly selected nutrients could increase their nutritive value and thus reduce to some extent the disadvantages of their consumption in large quantities. It must be borne in mind, however, that there is a danger that such fortification might frustrate the endeavours that are being made, or might be made, to check excessive consumption of these products and might even be used as publicity in their favour.

The respective advantages and disadvantages of fortification of these foods will need to be weighed in each case. The Committee considered that, as a general rule, it is preferable not to include such products among the possible vehicles for fortification programmes. However, it recognized that, in the case of populations that are in the habit of consuming large quantities of sugar and whose habits in that respect seem unlikely to change in the near future, the fortification of sugar cannot be ruled out *a priori*.

Before reaching a final decision on the selection of the vehicle, the technological aspects set forth below should also be considered.

3.3 Technological considerations

The most important technological factor to be considered in designing a fortification programme is, of course, the stage or stages in the processing or handling of the vehicle at which the nutrient(s) can be added. For this purpose, it is desirable that a single centre be designated within the region or country, in order to facilitate control of the programme and minimize the costs (see section 3.6, p. 23). In the case of flour fortification, this centre might be a milling plant, but if no suitable centre is available, the nutrient may be added in a local mill or at a local bakery, making use of pre-mixes that can be handled with moderate cost and dispensed with sufficient accuracy. Tests should be run periodically to ensure that the rate of addition is uniform and mixing is thorough. The range of vehicles used in past fortification programmes is briefly described in section 2.1, p. 12.

It must also be established that the nutrient is biologically available in the form in which it is added; that the availability is not adversely affected by the vehicle; and that the nutrient does not convey unwanted characteristics to the food (colour, taste, flavour, cooking properties) or unduly increase the cost of the product. As discussed in section 4.1, p. 25, iron presents serious problems in several of these respects. Protein fortification involves the addition of relatively large quantities of material and may influence the cooking properties of the fortified foods, the acceptability of which may depend upon the cooking practices of the region. Since some nutrients may be unstable and either be destroyed (or affected by specific antimetabolites or other agents in the food) or gradually confer undesirable colours, flavours, or odours to the food through a variety of reactions, it is essential to examine the stability and food quality under the conditions of air temperature, humidity, and light exposure that might be expected

in adverse storage situations. Provided that the nutrient remains biologically available, reluctance to accept slight changes in colour, flavour, or cooking properties may be overcome by an education programme. However, this will add to the cost. The effect of home cooking practices upon the retention of the nutrient should be checked. If such practices have a serious adverse effect (e.g., the washing of rice when the nutrients have been added in a coating on the kernel) they may need to be corrected by an education programme.

3.4 Assessment and monitoring of fortification programmes

To determine the effectiveness of a fortification programme in meeting a specific nutritional need, appropriate monitoring procedures should be employed. These will presumably include either clinical or biochemical assessment of the nutritional status of large groups and/or dietary surveys to evaluate the food and nutrient intake of target groups. Such assessment will need to be made periodically, since changes in the food supply or economic or other factors may alter food usage by the target group. Consequently, the kinds and amounts of nutrients used in the fortification programme may become inappropriate. Furthermore, the effectiveness of the vehicles used may change. The history of iron fortification provides an example of a programme that proved less successful than had been anticipated from information available at the time it was conceived and implemented.

Attention is also drawn to the need for periodic review of fortification policy, legislation, and other related matters. In some countries, outdated policies and legislation provide barriers to more effective programmes and there is no simple mechanism to provide for review and modification as the situation changes.

3.5 Legislation and control measures

3.5.1 *Legislation*

Countries have made laws and regulations governing the fortification of foods. Examination of these laws and regulations shows that they are extremely varied. Bigwood & Gérard,[1] reviewing the laws and regulations on fortification of foods in 12 countries, speak of a "truly chaotic situation ".

This situation has resulted in part from the difficulties experienced by some countries that already had complex food legislation in modifying their legislation when new procedures were proposed. Other factors have

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[1] Bigwood, E. J. & Gérard, A. (1968) *Objectifs et principes fondamentaux d'un droit comparé de l'alimentation*. Vol. 2 : *Eléments de motivation et éléments de qualification*, Basle, Karger.

been the diversity of views on the advisability of fortifying foods — views that did not invariably have a scientific basis — and the pressures of various kinds exerted in some countries in favour of or against fortification. It should also be remembered that terminology in regard to fortification differs from country to country.

It will be seen from the foregoing that it is difficult on the basis of existing legislation to prepare a " model " for countries that as yet have no legislation of their own on the subject. It may be pointed out, however, that several approaches are possible. Regulations may be designed :

(*a*) to make a particular programme compulsory ;

(*b*) to *permit* fortification ;

(*c*) to provide incentives to firms that produce fortified products ; or

(*d*) to ensure appropriate standards in food contracts for hospitals, schools, and other institutions.

The advantages and disadvantages of these different approaches should be considered at the national level. It would appear, however, that in the developing countries approach (*a*) will frequently be preferred. In some cases a programme encouraging a small firm to manufacture on its own initiative a special product with a formula that has been carefully investigated might also have good results.

3.5.2 *Control*

The best devised regulations can be ineffective if they are not accompanied by proper means of control. To permit the enforcement and control of a food fortification programme, procedures and facilities for assaying the levels of nutrients in the food are essential. Properly trained technical staff must also be available. There should be periodic scrutiny of the levels of nutrients added at the fortification point (and in the pre-mix if used) to ensure proper functioning of the equipment, and at the level of the consumer distribution centre to ensure that there has not been loss during storage.

Obviously, the greater the number of fortified foods and the nutrients put into them, the more problems control will involve. It will be noted also that more resources will be required if fortification is carried out by small firms than if it is done centrally.

3.5.3 *Labelling and publicity*

In some industrialized countries, the regulations contain specific provisions on these two points. In others, the manufacturers are left almost entirely free. In the absence of specific regulations, there is always a danger that unwarranted, inaccurate, and misleading statements concerning a

product are made in labelling and advertising, possibly interfering with the development of a sound nutrition programme.

The Committee considered that, in principle, the consumer has a right to be informed concerning the characteristics of the products he is buying.

3.5.4 *Possibilities of co-ordinating national fortification legislations*

There is a danger that the variety of national laws on fortification may make international trade in certain commodities difficult. Consequently, it would seem desirable to try to harmonize the legislation of different countries.

Complete harmonization, however, does not seem feasible, since the fortification measures to be prescribed or encouraged, the amounts of nutrients to be put into the selected vehicles, and the nature of the vehicles themselves have to be decided upon in relation to the special needs and eating habits of the population or population group whose state of nutrition it is desired to improve.

There seems to be a possibility that harmonization of legislation can at least be achieved on a regional basis, several countries having decided to promote identical measures to deal with comparable difficulties. FAO and WHO might assist in this effort.

3.6 Economic considerations

It has been stressed in the introduction to this report that the probable costs of nutritional programmes should be weighed against their predicted benefits and that various approaches to the same problem might be compared on this basis before a final decision is reached. It should be made clear that this is of major concern only when the proposed expenditure is large : some fortification programmes can be accomplished at a relatively low cost, while others are quite expensive and warrant close examination.

In considering these economic aspects of fortification programmes, the Committee examined the document recently prepared by the FAO/WHO/UNICEF Protein Advisory Group on amino acid fortification.[1] It is recommended that this document be consulted for a discussion of some of the specific factors to be considered in the evaluation of programmes of amino acid and protein fortification. The following are some general comments applicable to programmes involving most nutrients.

Evaluations of the costs and benefits of a fortification programme should always be conducted in the context of the special situation. Ideally each country should have well-defined short-term and long-term nutritional goals and a co-ordinated plan for achieving these goals. Such a plan

[1] FAO/WHO/UNICEF Protein Advisory Group (1970) *PAG Statement on amino acid fortification of foods*, New York, United Nations.

permits consideration of the cost of a fortification programme in terms of a re-allocation of limited resources and the effect of the programme upon the rate of progress toward long-term goals. For example, if the long-term goal is the improvement of the quality of the basic food supply, the fortification programme should not be permitted to interfere with the achievement of this goal.

Certain of the costs of a fortification programme, such as the capital costs of fortification equipment and the cost of purchase and transport of the nutrients, are direct and easily recognized. These costs may be passed on to the consumer in the form of an increase in the cost of the food. Programmes that cause even a moderate increase in the retail price of a staple food can be justified only if it can be shown that the expected benefits outweigh the additional food expenditure of the family; if the change in price is substantial, or if fortified and unfortified products appear on the market with a price differential, the programme may defeat itself.

Whether these costs are passed on to the consumer or met by the government (subsidized programme), there are other less direct costs that should also be recognized. To control the programme, laboratory facilities must be created and technologists trained and employed. As previously mentioned, in certain circumstances there may also be a need for educational programmes to ensure that the fortified product is used and that the nutrients are preserved.

As with all other programmes, there is a cost attached to preliminary field testing and continuous monitoring of the effectiveness of the programme. It will be recognized that many of these costs are related to the number of installations where fortification is carried out. For this reason, fortification at a central processing plant represents the ideal situation, whereas fortification at the communal mill represents the limit of decentralization that can be considered practical. Some authors have suggested a programme of " home fortification " through the supply of fortified wafers to be added to the cooking pot. In most instances, however, this would offer little or no advantage over the provision of direct supplements to each member of the target group, through periodic oral dosing or injection of the nutrient.

It should also be remembered that, since costs must be related to the number of persons in the target group who are reached by the programme and benefit from it, for maximum efficiency the food chosen as the vehicle should be one consumed specifically by the target group.

An economic consideration that should not be neglected in reviewing possible fortification programmes is the potential drain upon foreign currency reserves if vitamin and mineral preparations have to be purchased from sources outside of the country. In some instances, this problem may be avoided by developing special sources of the needed nutrients for

addition to foods (e.g., red palm oil as a source of vitamin A, locally produced protein concentrates, etc.).

4. NUTRIENTS REQUIRING SPECIAL CONSIDERATION

Other WHO publications have dealt with the particular approaches to and problems of the fortification of salt with iodine and the addition of fluoride to water supplies.[1] These are not considered in the present report. The following three types of fortifications, currently of interest to the international agencies, warrant special consideration.

4.1 Iron

The Committee has recommended that one of the factors to be considered in designing a fortification programme is the availability of the nutrient in the proposed vehicle (see section 3.3, p. 20). This factor presents considerable difficulty in the case of iron.

While iron fortification programmes have been in effect in North America and the United Kingdom for many years, there appear to have been few attempts to evaluate their effectiveness until recently. In recent years, several groups have questioned the availability of iron in flour and bread.[2] It is now apparent that the form of iron added, the nature of the vehicle, and the nature of other dietary constituents may all affect the availability of iron added to foods. Reports in the literature suggest that all these factors operate and may contribute to confusion of interpretation.

It now appears that some but not all preparations of " reduced iron " or " powdered iron ", as well as sodium iron pyrophosphate and perhaps other iron salts that have been used in fortification programmes, are relatively unavailable to the human being. Most of the evidence suggests that ferrous sulfate, used in some fortification programmes, is among the most available forms. Data on the availability of other forms of iron that might be used for fortification are too limited for them to be placed in a definite rank order. Furthermore, the availability may be affected by the nature of the vehicle, the processing to which the vehicle is subjected, and the diet with which it is consumed.

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[1] For references, see p. 9.

[2] Elwood, P. C. (1968) *Iron in flour*, London, H. M. Stationery Office (*Reports on public health and medical subjects*, No. 117); Committee on iron nutritional deficiencies, Food and Nutrition Board (1970) *Workshop on measures to increase iron in foods and diets*, Washington, National Academy of Sciences — National Research Council.

Selection of the iron salt to be used may be based on cost (Table 2) and on technological factors. Ferrous sulfate and some other forms that seem

TABLE 2. RELATIVE COST OF SOME FORMS OF IRON SALTS *

Iron source	Cost per lb of salt ($)	Cost per lb of elemental iron ($)
Ferrum reductum	0.40	0.41
Ferrous sulfate, anhydrous	0.28	0.47
Ferric orthophosphate	0.54	1.89
Sodium ferric pyrophosphate	0.39	2.69
Ferrous fumarate	0.95	2.89
Ferric ammonium citrate	0.67	3.94
Ferrous gluconate	0.91	7.85

* Committee on iron nutritional deficiencies, Food and Nutrition Board (1970) *Workshop on measures to increase iron in foods and diets*, Washington, National Academy of Sciences — National Research Council.

to be biologically available may produce disadvantageous colour or flavour problems when added at moderate levels to some foods, whereas with certain sparingly soluble (and presumably unavailable) forms these problems are not encountered. Interaction of foods with iron compounds might be prevented by such techniques as incorporation of the compounds in gelatin beadlets, as is done with certain of the vitamins, but this would further increase the cost.

In view of the uncertainty about the physiological availability of the various iron preparations, serious doubt must be cast upon the efficiency of at least some of the present iron fortification programmes and it is difficult to offer specific recommendations for future programmes. The Joint FAO/WHO Expert Group on Requirements of Ascorbic Acid, Vitamin D, Vitamin B_{12}, Folate and Iron [1] has recently made new recommendations for daily intakes of iron. In view of the prevalence of iron deficiency anaemia [2] and the size of the recommended intakes in relation to the usual iron intakes, the Committee agreed with the Joint FAO/WHO Expert Group that there is a clear need to increase the dietary iron intakes in many, if not most, populations. This might be most easily accomplished through fortification programmes, the alternatives being either the provision of direct iron supplements for vulnerable groups or a major change in dietary habits. The Committee endorsed the recommendations of the Joint FAO/WHO Group that research into effective methods of iron fortification be given high priority. In particular the Committee recom-

[1] *Wld Hlth Org. techn. Rep. Ser.*, 1970, No. 452, p. 54; *FAO Nutrition Meetings Report Series*, 1970, No. 47, p. 54.

[2] *Wld Hlth Org. techn. Rep. Ser.*, 1968, No. 405.

mended continuation and expansion, if possible, of current human studies and suggested that it might be advantageous to encourage comparative studies of absorption of iron in various species in the hope that information applicable to man might be developed. The Committee stressed that such studies, whether in man or in animals, should be concerned with the availability of iron when added in the form proposed for fortification to the proposed vehicle and fed in conjunction with usual diets. As a final confirmation of studies of this type, the Committee recommended a careful field evaluation of the ability of the fortified foods to maintain normal values for all blood constituents.

Concern has also been expressed about possible toxic effects of high levels of iron fortification and it has been suggested, though not established, that haemosiderosis is associated with the characteristically high iron intakes of the Bantu. The Committee was unaware, however, of any evidence of haemochromatosis or haemosiderosis associated with dietary iron intake in other populations except in occasional patients with absorptive abnormalities. Consequently, there does not seem to be any need for serious concern about the safety of iron fortification, but it is suggested that the possibility be considered when collecting data in field studies.

4.2 Vitamin D

The discovery of vitamin D, followed shortly afterwards by the availability of irradiated or fortified milk and other foods, resulted in a marked decline in the prevalence of rickets in many countries. Although the relative importance of the fortification programmes, better paediatric care, use of fish liver oils, etc., cannot be clearly defined, there is abundant evidence that milk and infant foods fortified with vitamin D are effective antirachitic agents. Nevertheless, the number of cases of rickets due to vitamin D deficiency reported from developed countries is sufficiently high to indicate that the preventive programmes are not totally effective. In many of the developing countries rickets is frequent in hospitalized infants. In a recent WHO survey in North Africa,[1] 45–60% of the infants examined were found to show signs of rickets.

The toxic effect of excessive intake of vitamin D has long been known but the possibility that the amounts used in fortification programmes might be hazardous was discounted until an increased incidence of hypercalcaemia in infants was reported in the United Kingdom.[2] This phenomenon was associated with an increase in the vitamin D content of the fortified national dried milk from 280 IU/oz (10 IU/g) to 500 IU/oz

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[1] *Wld Hlth Org. techn. Rep. Ser.*, 1967, No. 377, p. 31 ; *FAO Nutrition Meetings Report Series*, 1967, No. 42, p. 31.

[2] *Brit. med. J.*, 1956, **2**, 149.

(18 IU/g). In 1957, the Ministry of Health in the United Kingdom recommended that the vitamin D content of the national dried milk be reduced to 90–100 IU/oz (3.2–3.5 IU/g); that of infant cereal from 1000 IU/oz (35 IU/g) to 300 IU/oz (10 IU/g); and that of cod liver oil preparations from 800 IU to 400 IU per teaspoon. The prevalence of hypercalcaemia has apparently fallen to low levels since these changes were made. Another way of controlling the problem of toxicity due to high intake has been to prohibit the addition of vitamin D to a wide variety of foods. In Canada, vitamin D may be added only to milk (400–530 IU per imperial quart; 350–465 IU/litre) and to margarine. Following the reports of vitamin D toxicity in the United Kingdom some authors suggested that congenital supravalvular aortic stenosis might be related to excessive vitamin D intake. The Committee on Nutrition of the American Academy of Pediatrics [1] recommended that efforts be made to ensure an intake of approximately 400 IU daily for infants, but that fortification of foods other than milk and infant formulas be discontinued. In the United Kingdom, infants who happened to be receiving vitamin D from all three sources mentioned above (1½ pints of milk, 1 oz of cereal, and one teaspoon of cod liver oil) would at present have a total intake of the order of 1000–1200 IU/day.

It should be noted that during the time when foods highly fortified with vitamin D were available in the United Kingdom, the number of reported cases of hypercalcaemia was comparatively small compared to the large number of infants who must have consumed rather excessive amounts of vitamin D. Thus, it can be assumed that there are relatively large differences in susceptibility. These differences may have a genetic basis, but unidentified environmental factors may also play a role.

The continued occurrence of rickets in an appreciable number of infants in Canada, the United Kingdom, and the USA, where certain products fortified with vitamin D, especially fortified milks, are available on demand, indicates that such preventive programmes are not entirely satisfactory. The Committee assumed that such optional programmes would be even less satisfactory where standards of paediatric care and its utilization by the community are relatively poor. The prevalence of rickets in many countries is of great concern and should receive immediate attention. Because of the great differences in the severity of the problem and in the availability of suitable vehicles for fortification, the appropriate decisions must presumably be made upon a regional or national basis, considering both the need for increased vitamin D intakes and the dangers of excessive levels.

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[1] American Academy of Pediatrics, Committee on Nutrition (1953) The prophylactic requirement and the toxicity of vitamin D. *Pediatrics*, **31**, 512.

4.3 Protein and amino acids

In recent years, the possibility of fortifying foods with proteins or amino acids has attracted much attention among national and international bodies. The subject of amino acid fortification was recently discussed by the FAO/WHO/UNICEF Protein Advisory Group.[1] There are special problems to be considered in evaluating the need for and the benefits that may be derived from amino acid and protein fortification programmes.

It has been suggested earlier (section 1.3) that, as a first principle, fortification should be considered when a need for a nutrient can be demonstrated. Most of the vitamins and minerals can be considered in isolation from the rest of the diet. However, in the case of protein-calorie malnutrition the protein supply must be judged in relationship to other aspects of the diet, notably, the calorie intake (see Part II of this report). When the protein intake is found to be low in a particular population, it is likely that the calorie intake is equally inadequate, if not more so. In such circumstances, it is uncertain whether there is any benefit to be gained from providing only additional protein or amino acids. As has already been stressed in the introduction, the relative merits of such fortification programmes must be judged against the other approaches that might be undertaken. In the example cited, the question might be whether it would be better to increase the food supply in general or merely to provide additional protein. However, the general principle applies that the protein or amino acid intake must be a limiting factor in the diet of a significant proportion of the population if beneficial results are to be expected from a fortification programme.

Should a protein fortification programme be under consideration, attention should be given to the possible complementary effect of the added protein on the proteins already being consumed. If it is possible to provide a protein source of the limiting amino acids in the diets consumed in a particular region, the total protein supply as well as the quality of the protein in the diet will be improved. In this regard, the Committee considered the search for locally available protein sources that can be used in fortification programmes to complement indigenous dietary proteins to be a desirable approach that may have economic as well as health benefits.

The unique advantage of amino acid fortification as compared with protein fortification lies in the fact that such fortification is unlikely to affect the properties of the food and hence the acceptability of the fortified product, which is a potential problem in the case of protein fortification. However, prediction of the benefit that may result from such a

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[1] FAO/WHO/UNICEF Protein Advisory Group (1970) *PAG Statement on amino acid fortification of foods*, New York, United Nations.

programme is even more difficult than in the case of protein fortification. The amino acid requirements for various population groups are not well established. Although the protein score can prove useful in assessing the relative value of national supplies, it is not fully satisfactory for screening an amino acid deficiency in the diets actually consumed by a particular group.

It is well known that amino acid fortification of cereals increases the quality of the available protein supply when cereals are the only food consumed, but experience with mixed diets is very limited. The practical significance of the findings is questionable, since they relate to dietary conditions that differ from those that may exist in population groups.

The response that may be expected from the fortification of a diet with a single amino acid, such as lysine, will presumably be determined by the degree to which this amino acid is limiting and the supply of the second or even the third most limiting amino acid. If the supply of the second most limiting amino acid is not appreciably higher than that of the first, the benefit may be expected to be marginal. Since relatively few essential amino acids are now available at reasonable cost, a careful analysis of the specific conditions is required. There is a clear need for more experimentation and practical field experience before firm recommendations can be made.

At the present time, the costs of amino acid fortification — in particular, lysine fortification — are relatively high compared to the usual vitamin and mineral fortification programmes. Current estimates of the increase in the cost of bread are in the range of 5–7% for lysine fortification. These costs may fall markedly in the future with increased amino acid production. As has been discussed previously (section 3.6) and in the statement of the FAO/WHO/UNICEF Protein Advisory Group, the effects of such costs upon food consumption patterns, foreign exchange, cost of living index, etc., may be serious and may nullify the expected benefits.

Attention is again drawn to the Committee's basic recommendation that the benefits of a fortification programme be weighed against its costs and those of alternative approaches to the same objective.

5. IMPLEMENTATION OF PROGRAMMES IN DEVELOPING COUNTRIES

5.1 Introduction

In its approach to food fortification, the Committee constantly had in mind the need to differentiate between three groups of countries : (*a*) those with well-developed food industries, (*b*) those where food preservation and processing are carried out largely in the household or as cottage or village

industries, and (*c*) those in a transitional stage. This section of the Committee's report is devoted to some of the special problems of developing countries, particularly to the questions that should receive special consideration in fortification programmes.

The Committee recognized that there are considerable differences even between neighbouring regions in the developing world — for example, Central and South America; South-East Asia and other parts of Asia; and the Middle East and Africa south of the Sahara. Moreover, there are wide differences from country to country within each region and from one part of a country to another. For example, many countries are in a transitional stage and include, on the one hand, large areas based on subsistence agriculture, and, on the other hand, urban and other centres of industrialization based on petroleum or other national resources. In many of these countries, food industries are growing rapidly in parallel with other industries.

It has always to be borne in mind, therefore, that the developing countries vary greatly in size, total population, population density and distribution, natural resources and financial reserves, climatic conditions, agricultural systems and potentialities, and general cultural patterns.

Because of these differences it is emphasized that improvement of food supplies and nutritional status will depend in large measure on decisions made in the light of circumstances and possibilities within individual countries. Furthermore, within any one country it will in many cases be necessary to take into account differences from one part of the country to another. Because of poor systems of communication, differences in agricultural patterns and in food consumption patterns may be much more pronounced than in an industrialized country of the same size.

5.2 Basic information for a national food fortification policy

Food fortification programmes are one of several approaches to the improvement of diet and nutritional status. As such they are part of a food and nutrition policy at national level. Where a food fortification programme is under consideration, special attention must be given to the following factors that normally constitute the basis for a food and nutrition policy:

(*a*) estimated food and nutrient requirements, taking into account ecological conditions and environment;

(*b*) food production, distribution, and consumption, and food habits at various income levels;

(*c*) agriculture patterns and possibilities of change;

(*d*) national and local food preservation and processing industries;

(*e*) food imports and exports;

(*f*) assessment of nutritional status in various areas of the country and in different socio-economic groups.

National food and nutrition committees, established on an interministerial and interdisciplinary basis and serviced by competent specialists, are appropriate bodies for advising the governments on food fortification policies and programmes.

The estimates of requirements are all-important. It is necessary to obtain as precise a picture as possible for various groups of the population and to assess the situation in terms of requirements based on physiological standards, taking into account environmental factors.

The survey of needs must clearly indicate those of special groups, such as pregnant and nursing mothers and children, and the special problems associated with protein-calorie malnutrition in infants and young children; it should cover not only proteins and calories but also vitamins and minerals. Deficiencies in the nutrients available may vary, depending on the locality; the identification of geographic areas with special problems is important in enabling remedial action to be taken.

5.3 Food imports

Many developing countries import considerable quantities of food through commercial channels; they may also receive food supplies through the World Food Programme, UNICEF, or bilateral aid schemes, or from voluntary bodies. Decisions are required as to whether or not such foods should be fortified. These decisions can be based in part on the general criteria discussed earlier (section 1.3) but some special points should be noted.

The Committee considered it desirable that donor agencies or groups should discuss fully with recipient countries the question of fortification of donated foods and should hold consultations with FAO and WHO. Although in general fortification should be based on local needs, there may be good social and psychological reasons for ensuring that food donations should reach the quality (including nutritional quality) of foods actually used in the exporting country. In many cases (e.g., dried milk, white flour) fortification may be important.

5.4 Scientific and technical personnel and facilities

Fortification programmes require scientific and technical personnel (*a*) to carry out the practical operations within the food industries; (*b*) for laboratories concerned with control at factory and governmental level; (*c*) for research and developmental work; and (*d*) to provide nutritional guidance at all stages from agricultural production to consumption.

Attention has already been drawn to the importance of nutrition education and training programmes, both for medical and paramedical personnel and for those engaged in agriculture. The FAO Conference in 1967 stressed the importance of renewed efforts to promote nutrition teaching in colleges and schools dealing with agriculture.

The Committee noted that there is an acute shortage of personnel trained in food science and technology in the majority of developing countries, but that efforts are being made in many countries to establish food science departments in universities or associated institutions and courses in food processing in technical and other colleges. It is clearly of importance that provision should be made for the teaching of nutrition in these departments of food science and technology. The Committee recommended that the international agencies should give increased support to such developments.

PART II.
PROTEIN-CALORIE MALNUTRITION

1. INTRODUCTION

Seven Joint FAO/WHO Expert Committees on Nutrition have met since 1949. The first Committee recommended that studies be made of the clinical characteristics of PCM and its relation to food habits, especially during pregnancy, lactation, infancy, and early childhood.[1] As a result, a joint FAO/WHO team made a quick survey in Africa.[2]

The report of the second Committee [3] stressed the need for the dissemination of knowledge on kwashiorkor, which is a form of PCM, described practical measures for the prevention and treatment of PCM, including the use of skimmed milk, and recommended that information be obtained on the prevalence of the condition in Latin America, South-East Asia, and the Western Pacific Region. As a result, two joint FAO/WHO surveys were carried out in Central America and Brazil [4,5] and a WHO-sponsored study was conducted in southern India.[6]

The meeting of the third Committee [7] was devoted to malnutrition in mothers and children, special attention being paid to protein malnutrition and its effects on child health.

The fourth Committee discussed protein-rich foods other than milk for feeding infants and children, and recommended that FAO and WHO encourage and assist in the development of such foods.[8] The criteria for the selection of these foods were laid down by the fifth Committee in 1957,[9]

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[1] *Wld Hlth Org. techn. Rep. Ser.*, 1950, No. 16.

[2] Brock, J. F. & Autret, M. (1952) *Kwashiorkor in Africa*, Geneva, World Health Organization (*Monograph Series*, No. 8) and Rome, Food and Agriculture Organization of the United Nations (*FAO Nutritional Studies*, No. 8).

[3] *Wld Hlth Org. techn. Rep. Ser.*, 1951, No. 44 (*FAO Nutrition Meetings Report Series*, No. 5).

[4] Autret, M. & Behar, M. (1954) *FAO Nutritional Studies*, No. 13 ; *Bull. Wld Hlth Org.*, **11**, 891-966.

[5] Waterlow, J. & Vergara, A. (1956) *FAO Nutritional Studies*, No. 14 ; *Bull. Wld Hlth Org.*, **15**, 165–201.

[6] Rao, K. S. et al. (1959) *Bull. Wld Hlth Org.*, **20**, 603.

[7] *Wld Hlth Org. techn. Rep. Ser.*, 1953, No. 72 (*FAO Nutrition Meetings Report Series*, No. 7).

[8] *Wld Hlth Org. techn. Rep. Ser.*, 1955, No. 97 (*FAO Nutrition Meetings Report Series*, No. 9).

[9] *Wld Hlth Org. techn. Rep. Ser.*, 1958, No. 149 (*FAO Nutrition Meetings Report Series*, No. 19).

when the activities of the FAO/WHO/UNICEF Protein Advisory Group were reviewed for the first time since its establishment in 1955.

The sixth Committee [1] suggested that not only kwashiorkor but all the forms of protein-calorie deficiency disease be investigated, and advocated a greater emphasis in all nutrition and public health programmes on the major role of infections in the development of nutritional deficiencies. This Committee also drew attention to the need (*a*) to improve feeding practices during and immediately after weaning, (*b*) to organize regional programmes for the evaluation of the treatment of various forms of protein-calorie deficiency, and (*c*) to develop locally available foods of satisfactory protein content for feeding young children. Finally, the Committee proposed a new classification of nutritional diseases that placed emphasis on the responsible nutrient; some of these proposals were adopted in the eighth revision of the International Classification of Diseases.[2]

The seventh Committee [3] discussed protein-rich foods for infant feeding, nutrition in pregnancy and lactation, and the effect of nutrition on mental development.

PCM and its implications have also been discussed at a number of seminars and international meetings sponsored by FAO, WHO, UNICEF, and other bodies.

In recent years much new information has accumulated on the etiology, prevention, and treatment of PCM and on its sequelae, with their socio-economic implications. Differences of opinion in certain areas have an important bearing on the preventive measures to be adopted and need to be resolved as far as possible. In convening the present Committee, FAO and WHO therefore considered that the time was ripe for a comprehensive review of PCM.

The present report gives special attention to the following points:

(1) The urgent need to study the incidence and prevalence of PCM. A prerequisite for such studies is agreement on definitions and classification.

(2) The possibility of a world-wide trend towards an earlier age incidence of PCM and the causes of this trend.

(3) The assessment of the relative importance of deficiencies of protein, calories, and other nutrients in the etiology of PCM.

(4) The role of infection in the etiology of PCM.

(5) The increasing evidence that malnutrition may permanently impair mental and physical development.

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[1] *Wld Hlth Org. techn. Rep. Ser.*, 1962, No. 245 (*FAO Nutrition Meetings Report Series*, No. 32).

[2] *Manual of the international statistical classification of diseases, injuries, and causes of death, 1965 revision*, Vol. 2, Geneva, World Health Organization, 1967.

[3] *Wld Hlth Org. techn. Rep. Ser.*, 1967, No. 377 (*FAO Nutrition Meetings Report Series*, No. 42).

(6) The influence of malnutrition in childhood and its sequelae on the socio-economic development of a country.

(7) The re-assessment of practical approaches to the prevention of PCM.

(8) The relationship between PCM and maternal and fetal nutrition.

2. NOMENCLATURE AND CLASSIFICATION

2.1 Nomenclature

The term " protein-calorie deficiency diseases ", adopted by the sixth Committee,[1] is inappropriate, since the word " diseases " suggests too narrow a concept.

In malnutrition in the pre-school child, not only protein and calorie deficiencies but also other nutrient deficiencies and infections are involved. Thus the term " protein-calorie malnutrition " does not fully reflect the etiology of the entire spectrum of infant and child malnutrition. However, since this term is widely used the Committee considered it convenient to retain it for the time being.

2.2 The current concept of PCM

PCM includes many different clinical syndromes, all of which are accompanied by retardation of growth and development. The severe cases show clinical and metabolic changes, which vary according to the severity and duration of the nutritional deficiency, whereas the more frequent, milder forms only manifest retardation of growth and development, with few clinical symptoms.

The manifestations of PCM vary widely according to the nature of the causative factors, the time for which they operate, and the age of the patient. Two severe clinical forms are recognized : nutritional marasmus and kwashiorkor. Between these a wide range of variation and graduation exists. Moreover, a child with nutritional marasmus may develop kwashiorkor, and a child with kwashiorkor may present a picture of nutritional marasmus after losing oedema. In general, kwashiorkor is a more acute condition than marasmus. However, neither of these conditions presents such an important problem as does the widespread occurrence of mild and moderate PCM in a community.

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[1] *Wld Hlth Org. techn. Rep. Ser.*, 1962, No. 245 (*FAO Nutrition Meetings Report Series*, No. 32).

2.3 Classification of PCM

The definition and classification of PCM present an extremely difficult problem for several reasons :

(*a*) in common with other nutritional states, there is no sharp dividing line between the normal and the pathological ;

(*b*) PCM is often associated with deficiencies of vitamins and minerals ;

(*c*) infection may cause a marginal state of nutrition that permits survival and perhaps moderate growth to change into frank malnutrition ; and

(*d*) the earliest sign of PCM in infants and children is failure of growth, but it follows from (*b*) and (*c*) that this is a non-specific effect.

The choice of a system of classification will depend upon whether it is to be used for prevalence studies in the field, for clinical diagnosis and investigation, for recording the causes of death, or for the development of preventive measures. A complete description of PCM should include the age of the patient and the severity, type, and duration of the condition.

2.3.1 *Classification in field studies*

The terms kwashiorkor and nutritional marasmus are of little relevance in field studies, as the number of frank cases of either condition is always small compared with the total number of children who are malnourished by any acceptable criteria.[1]

The original classification by Gomez [2] into three degrees of malnutrition based on weight deficit takes account of the age of the child and the severity, but not the type or duration, of the condition. The cardinal criterion, on which all authors are agreed, for distinguishing between kwashiorkor and marasmus is the presence or absence of oedema. It has been suggested by some workers that cases with oedema be classified as third degree malnutrition, regardless of the weight loss or extent of the growth failure. This suggestion implies that a child who is 50% of standard weight without oedema and a child who is 80% of standard weight with oedema are in the same category as regards the severity of their condition.

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[1] Bengoa, J. M. (1970) *Recent trends in public health nutrition. Protein-calorie malnutrition.* In : *Nutrition. Proceedings of the Eighth International Congress, Prague, September 1969*, Amsterdam, Excerpta Medica.

[2] In 1942 Gomez devised a classification of malnutrition in children aged 1–4 years using weight for age as the criterion. The purpose of the classification was to group cases of similar prognosis and to guide physicians in selecting the place of treatment (home, out-patient clinic, or hospital). It was not originally intended to use the classification as a diagnostic tool in community surveys, nor to extend its application to other age groups. However, Gomez' classification is now used also in community surveys for determining degrees of malnutrition. See : Gomez, F. (1956) *J. trop. Pediat.*, **2**, 77.

In recent years it has been increasingly realized that the measurement of deficit in height or body length gives valuable information about the chronicity of malnutrition, complementary to that given by the measurement of weight deficit. A reduction or stunting of height is evidence of past malnutrition; a low body weight in relation to height is evidence of present malnutrition. It is therefore important to take account, whenever possible, of height as well as of weight. However, the combination of weight deficit, height deficit, and the presence or absence of oedema in a single index for evaluation is unsatisfactory, because children with the same evaluation may differ in their clinical picture, history, and prognosis.

In view of these difficulties it does not seem feasible to devise a workable system of classification that fulfils all the criteria or that takes account of the age of the patient and the severity, type, and duration of the condition.

The Committee therefore considered that, in community surveys, attention should be concentrated on the systematic collection and grouping of data (see section 3.2, p. 42) and that it is not necessary to try to fit these data into preconceived categories.

2.3.2 *Classification for clinical purposes*

In clinical investigations the situation is different. It is often convenient to group the conditions of patients as kwashiorkor, nutritional marasmus, or the intermediate state of marasmic kwashiorkor for the purpose of analysing etiological factors, comparing biochemical and metabolic changes, etc. By way of example, a simplified scheme for defining these terms is set out in Table 3.

TABLE 3. SIMPLIFIED CLASSIFICATION OF PROTEIN-CALORIE MALNUTRITION [1]

	Body weight as % of standard [a]	Oedema	Deficit in weight for height [b]
Underweight child	80–60	0	Minimal
Nutritional dwarfing	< 60	0	Minimal
Marasmus	< 60	0	++
Kwashiorkor	80–60	+	++
Marasmic kwashiorkor	< 60	+	++

[a] Standard taken as 50th percentile of the Harvard values. See: Nelson, W. E. (1964) *Textbook of pediatrics, 8th edition*, Philadelphia, W. B. Saunders, pp. 48–53.

[b] Weight for height $= \frac{\text{weight of patient}}{\text{weight of normal subject of same height}} \times 100$

[1] Unpublished report to the Wellcome Trust, 1968.

2.3.3 *PCM in the International Classification of Diseases*

At its meeting in 1961, the Committee reviewed the classification of diseases of nutritional origin in the International Classification of Diseases [1] and suggested the following classification of PCM : [2]

1. Protein-calorie deficiencies
   A. Kwashiorkor (including marasmic kwashiorkor)
   B. Marasmus (e.g., athrepsia, cachexia, extreme wasting)
   C. Unspecified (including starvation in adults, famine oedema).

However, the 1965 revision of the International Classification of Diseases [3] includes :

267 Protein malnutrition
Kwashiorkor
Kwashiorkor — marasmus type
Multiple deficiency syndrome
Protein deficiency

268 Nutritional marasmus
Athrepsia, Cachexia, Extreme wasting, Marasmus } NOS [4] or stated to be due to malnutrition

269 Other nutritional deficiency
269.9 *Other and unspecified*
Famine oedema
Malnutrition NOS
Nutritional oedema
Underweight

The Committee felt that the present revision does not fully reflect the opinions of most specialists in this field.

In March 1970, the classification of nutritional diseases was considered at a meeting of the Pan American Health Organization (PAHO) held to discuss the Inter-American Investigation of Mortality in Childhood (un-

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[1] *Manual of the international statistical classification of diseases, injuries, and causes of death, 1955 revision*, Vol. 1, Geneva, World Health Organization, 1957.

[2] *Wld Hlth Org. techn. Rep. Ser.*, 1962, No. 245, p. 27 (*FAO Nutrition Meetings Report Series*, No. 32, p. 27).

[3] *Manual of the international statistical classification of diseases, injuries, and causes of death, 1965 revision*, Vol. 1, Geneva, World Health Organization, 1967, p. 128.

[4] Not otherwise specified, i.e., cause not specified.

published report). It was recommended that PCM be considered under the following sub-headings:

260 Kwashiorkor
261 Nutritional marasmus
262 Severe PCM, unqualified
263 Other and unspecified PCM (particularly of moderate type)
264 Late effects of PCM (which include dwarfism, physical retardation, arrested development)

The Committee endorsed the classification proposed by PAHO with slight alterations, as given in Annex 1, and suggested that it be taken into consideration in preparing the 1975 revision of the International Classification of Diseases.

3. PREVALENCE OF PCM

3.1 Present knowledge

Community surveys, representative of the population under study, are the only satisfactory method of estimating the prevalence of PCM. The existing data are incomplete and scanty; the available literature, covering 80 surveys in over 39 countries from 1966 to 1969, has recently been reviewed.[1]

3.1.1 *Prevalence of severe PCM*

Different authors have used different criteria for defining the clinical manifestations of kwashiorkor and nutritional marasmus and different methods for sampling populations. The limited data available seem to indicate that, in some of the surveys, the point prevalence of nutritional marasmus was higher than that of kwashiorkor, but this question requires careful examination.

Kwashiorkor is an acute and severe condition and the child who does not receive medical attention usually dies within a few days or weeks. A child who is treated and survives recovers rapidly and no specific signs of kwashiorkor can be found a few weeks later. In nutritional marasmus, however, the child may survive for several months without showing any significant change, even if no medical attention is given. The turnover rate of cases in a community may therefore be significantly higher in kwashiorkor than in nutritional marasmus, and thus even where the two conditions have the same point prevalence more children are affected with kwashiorkor

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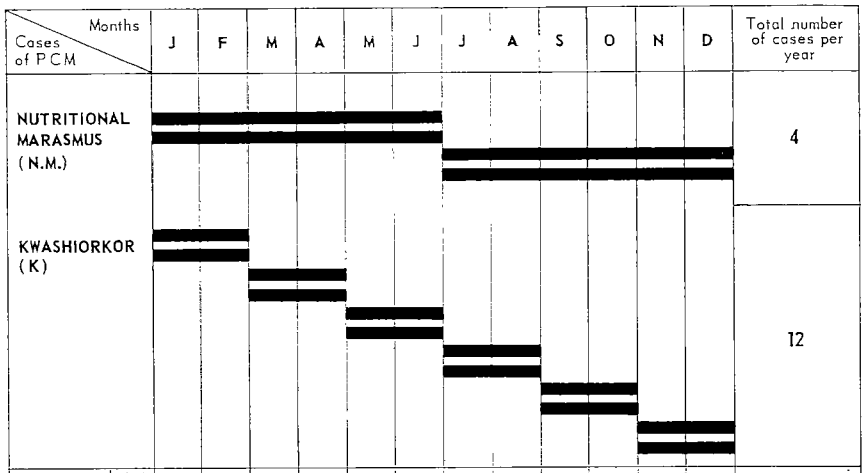
[1] Bengoa, J. M. (1970) *Recent trends in public health nutrition. Protein-calorie malnutrition.* In: *Nutrition. Proceedings of the Eighth International Congress, Prague, September 1969*, Amsterdam, Excerpta Medica.

than with nutritional marasmus in any one year (Fig. 1). The difference in turnover rates will depend, among other factors, on seasonal variations and on the fatality rates of the two conditions.

FIG. 1. THEORETICAL EXAMPLE OF THE DIFFERENCE BETWEEN POINT PREVALENCE, MONTHLY INCIDENCE, AND TOTAL NUMBER OF CASES PER YEAR *



		J	F	M	A	M	J	J	A	S	O	N	D
Point prevalence	N.M.	2	2	2	2	2	2	2	2	2	2	2	2
	K	2	2	2	2	2	2	2	2	2	2	2	2
Monthly incidence	N.M.	2	0	0	0	0	0	2	0	0	0	0	0
	K	2	0	2	0	2	0	2	0	2	0	2	0

4-0 90934

* Reproduced from: Bengoa, J. M. (1969) *Recent trends in public health nutrition. Protein-calorie malnutrition.* In: *Proceedings of the Eighth International Congress on Nutrition, Prague, Czechoslovakia, August 28-September 5, 1969, Amsterdam* (Excerpta Medica International Congress Series No. 213), p. 15.

The point prevalence of severe PCM (either kwashiorkor or nutritional marasmus) in the limited surveys conducted between 1966 and 1969 ranges between 0% and 7.6% in children below 5 years of age.[1] The prevalence of severe PCM has also been estimated from the proportion of children who are below 60% of the standard weight for a given age (corresponding to third-degree malnutrition in the Gomez classification). These surveys showed the prevalence of severe malnutrition to be 0.5–4.6%.

3.1.2 *Prevalence of moderate PCM*

Both from the public health and socio-economic points of view, the prevalence of moderate cases of PCM is even more important than is that of severe cases.

[1] See footnote 1, page 40.

The terms that have been used to define moderate PCM, such as " pre-kwashiorkor ", " general under-nutrition ", and " poor nutritional status ", are vague and difficult to interpret and should no longer be used. Using the Gomez classification, the prevalence of moderate PCM (second-degree malnutrition) varied from country to country between 4.4% and 43.1% in children up to 5 years of age.[1]

It is clear from the above considerations that existing knowledge is inadequate and that, from the available data, it is difficult to obtain even a rough estimate of the total number of malnourished children in the world.

The following general requirements must be met so that field studies can provide an accurate picture of the prevalence of PCM :

(*a*) Studies should be concerned with the total picture of nutrition in the community, including important forms of malnutrition that commonly coexist with PCM in many regions, e.g., anaemia or vitamin A deficiency.

(*b*) Studies must be planned on a sound epidemiological and statistical basis if they are to be representative of the country or region concerned. If possible, sampling methods and the age groups to be studied should be standardized. Allowance must be made for both seasonal and geographic variations.

(*c*) Uniform criteria should be adopted for the recording, grouping, and reporting of clinical data (see section 3.2 below).

The data that can be obtained from point prevalence studies are limited and should be supplemented wherever possible by information obtained from longitudinal studies.

3.2 Guidelines for community studies of prevalence

The Committee considered that, in the collection of data in field studies, a pre-defined classification serves no useful purpose and recommended that attention be given instead to obtaining basic data in a standardized manner. There are four stages in this process :

3.2.1 *Recording of basic data*

The basic data are age, weight, height, presence or absence of oedema, and, when available, birth weight.

This information should be obtained from all subjects in the group to be studied, without selection or bias. Other clinical signs of PCM,

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[1] Bengoa, J. M. (1970) *Recent trends in public health nutrition. Protein-calorie malnutrition.* In : *Nutrition. Proceedings of the Eighth International Congress, Prague, September 1969*, Amsterdam, Excerpta Medica.

e.g., hepatomegaly and changes in skin, mucosae, and hair, should be recorded.

As has been emphasized above, it is essential not to overlook the presence of associated deficiency states, e.g., anaemia or avitaminosis A, which are common in some regions.

3.2.2 *Grouping and presentation of data*

In order to make international comparisons possible, the data must be related to some common standard. For this purpose, the Harvard standards and percentile distribution of height and weight [1] have been widely used. Standards of this kind should be regarded as a yardstick and not necessarily as a target or norm. Individual countries or regions may find it convenient to adopt local standards for additional comparisons.

The Committee recommended that FAO and WHO examine the feasibility of developing and adopting international standards for heights and weights and that, as an interim measure, the Harvard standards be used in field studies on PCM.

3.2.3 *Analysis of data*

The data must be analysed in order to show the severity, duration, and type of PCM and any associations between different sets of observations. Such analyses can be greatly facilitated by the use of computers. The Committee recommended that, as a necessary first step, WHO promote a uniform system for the collection of basic data for community studies on the prevalence of PCM.

3.2.4 *Additional information*

Additional anthropometric, haematological, and biochemical information can be obtained on the whole sample or on a sub-sample, according to local facilities, conditions, and problems. Since anaemia is an urgent public health problem in many countries, measurements of haemoglobin or haematocrit should always be made, at least on a sub-sample.

The Committee emphasized that the basic data are in themselves of great value and that their collection must represent a primary objective. Simplicity and accuracy must not be sacrificed for an elaboration of detail that may increase costs out of proportion to any extra useful information gained.

The anthropometric and biochemical methods that are most useful

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[1] Jelliffe, D. B. (1966) *The assessment of the nutritional status of the community*, Geneva, World Health Organization (*Monograph Series*, No. 53).

for the appraisal of nutritional status have been considered in detail in previous publications.[1, 2, 3, 4]

3.3 Indirect indicators of the prevalence of PCM

3.3.1 *Age-specific death rates*

As emphasized in the report of the WHO Expert Committee on Medical Assessment of Nutritional Status,[1] age-specific mortality rates in children between 1 and 4 years of age are related particularly to malnutrition and can be used to indicate the nutritional status of this age-group. However, the relative importance of malnutrition and infectious diseases in causing this mortality varies in different circumstances. Moreover, the reliability of vital statistics varies greatly from one country to another. Under-reporting, particularly in the younger age-group, is likely to occur more frequently in the developing countries.

Infant mortality is greatly influenced by malnutrition in the first year of life, particularly in those countries where weaning is early and the weaning foods are inadequate.

Neonatal deaths, occurring in the first 28 days of life, are due mainly to congenital defects, obstetric complications, prematurity, and neonatal tetanus. Although these causes are not influenced to any great extent by the child's diet, the neonatal mortality rate is higher among children of low birth weight for length of gestation, which suggests that it may be affected by the nutritional status of the mother.

Post-neonatal infant mortality, i.e., the mortality between 28 days and 1 year of life, is higher in the developing countries than in the advanced, industrialized areas. This difference, like that in the entire second year, is due mainly to a combination of factors: malnutrition causes a lowered resistance to infection, while frequent episodes of infectious diseases precipitate clinical malnutrition. The same factors continue to operate, but with decreasing importance, during the remaining pre-school years; the magnitude of their consequences obviously depends on the medical services provided.

The Committee discussed the preliminary results of the Inter-American Investigation of Mortality in Childhood, which is a continent-wide collaborative study started in 1968 by PAHO. The overall objective of this study is to determine accurate and comparable mortality rates for children

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[1] *Wld Hlth Org. techn. Rep. Ser.*, 1963, No. 258, p. 11.

[2] Jelliffe, D. B. (1966) *The assessment of the nutritional status of the community*, Geneva, (*World Health Organization: Monograph Series*, No. 53).

[3] Committee on procedures for appraisal of protein-calorie malnutrition of the International Union of Nutritional Sciences (1970) *Amer. J. clin. Nutr.*, **23**, 807.

[4] Simmons, W. K. & Bohdal, M. (1970) *Bull. Wld Hlth Org.*, **42**, 897.

under 5 years of age in 15 widely separated areas of the Americas. Information will be collected on about 35 000 deaths, using hospitals, clinics, private physicians, pathology records, and family interviews as sources to determine both the multiple causes of deaths occurring over a two-year period and also the relevant ecological, socio-economic, and demographic conditions.

The preliminary results indicate that nutritional deficiency is directly or indirectly responsible for a high proportion of deaths under 5 years of age, excluding neonatal deaths. The death-rates in the age-group 1–4 years are principally due to the synergistic effects of malnutrition and infection, regardless of what is the terminal event; close relationship was found between nutritional deficiency and the death rate from all causes in this age-group. Among all deaths associated with nutritional deficiency, this condition was classified as a contributory cause of death in approximately 70% of cases.

The Committee felt that the final results of the Inter-American Investigation of Mortality in Childhood will help to clarify many questions related to the interaction of malnutrition and infection.

In the developing countries, deaths in the second year of life commonly account for one-half of all deaths between 1 and 4 years of age. After the second year death rates decline progressively, at a rate depending upon local conditions.

The Committee recommended that countries present their mortality data separately for each of the first 5 years of life. Much valuable information about PCM in the pre-school child can be obtained from the analysis of data presented in this manner.

3.3.2 *Disease-specific death rates*

In principle, death rates by cause should be extremely useful in assessing nutritional status and the effects of programmes for the improvement of nutrition. In practice, however, the classification of deaths associated with malnutrition is so unreliable as to be almost worthless. Moreover, few nutritional disorders are diagnosed and reported as such. In a two-year study in Guatemala, all but one of 40 deaths from kwashiorkor in children aged 1–4 years were attributed in the official records to worms, parasites, or dysentery.[1] The one case diagnosed as due to malnutrition was the only one to die in hospital, and the only one to be medically certified.

The most striking example of the value of disease-specific death rates as an indicator of the nutritional status of children is the variation in the mortality rate from measles, which is several hundred times higher in some developing countries than in North America and Europe. This variation

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[1] Béhar, M., Ascoli, W. & Scrimshaw, N. S. (1958) *Bull. Wld Hlth Org.*, **19**, 1093.

is not due to differences in the incidence of measles, since nearly everyone acquired the disease in childhood prior to the recent advent of measles vaccine, nor to differences in virulence, since the higher-income groups in the developing countries do not share the high fatality rates. Neither is it due to differences in medical care alone, since few children in the industrialized countries need any treatment for measles in order to ensure their survival. Almost certainly it is due primarily to differences in resistance to disease, resulting from differences in nutritional status. An earlier age of onset of measles among less privileged children is often due to their contracting the disease as weanlings, when they are most likely to be malnourished and consequently more susceptible.

In longitudinal or prospective population studies, investigation of the causes of all child deaths can yield valuable information on disease-specific mortality rates if the sample is large enough and the duration of study sufficiently long. Even when the period of observation is too short for mortality rates to be obtained, the ratio of fatalities to cases can give valuable information on the susceptibility of a population to disease. Such investigations can be made in studies of epidemics or in prospective field studies in which accurate mortality data are obtained.

If the proposed change (see section 2.3.3, p. 39 and Annex 1, p, 70) in the International Classification of Diseases to include severe unqualified PCM and moderate unspecified PCM is accepted, more useful data on these different types of PCM may become available in the vital statistics of countries, particularly if the associated causes of deaths are included. In general, it can be assumed that it will be some time before most deaths from malnutrition in developing countries are recorded under a specific diagnosis. This is because many deaths are not medically certified and lay knowledge is insufficient to identify malnutrition as a primary, or even a secondary, cause of death.

3.3.3 *Occurrence of disease*

There is extensive evidence that PCM in children, as judged by low weight for age, is associated with a greater frequency and severity of some infectious diseases, especially in populations living under conditions of poor environmental sanitation and personal hygiene.[1] Since PCM is often related to certain infectious diseases, properly collected and interpreted data on the frequency and duration of infectious diseases, by broad categories, can provide an indirect indication of the prevalence of PCM.

The most common condition among malnourished pre-school children is weanling diarrhoea.[1] This is caused by reduced resistance to a variety of organisms due to malnutrition, which is common during the weaning period.

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[1] Gordon, J. E., Chitkara, I. D. & Wyon, J. B. (1963) *Amer. J. med. Sci.*, **254**, 345.

The amount of respiratory illness and the severity of the common communicable diseases of childhood and their complications are also influenced by nutritional status. Recent studies have shown a decrease in the total days of infectious diseases, as well as in the morbidity from diarrhoeal diseases, after the introduction of supplementary feeding.[1]

Moreover, in situations where PCM occurs a seasonal increase in the frequency of diarrhoeal disease, or an epidemic of an acute communicable disease, is usually followed by an increase in severe PCM. Information on the morbidity due to infectious diseases may therefore contribute to the planning of public health measures for the prevention of PCM.

Since published data on the incidence of infectious disease in population groups are unreliable and incomplete, this kind of information must be collected by special surveys. It appears that 2 weeks is about the longest interval over which mothers can remember accurately episodes of common diseases, such as respiratory infections and diarrhoea, in their pre-school children. The collection of reliable morbidity data over a long period of time, therefore, requires a personal interview at least every 2 weeks. Mothers can be interviewed either during home visits or at a maternal and child health centre when they are participating in a programme requiring them to visit the centre regularly. In nutritional surveys for point prevalence or 2-week period prevalence, data on morbidity from diarrhoeal and other infectious diseases in children under 5 years of age provide valuable supplementary information relevant to the extent of PCM in this age-group.

4. RELATIONSHIP BETWEEN SOCIO-ECONOMIC DEVELOPMENT AND PCM

4.1 Socio-economic development and the prevalence of PCM

The factors that influence the nutritional state of a population and those that determine its socio-economic development are complex and interrelated. Food consumption is regulated by its availability to families, its cost in relation to income, its acceptability, and the degree of development of the chain of distribution. Other factors that influence the nutritional state include the degree of literacy, the development of environmental sanitation, and the extent to which a change has occurred from a subsistence to a cash economy and from rural to urban living.

Income and purchasing power affect food consumption. As incomes rise, the proportion spent on food tends to decrease, although there may

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[1] Gordon, J. E., Ascoli, W., Mata, L. J., Guzman, M. A. & Scrimshaw, N. S. (1968) *Arch. environm. Hlth*, **16**, 424 ; Scrimshaw, N. S., Béhar, M., Guzman, M. A. & Gordon, J. E. (1969) *Arch. environm. Hlth*, **18**, 51.

be an increase in the total expenditure on food. Food consumption habits tend to be formed early in life and to persist.

Migration from rural to urban areas, for whatever reason, has socio-economic implications that may affect the nutritional state of families and young children. The Committee emphasized the urgent need for studies on the incidence and prevalence of PCM and on its epidemiology during the change from a subsistence to a cash economy and from rural to urban living.

A " socio-economic development index " has been developed by the United Nations Research Institute for Social Development. When this index is compared with the mortality rate in the age-group 1–4 years, an inverse correlation is observed (Table 4).

TABLE 4. INFANT MORTALITY RATE, MORTALITY RATE FOR THE AGE-GROUP 1–4 YEARS, AND " SOCIO-ECONOMIC DEVELOPMENT INDEX "

Country	Infant mortality rate per 1000 live births	Mortality rate in children 1–4 years old per 1000 children of the same age	Socio-economic development index [a]
United States of America (1964)	24.8	1.0	111
England (1964)	20	0.8	104
Sweden (1963)	14.2	0.6	103
Australia (1964)	19.1	1.0	93
Argentina (1963)	60	3.7	73
Venezuela (1962)	30	6.0	62
Chile (1962)	114	7.2	61
Costa Rica (1964)	75	7.5	50
Panama (1964)	42.7	8.0	48
Colombia (1964)	84	13.7	46
Mexico (1964)	64	12.7	44
El Salvador (1962)	70	16.0	32
Ecuador (1962)	39	20.2	31
Guatemala (1962)	91	26.9	21

[a] Calculated by United Nations Research Institute for Social Development, Geneva, July 1970.

Malnutrition in this age-group appears to be closely related to the socio-economic level of the community. However, the reported infant mortality rates do not show such a clear tendency to fall with a rise in the socio-economic development index. Chile has one of the lowest mortality rates for the age-group 1–4 years and yet has a very high infant mortality rate. This apparent contradiction results from the fact that, in Chile, weaning tends to occur very early. In countries with a high level of socio-

economic development, early weaning does not produce malnutrition; in the less highly developed countries, however, where people cannot afford to buy milk, where milk substitutes are not readily available, and where sanitary conditions are poor, PCM prevails.

4.2 Regional differences in the pattern of PCM

Socio-economic factors influence not only the prevalence of PCM, but also its pattern, e.g., the age of onset and its clinical characteristics. Other factors, such as climatic and seasonal conditions and food habits, result in marked geographic differences in the pattern of PCM.

In recent years, many authors have emphasized that, because of the rapid growth of cities and the migration from rural to urban areas, it is likely that, in general, malnutrition will develop at an increasingly early age and will tend more and more towards the marasmic type. It is important to establish whether this tendency exists and, if so, its extent. The pattern of PCM, and in particular its age of onset, is relevant to the organization of preventive measures, since different measures will be required in the first months of life and in pre-school children. There is an urgent need, therefore, to obtain more information on the pattern and age incidence of PCM and to monitor the changes that may be occurring in different parts of the world.

Conditions are likely to vary widely in different regions and generalizations may be misleading. For example, although migration to towns is a widespread phenomenon, the reasons for it and the nature of the people migrating are different in different countries. Because of wide variations in socio-economic conditions, although the principles for prevention remain the same, the detailed measures may differ from place to place and must be based on a sound appreciation of the local situation.

Information on patterns of PCM must be obtained as a matter of urgency, ideally through community surveys of incidence and prevalence. However, such surveys require careful epidemiological planning, the employment of special staff, and much time for their organization and financing. In the meantime, certain information that can be obtained more quickly may be useful. For example, the age of onset of malnutrition can be obtained from two sources that should be readily available in most places:

(*a*) The records of infant welfare or other centres. These usually represent a highly selected population.

(*b*) The records of hospital inpatient and outpatient departments. These too represent a highly selected population. Hospital statistics on the relative frequencies of kwashiorkor and marasmus are difficult to interpret because they depend on variable criteria for admission and

diagnosis. Some data reported from selected hospitals in different countries are presented in Table 5.

TABLE 5. REGIONAL DIFFERENCES IN THE PATTERN OF PCM (HOSPITAL CASES)

Country	Percentage of cases classified as :			Percentage of cases less than 1 year of age
	kwashiorkor	marasmus	unspecified	
Chile (Santiago)	3	97	—	83
Iran	33	66	—	45
Jamaica	32	34	34	52
Jordan	24	15	61	
Senegal (Dakar)	45	55	—	
South Africa (Johannesburg)	96	4	—	48
Sudan	92	8	—	50
Thailand	44	46	10	18

Large differences are seen in the patterns of PCM in Chile (Santiago) at one extreme and in South Africa (Johannesburg) at the other, with other countries showing intermediate patterns. One cannot be certain whether the differences are real or whether, in some hospitals, marasmus is regarded as a condition not requiring admission.

Despite their shortcomings, these data give presumptive evidence of regional differences; they would be more valuable if diagnostic criteria were more uniform.

In view of the urgency of the problem, the Committee recommended that WHO explore ways of obtaining, within the shortest possible time, a wider range of information about the ages of onset and the clinical types of PCM in different countries and regions of the world. The information to be collected in such studies should be of the simplest kind and need not include more than the basic data recommended for prevalence studies in section 3.2, p. 42.

5. INTERRELATIONSHIP OF DIETARY FACTORS IN THE ETIOLOGY OF PCM

Malnutrition in childhood is not only due to protein and calorie deficiency. Although these may be the major deficiencies in the developing countries, other nutrients, such as vitamin A, iron, folic acid, and riboflavin, are often lacking to varying degrees depending upon local conditions.

The clinical picture varies widely, reflecting the complex interrelationship of the causative factors, and is influenced mainly by the age of weaning. There has been a tendency to over-emphasize the importance of either protein or calorie deficiency alone, whereas in fact the two almost always occur together. The questions of whether the clinical pictures of kwashiorkor and nutritional marasmus reflect real differences in etiology and whether the nature of the predominant deficiency can be deduced from the clinical, biochemical, and other changes have an obvious bearing on diagnosis and on the planning of preventive measures.

Much research has been devoted to this problem in recent years and there is a large amount of literature on the significance of the various clinical and biochemical changes. Although there is a wide area of agreement on the significance of these changes, opinions differ on the importance to be attached to many of them. It is generally accepted that some clinical and biochemical changes probably reflect a state of protein depletion, notably oedema, hypo-albuminaemia, a reduction of some serum enzymes, and distortion of the serum amino acid pattern. However, a state of protein depletion does not result from dietary protein deficiency alone; calorie deficiency may act as a contributory factor by promoting the utilization of protein for energy production, and infections can cause protein loss (see section 6.3, p. 55). The condition of a child frequently reflects a recent episode superimposed on a more chronic state of malnutrition.

Thus the clinical and biochemical pictures in PCM are not reliable indicators of the relative importance of protein and calorie deficiency as causative factors.

Dietary studies fail to provide conclusive evidence. In the early descriptions of " sugar babies " in the West Indies, both the dietary histories and the presence of ample amounts of subcutaneous fat suggested that the calorie intake had been relatively high. On the other hand, a detailed study in India of the dietary habits of patients with the clinical pictures of nutritional marasmus and kwashiorkor did not show any quantitative or qualitative difference in the previous diets of the two groups.

However, isolated instances are on record in which it has been possible to show a relationship between the clinical picture and the recent dietary history. For example, cases have been described of typical kwashiorkor developing in children whose diets were adequate in calories but deficient in protein.[1]

It must therefore be concluded that the information about dietary background that can be derived from clinical and biochemical findings and retrospective dietary histories is usually of limited value and is unlikely to provide a sound basis for the planning of preventive measures.

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[1] Monckeberg, F. (1968) *Adaptation to caloric and protein restriction in infants.* In: McCance, R. A. & Widdowson, E. M., ed., *Calorie deficiencies and protein deficiencies*, London, Churchill, p. 91.

The next question to arise is the value of information that can be derived at the level of the community, from studies on the family and the pre-school child in their natural environment.

In general, the clinical picture of PCM tends to be that of kwashiorkor in regions where breast-feeding is continued into the second year of life, whereas marasmus is the typical result when weaning occurs early, as in Chile.[1] However, the type of diet available is not always a good indicator of the type of PCM that develops. In the Amazon region of Brazil, where cassava is the staple food, the prevailing form of PCM was found to be marasmus, whereas in areas of Brazil where maize is the staple food the prevailing picture was kwashiorkor, in spite of the higher protein content of the diet.[2]

Although the staple foods differ in different regions, the type of PCM is influenced mainly by the age of the child, the feeding practices before and during weaning, the age at which weaning is completed, the age at which various supplementary foods are introduced, and the form in which these are given. Some weaning diets are bulky and have a high water content with a low concentration of calories and proteins, so that the child cannot eat enough to satisfy his needs. Finally, it should be emphasized that the frequency and severity of infections at the time of weaning may be important in determining the type of PCM.

In view of the complexity of these interrelationships, the only way to ascertain which are the most important causative factors in PCM, and hence to establish priorities for preventive measures, is by studying conditions in a particular community.

While recognizing the difficulties and limitations involved, the Committee stressed the need to obtain more information about the diets of pre-school children, which might serve as a basis for the planning of preventive programmes.

6. OTHER FACTORS OF SPECIAL IMPORTANCE IN THE CAUSATION OF PCM

6.1 The significance of fetal nutrition

Birth weight in relation to length of gestation is generally accepted as one of the main indices of fetal development. The relationship between birth weight, even at full term, and maternal nutrition during pregnancy

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[1] Monckeberg, F. (1970) *Factors conditioning malnutrition in Latin America, with special reference to Chile.* In : György, P. & Kline, O. L., ed., *Malnutrition is a problem of ecology*, Basel, Karger, p. 23.

[2] Waterlow, J. & Vergara, A. (1956) *Bull. Wld Hlth Org.*, **15**, 165 ; *FAO Nutritional Studies*, No. 14.

require further investigation, with regard to the following problems in particular:

(1) Fetal development and the outcome of pregnancy may be influenced by many factors other than maternal nutrition, e.g., genetic factors, infections, parity, pregnancy interval, multiple births, and the state of the placenta.

(2) It is difficult to isolate the effects of maternal malnutrition from those of the many social and economic factors that accompany poverty. Therefore it is hard to draw valid conclusions from the generally observed close correlation between low birth weight and poor socio-economic status, for the purposes either of international comparisons or of comparisons between different population groups within a country.

(3) It is generally believed that women who have suffered from chronic, moderate under-nutrition in childhood produce children of low birth weight more commonly than do women who were formerly well nourished and are subjected to acute food restriction. This belief is based on: (*a*) observations of pregnancy under famine conditions; (*b*) the observed positive correlation between birth weight and maternal height; this leads to the assumption that the median height of a socio-economic group is a valid index of its nutritional status in infancy and childhood; and (*c*) the fact that prematurity is more strongly associated with the social class of a child's maternal grandfather than with that of its father.

(4) There is controversial evidence on the effectiveness of dietary supplements during pregnancy, among severely undernourished women in developing areas, in increasing birth weight.[1, 2, 3]

Recent research has led to a greater understanding of the significance of fetal nutrition and its influence on mental and physical development in infancy and childhood.

The most convincing evidence comes from longitudinal studies of monozygotic twins of different birth weights, which showed marked differences both *in utero* and in their physical and mental development throughout the observation period of over 15 years.[4]

Studies on fetal growth have shown that, up to 26 weeks, the mean growth curve is similar in the developing countries to that in industrialized countries, such as the USA, but that, in the developing countries, fetal growth slows down after 26 weeks, resulting in a greater proportion of small-for-dates babies.

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[1] Acosta-Sison, H. & Villanueva, J. (1954) *J. Philipp. med. Ass.*, **30**, 151.

[2] Neven, M. & Holemans, K. (1959) *Ann. Soc. belge Méd. trop.*, **39**, 299.

[3] Venkatachalam, P. S. (1962) *Bull. Wld Hlth Org.*, **26**, 193.

[4] Willerman, L. & Churchill, J. A. (1967) *Child Develop.*, **38**, 623.

Small-for-dates babies not only have high rates of perinatal mortality and morbidity but also suffer a high incidence of sublethal damage that has long-lasting effects.

In the absence of conclusive evidence on which to base specific preventive measures, the following general principles, which are likely to improve fetal nutrition, the outcome of pregnancy, and lactation, should be observed:

(1) The life stages of adolescence, motherhood, fetal life, infancy, and childhood should be viewed as a continuous cycle, thus indicating the need to initiate dietary improvement as early as possible in the life of the future mother.

(2) Antenatal, natal, and postnatal care should include general advice on food, dietary habits, personal hygiene, and the additional nutritional requirements during pregnancy and lactation.[1]

(3) Nutritional advice should be integrated into broader maternal and child health advisory activities on such topics as (*a*) family planning to space pregnancies and to defer the first pregnancy until adolescent growth and development have been completed; (*b*) the management of common infections; and (*c*) the avoidance of hard physical work during the latter part of pregnancy.

(4) Small-for-dates babies should be considered at high risk and appropriate measures taken for their care.

The Committee recommended that studies on the etiology of fetal malnutrition and on effective preventive measures for reducing the incidence of low birth weight be encouraged and vigorously pursued.

6.2 Premature weaning

In developing countries, particularly in rural areas, babies are usually suckled until the age of 2 years or more or until the mother becomes pregnant again. This practice is favoured in some societies by polygamy or by rigid customs that enforce a long period of sexual abstinence after childbirth. These social controls are rapidly disappearing, however, and early weaning is becoming increasingly common, but the complex and interrelated factors that predispose to early weaning are not clearly understood and require further study.

In the developed countries, the present fashion is either not to breast-feed at all or to do so for only a month or two. This fashion has spread rapidly to the towns and cities of the developing countries, where the period of breast-feeding is becoming shorter. Mothers in towns and cities

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[1] *Wld Hlth Org. techn. Rep. Ser.*, 1965, No. 302.

generally have to work away from home in circumstances that make it difficult for them to have their children with them, and they have no alternative, therefore, but to resort to artificial feeding. Moreover, most of them cannot afford the milk and milk substitutes, nor the time for proper home care of the infant, that are required for successful artificial feeding; thus PCM may be expected to show a tendency to occur at an earlier age. There is also a general shortening of the duration of breast-feeding in response to advertisements, in the mistaken belief that this is good for infants, and from a desire to imitate the better-educated section of the community. Short spacing of pregnancy is also a contributory cause of early weaning. Even where a mother would normally continue breast-feeding for a long time she may stop as soon as she misses her period; thus weaning takes place earlier as the intervals between pregnancies become shorter.

Artificial feeding may be unsatisfactory for several reasons. The formulation of the food may be wrong, because of mistaken motives of economy or lack of true understanding of what is involved. Most of those responsible for preparing the feeds for the infants of working mothers use unhygienic methods, and artificially fed infants are thus more predisposed than are breast-fed infants to attacks of gastroenteritis, hence to early PCM.

Breast milk by itself is adequate as food for the young infant. However, all the available evidence indicates that breast-feeding alone is not adequate for infants aged 4 months or more, who weigh less and make poorer progress when supplements are not given. No good supplementary foods are at present available in most developing countries, and efforts to develop foods suitably concentrated in calories and proteins need to be intensified. The Committee emphasized that, in spite of some evidence that there are foods not based on milk that can be used as a milk substitute for very young infants, the general consensus is that milk is still the best basis for food for infants aged 6 months or less.

The Committee deprecated the universal trend towards the early weaning of infants and recommended that every effort be made to encourage mothers, particularly in the developing countries, to breast-feed their infants at least throughout the first year of life. The advantages of breast-feeding should be taught to health and community workers at all levels, and they in turn should educate mothers. There is a need for health education, incentives, and legislation to slow down or stop this trend, which is having such disastrous consequences especially in the developing countries.

6.3 Interrelationships between nutrition and infection

In developing countries, a major factor in PCM is the effect of the frequent infections experienced by children during the first years of life.

Recent studies in areas as widely separated as Guatemala,[1] Ethiopia,[2] and India have shown that diarrhoeal diseases, respiratory infections, the common communicable diseases of childhood, and other infectious diseases are frequent in most children in rural low-income groups, and that intestinal parasitism is also widespread.

The way in which infections adversely affect nutritional status are well known, but difficult to quantify. They include decreased appetite, reduced food intake, and diminished absorption when diarrhoea is present. The reduced food intake frequently results in calorie deficiency, hence in the less efficient utilization of the dietary protein, since some of this is used to meet energy requirements.

The metabolic loss of nitrogen in the urine is increased with even the mildest infections, e.g., bronchitis, otitis media, pharyngitis, and small staphylococcal abscesses, and has also been shown to occur with immunization against smallpox, measles, and yellow fever.[3] The nitrogen that is lost must be replaced once the infection is over. Infection also increases needs for calories, vitamin A, vitamin C, and probably for most other essential nutrients. If the diet does not provide adequate quantities of these nutrients the child may recover slowly or not at all and be left more depleted than before.

There is extensive evidence that resistance to infections is markedly reduced in severe PCM and that even a mild degree of PCM in the pre-school child increases susceptibility to diarrhoeal and respiratory diseases and to other serious infections of childhood. There is evidence that the following factors contribute to this lowering of resistance in severe PCM : reduced antibody formation ; reduced leucocyte activity ; altered epithelial integrity ; changes in the nature and distribution of the gastrointestinal flora ; and, possibly, endocrine changes. However, the relative importance of these mechanisms in mild or moderate PCM needs clarification.

There is some evidence that supplementary feeding of pre-school children with mild or moderate PCM will reduce the incidence and severity of diarrhoeal and respiratory diseases.[4] In one study over a 2-year period, no deaths from measles were observed in children receiving supplementary food, although there was a high case-fatality rate from this disease among the children in the surrounding villages.

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[1] Scrimshaw, N. S., Salomon, J. B., Bruch, H. A. & Gordon, J. E. (1966) *Amer. J. trop. Med. Hyg.*, **15**, 625.

[2] Eksmyr, R. (1969) *A trial to change infant feeding practices in an Ethiopian village (a longitudinal study of 11 cases)*, Addis-Ababa, Ethiopian Nutrition Institute.

[3] Scrimshaw, N. S., Taylor, C. E. & Gordon, J. E. (1968) *Interactions of nutrition and infection*, Geneva, World Health Organization (*Monograph Series*, No. 57).

[4] Gordon, J. A., Ascoli, W., Mata, L. J., Gusman, M. A. & Scrimshaw, N. S. (1968) *Arch. environm. Hlth*, **16**, 424.

PCM and infection act synergistically and must both be taken into consideration, therefore, in programmes of prevention. Thus programmes of environmental sanitation, personal hygiene, and immunization can decrease the frequency and severity of PCM, while measures to improve the nutritional status of pre-school children are likely to reduce the frequency and severity of infectious diseases. Programmes to improve nutrition and to reduce infectious disease are thus complementary and should proceed simultaneously in populations with PCM.

7. TREATMENT AND REHABILITATION

7.1 Treatment

The treatment of mild or moderate cases of PCM includes an adequate diet and the control of infection. These can be achieved routinely on an ambulatory or semi-ambulatory basis and should, in all cases, be accompanied by nutritional and health education of the mother and of other persons taking care of the child.

Severe cases may require hospitalization, particularly when, as frequently occurs, they are complicated by dehydration and when infection demands immediate attention.

A suitable diet is the mainstay of treatment. Complications may arise, however, especially in the early stages of treatment, that require special therapeutic measures.

The basic principle of treatment is to raise the child's nutritional level as quickly as possible by providing sufficient calories and high-quality protein. The child may initially have to be tube-fed and the diet must therefore be in a form that allows this. It is generally agreed that a daily intake of 100–200 kcal per kg body weight, depending on the clinical form of PCM and the age of the child, and 3–4 g of good quality protein per kg body weight are sufficient to cover the child's needs. With such levels of protein intake there is evidence that the weight gain depends on the calorie intake.[1] There is no advantage in giving much larger amounts of protein, as is sometimes recommended.

The protein used in treatment will depend on the local resources that are available. Whole milk is generally considered to be one of the best sources of protein, the most easily administered, and the best assimilated. Skimmed milk, being less expensive, is generally used but has the disadvantages of a lower calorie value and a high lactose content, which may cause diarrhoea if lactase deficiency exists. The latter disadvantage can be partly corrected by the addition of casein, which reduces the proportion

[1] Waterlow, J. C. (1961) *J. trop. Pediat.*, 7, 16.

of lactose as compared to proteins. The lack of vitamin A in skimmed milk can easily be overcome by adding it to the milk or by administering it as a supplement.

It is impossible to overestimate the importance of correct and vigilant care and strict hygiene as essential prerequisites to successful treatment. Sufficient auxiliary staff are therefore needed to take care of the children. Most of this staff do not need extensive training or much technical knowledge, since their functions consist almost entirely of feeding the children properly and keeping them clean. After a short period of training, even young girls can easily perform these duties under the supervision of trained nurses.

In many parts of the world the mother is usually hospitalized with her sick child. This provides an excellent opportunity for educating the mother in the consequences of inadequate diets, the importance of proper feeding and hygiene, and how these can be achieved within the cultural and socio-economic conditions of the family. Where mothers are not hospitalized with their children, rehabilitation centres for the treatment of uncomplicated cases of PCM might offer similar opportunities.

The period of hospitalization for severe cases of PCM, both kwashiorkor and marasmus, should be kept to a minimum. After 2–4 weeks a large majority of such children are out of danger and well on their way to recovery. A paediatric ward is not the best environment for children who are at the stage of " consolidation of cure ", when the only treatment being provided is an adequate diet, since they are at risk of cross infection, which delays recovery. When children cannot be properly cared for after discharge, then rather than being kept in hospital they should be transferred to a nutritional rehabilitation centre ; here they can stay until they have completely recovered, which may take from 2 to 4 months. Such rehabilitation costs much less than hospital treatment. The use of nutritional rehabilitation centres also reduces the length of stay in hospital, thereby freeing beds in the paediatric wards, which are usually in short supply. (For further details of treatment, see Annex 2, p. 71.)

7.2 Nutritional rehabilitation services

In recent years, many countries have established nutritional rehabilitation services in order to educate mothers through their active participation in the nutritional rehabilitation of their children. These services cost very little to run compared with hospital treatment.[1]

Malnourished children can be treated by even less expensive means, such as supplementary feeding or long-range nutritional education programmes, but the treatment usually takes much longer and during this

[1] Bengoa, J. M. (1967) *J. trop. Pediatr.*, **13**, 169.

time the children may be exposed to the additional risks of infectious diseases. To be effective, both supplementary feeding and nutritional educational programmes require very close home supervision.

The Committee felt that, in areas with a high prevalence of PCM, nutritional rehabilitation services may be a useful means of reducing mortality and morbidity rates through education of the mother and adequate dietary treatment of the malnourished child. They should be viewed as an integral part of the basic health services, particularly of the maternal and child health services, and as only one link in the chain of activities aimed at the prevention of PCM (see section 9).

The nutritional rehabilitation services now in operation have already achieved results in some areas. The Committee recommended that further cost-benefit studies be undertaken to compare the results that can be achieved through different types of activities aimed at the nutritional rehabilitation of malnourished children and the education of their mothers.

8. LONG-TERM CONSEQUENCES OF PCM

Experiments on animals of various species have shown that moderate or severe deprivation of food imposed shortly after birth has permanent and obvious effects on subsequent growth, whereas malnutrition that arises after weaning suppresses growth only during the period of malnutrition, without affecting the ultimate size of the animal. Whether the effect on growth is transient or permanent appears to depend on the severity and duration of deprivation and the age of the animal, the effect being greatest when malnutrition occurs early in life.

For man, information on the later effects of early malnutrition is both fragmentary and scanty. This is so largely because malnutrition in man does not occur in isolation and many of the non-nutritional factors that accompany it or contribute to it may themselves influence growth and development. It is difficult, therefore, to assess the specific effect of an episode of inadequate nutrient intake on ultimate body size and function. The interpretation of the few published data is further impeded by a lack of knowledge about the genetic potential of the children under study, the adequacy of their dietary intake, and the health care given to them in their home environment.

Studies published with these limitations show that children with chronic malnutrition and an acute episode of superimposed deficiency have a height and weight corresponding to those of children in their own social class, as represented by their siblings. It takes them several years to reach the growth norms for the upper social class of their ethnic group. A controlled study showed that compensatory growth was very rapid at the beginning of the recovery period, but that when the expected weight for height was

reached food intake fell abruptly by 30% and growth rates dropped to the level of normal children of the same weight and height but of younger age.[1] Considering both the calories needed for new tissue formation, i.e., 8 kcal per g,[2] and the home conditions under which children at high risk of malnutrition live, it is extremely unlikely that these children will consume adequate diets and therefore stunting of growth may continue for a long time.

The stunting of growth due to malnutrition early in life should be clearly documented, in view of data showing that, in industrialized societies, the risk of perinatal death is strongly associated with maternal height. For example, among the offspring of primigravidae less than 29 years of age in Aberdeen, Scotland, the perinatal death rate due to birth trauma was 2.7 per 1000 infants born to mothers whose height was about 64 inches, and 8.6 per 1000 for mothers whose height was 60 inches or less.[3]

Evidence has accumulated in the past dozen years that leads to the general conclusion that malnutrition in the first year of life, if severe enough markedly to retard physical growth and to necessitate admission to hospital, may cause mental impairment.[4] If the deprivation is severe and prolonged and occurs during the first months of life, the retardation of brain development and function so produced may be so severe that it cannot be completely cured by nutritional rehabilitation. The lag in mental development is not restricted to the motor components of behaviour. Problem-solving ability, language, personal-social development, general intelligence, intersensory integration, and perceptual visual competence are significantly below the level obtained by siblings or matched controls. When extra mental stimulation is provided during recovery the performance obtained is better, but usually not up to the normal level expected for the particular age.[5]

The lower intellectual performance and inferior learning capacity found in survivors of severe malnutrition in early life must be seen in the context of the growing body of evidence on the vulnerability of the central nervous system to nutritional insults at critical periods of development. It has been shown in experimental animals that changes in the number of brain cells, in cellularity patterns, and in myelin lipids occur only when the animal is

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[1] Ashworth, A. (1969) *Brit. J. Nutr.*, **23**, 835.

[2] McCracken, K. J. (1968) *Proc. Nutr. Soc.*, **27**, 40A.

[3] Thomson, A. M. (1968) *The later results in man of malnutrition in early life.* In : McCance, R. A. & Widdowson, E. M., ed., *Calorie deficiencies and protein deficiencies*, London, J. & A. Churchill, p. 289.

[4] Cravioto, J. & Robles, B. (1962) *The influence of protein-calorie malnutrition on psychological test behaviour.* In : *Mild and moderate forms of protein-calorie malnutrition, First Symposium of the Swedish Nutrition Foundation*, Uppsala, Almquist & Wiksells, p. 115 ; Scrimshaw, N. S. & Gordon, J. E., ed. (1968) *Malnutrition, learning and behaviour*, Cambridge, Mass., The M.I.T. Press ; Cravioto, J., DeLicardie, E. R. & Birch, H. G. (1966) *Pediatrics*, **38**, 319.

[5] Yaktin, U. S. & McLaren, D. S. (1970) *J. ment. Defic. Res.*, **14**, 25.

malnourished during the period of rapid growth, when the rate of cellular multiplication is close to its maximum. Permanent effects have been obtained under these conditions, even with moderate levels of food restriction.[1]

Although many non-nutritional factors that either accompany or precipitate malnutrition can themselves probably influence mental development, it is important to remember that the age of hospitalization for severe malnutrition early in life coincides with critical periods in behavioural development, which depends on an adequate environment and opportunities for acquiring experience. The effects of malnutrition on mental performance may, therefore, also reflect interference with the gaining of experience and the differentiation of behaviour.

At present, there are not enough data to identify the particular contributions of nutritional and non-nutritional factors to defective mental function following malnutrition. Both types of factor probably have effects that are independent but that interreact. Longitudinal studies, now in progress, should enable the differential effects of these factors to be assessed. The data so far available indicate that survivors of severe malnutrition in the first year of life frequently show low levels of intelligence and a low level of competence in learning basic skills.

9. PREVENTION

Because of the global scale of PCM as a public health problem and its adverse effects on the survival, health, performance, and progress of population groups, preventive action on a world-wide basis is urgently needed. The prevention of PCM should usually be planned at the national level. Emphasis in this report is therefore on national efforts, but these can be facilitated by international action.

In many parts of the world, the main obstacles to the effective control and prevention of PCM have been the failure to apply preventive measures on a community basis, as a result of deficiencies in programme planning and organization; the poor development and utilization of material resources; the shortage of personnel and the inadequacy of their training; and a growing demand for food, health, and nutritional services due to a rapidly expanding population.

PCM can ultimately be controlled only by general economic and social development and a co-ordinated approach in the fields of agriculture, education, the social services, and public health. Since the control of

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[1] Dobbing, J. (1968) *Vulnerable periods in developing brain.* In: Davidson, A. N. & Dobbing, J., ed., *Applied neurochemistry*, Oxford, Blackwell Scientific Publications; Winick, M., Fish, I. & Rosso, P. (1968) *J. Nutr.*, **95**, 623.

PCM is a long-term process, it should be incorporated within the overall objectives of national development plans and national food and nutrition policies, not only as an ultimate goal but also as an immediate and intermediate goal.

There is a reasonable chance that the average quantity of food needed per person will be available over the next few decades through the achievements of the " green revolution ", which has led to greater yields of some new varieties of cereal provided they are properly cultivated. However, the concentration and quality of protein in existing cereals is not fully adequate for the needs of the young child. Where roots and tubers are staple foods this is an even more serious problem. Quantitatively, legumes could provide the most important vegetable protein supplements to staple diets in most developing countries.

There is a serious danger that government support for, and the greater profitability of, cereal production will lead to a lowering in the production of grain legumes ; this would have serious repercussions on the quantity and quality of protein in diets. It is important, therefore, to increase the production of grain legumes as well as of cereals. It is highly desirable too that the quality and quantity of protein in cereals be improved by genetic means. For example, the incorporation of the Opaque-2 gene into maize greatly improves the quality of its protein, and varieties of rice with higher protein content can be produced.

There is no simple solution to the problem of PCM. Indeed, it is so complex that many approaches have to be explored to meet the various requirements of particular countries, of different areas, both rural and urban, within countries, and of different population groups, particularly those that are vulnerable.

Many types of action are necessary : the increased production of foods that will provide adequate protein, calories, and other essential nutrients, by means of agriculture, animal husbandry, and fisheries ; the reduction of losses during harvesting and storage and the better distribution and utilization of supplies ; the development of nutritious food mixtures for weaning and of industries for the preservation and processing of food ; education and training, including the education of consumers ; a broad programme of environmental sanitation and disease prevention, especially in childhood ; and studies to provide better information on dietary intake and the factors that influence it. All these activities must fit into national plans for economic development, aimed at increasing the purchasing power of the population. Where practicable, assistance to vulnerable groups through institutional feeding or other programmes should be included in such plans.

9.1 Preventive programmes : objectives and strategies

The following guidelines may help in making the best possible use of available preventive measures under prevailing conditions :

(*a*) To be effective, a preventive programme should be based on a knowledge of the epidemiology of PCM in the community. Some aspects of the programme may also need to be related to the level of social and economic development, the local patterns of administration and service, food production and supply, dietary habits, cooking practices, environmental and housing conditions, the purchasing power of the population, etc.

(*b*) The aim of a preventive programme is to eliminate the morbidity and mortality due to PCM. A control programme may be considered to be successful if it reduces PCM to a low level and eliminates mortality from this cause, even if less severe forms continue to occur.

(*c*) In formulating a strategy for a preventive programme, one must clearly define immediate and ultimate goals, specific objectives, target groups, priority measures, and criteria for the periodic evaluation of programme effectiveness and efficiency.

For the purpose of achieving the above objectives, priority should be given to the following target groups:

(*a*) Population groups who are undergoing periods of physiological stress, namely, pregnant and lactating women, and infants and children in the growth period;

(*b*) Mothers and children who are considered to be at high risk through living in low-income, high birth rate areas;

(*c*) Families in transition from a rural to an urban environment and low-income families in peri-urban and rural areas, where most high-risk infants and children live. The Committee emphasized the need for preventive measures to start in the home, where the mother must know how to prepare locally available foods in such a way as to satisfy the nutritional needs of her children. Means of educating mothers in this respect must be developed through every possible approach.[1]

In planning preventive measures, the most important causes of PCM should be given priority. This report emphasizes the health aspects of prevention, since previous reports [2] have already stressed the importance of economic and educational measures and food production (including the production of processed foods).

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[1] Autret, M. (1964) *Nutrition of the pre-school child: a consideration of new approaches*, Rome, Food and Agriculture Organization of the United Nations, (unpublished document); FAO/WHO/UNICEF Protein Advisory Group (1971) *Report of an ad hoc group on feeding the pre-school child* (unpublished document, available from the FAO/WHO/UNICEF Protein Advisory Group, United Nations, New York).

[2] *Wld Hlth Org. techn. Rep. Ser.*, 1967, No. 377 (*FAO Nutrition Meetings Report Series*, No. 42); *International action to avert the impending protein crisis. Report to the economic and social council of the advisory committee on the application of science and technology to development*, New York, United Nations, 1968; Johnston, B. F. & Greaves, J. P. (1969) *Manual on food and nutrition policy*, Rome, Food and Agriculture Organization of the United Nations (*FAO Nutritional Studies*, 1969, No. 22).

9.2 Specific public health measures

Specific preventive measures have the following main objectives :

(*a*) the improvement of nutrition and the maintenance of good nutritional status ;

(*b*) the control of infectious and diarrhoeal diseases ;

(*c*) minimizing the effects of infectious diseases ;

(*d*) the early detection and management of mild cases of malnutrition ;

(*e*) the improved treatment, and the early and complete rehabilitation, of moderate and severe cases of malnutrition.

Preventive measures should aim at interrupting the natural course of PCM at the three basic levels of prevention : health promotion and specific protection (primary prevention) ; early detection and treatment (secondary prevention) ; and the prevention of disability and the restoration of functions (tertiary prevention). In this context the basic health services should be given special consideration, while integrated preventive measures, to attack simultaneously as many vulnerable points as possible in the chain of causation, should be initiated early in life.

Since the problem is nearly always too large to be dealt with by local resources, the programme needs to be implemented in stages. The *first stage* is directed mainly towards the treatment and nutritional rehabilitation of young children, while efforts towards specific protection and health promotion are progressively increased. The *second stage* should aim at achieving a better balance between treatment and rehabilitation, on the one hand, and specific protection and health promotion, on the other. The purpose of the *third stage* is specific protection and the general improvement of the nutritional status and food habits of the community, rather than the treatment of PCM and rehabilitation.

The various activities that could form part of a comprehensive preventive programme at the community level, with the above objectives, have recently been described by Bengoa,[1] based on experience from various countries. These activities are briefly described below as they provide a useful guide in relating preventive measures to objectives, local conditions, and available resources (see also Table 6).

(*a*) *Improvement of nutrition or maintenance of good nutritional status*

(1) Measures directed towards pregnant and lactating women : education, with more emphasis on maternal nutrition in antenatal, natal, and postnatal care ; the management of lactation ; the distribution of local foods as supplements to family diets ; and family planning.

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[1] Bengoa, J. M. (1970) *WHO Chronicle*, **24**, 560.

TABLE 6. OBJECTIVES AND ACTIVITIES IN THE CONTROL OF PCM IN YOUNG CHILDREN

Levels of intervention	Objectives	Activities
I. GENERAL	To establish a food and nutrition policy, to develop agriculture, to expand education, to improve environmental sanitation, and to raise standards of living	Establishment of an interministerial food and nutrition board Food production programmes, including development of agricultural industries Fundamental education Socio-economic measures directed towards the less privileged groups, and the development of opportunities for employment Policies on food prices and minimum wages
II. SPECIFIC Health promotion	(*a*) Improvement of nutrition or maintenance of nutritional status	1. Measures directed towards pregnant and lactating women (education, distribution of supplements, etc.) 2. Promotion of breast-feeding 3. Development of low-cost weaning foods 4. Measures to improve family diets, including food distribution programmes 5. Education on nutrition, in co-operation with health and agricultural extension services, schools, and social and home economics services
Health protection	(*b*) Control of infectious and diarrhoeal diseases	6. Expansion of immunization programmes 7. Promotion of hygienic food preparation and personal hygiene 8. Promotion and provision of more suitable domestic utensils for the preparation of infant foods and for feeding infants
Treatment and rehabilitation	(*c*) Minimizing the effects of infectious diseases	9. Development of programmes for the early rehydration of young children with diarrhoea 10. Development of supplementary feeding programmes during epidemics 11. De-worming of heavily infested children
	(*d*) Early detection and management of mild cases of malnutrition	12. Periodic surveillance of the population at risk
	(*e*) Improved treatment, and early and complete rehabilitation, of moderate and severe cases of malnutrition	13. Ambulatory treatment; nutritional rehabilitation services 14. Hospital treatment 15. Follow-up care, through supplementary feeding and nutrition education

(2) The promotion of breast-feeding, initiated shortly after birth and continued as the sole source of food and water for at least the first 4 months of life. It should be continued as a supplement to other baby foods during the weaning period, up to the age of 9, 12, 18, or 24 months or more, depending on the local customs and on the availability of good quality protein; efforts to slow the trend towards the early cessation of breast-feeding, particularly among lower socio-economic groups, should be intensified.[1]

Every effort should therefore be made to discourage early weaning, particularly among low socio-economic groups. In countries that are developing industrially, and particularly in urban populations, the trend towards early weaning is already so evident that immediate measures are necessary to combat it and counter its ill effects.

(3) The development of low-cost weaning foods. This subject was discussed at the seventh meeting of the Joint FAO/WHO Expert Committee on Nutrition.[2] In practice, some of these mixtures have also been used as supplements to breast milk for children under 6 months of age.

The Committee considered that, where the need is established, pre-cooked and easily assimilated food mixtures might be used as supplements for infants under 6 months of age, provided that they are properly tested.

The Committee recommended that FAO and WHO continue investigations to develop suitable processed protein food mixtures that can be used as a supplement to or a substitute for breast milk when lactation fails, and in countries where cow's milk is not available. The development of such mixtures should not, however, be allowed to interfere with efforts to encourage and promote prolonged breast-feeding. Substitutes for breast milk should not be unduly promoted by advertising.

(4) The improvement of weaning foods, and measures to improve family diets in general, including food distribution programmes.

(5) Education on nutrition, including the production, preservation, storage, buying, and preparation of food; such education should be directed to mothers and/or their substitutes (grandmothers, elder sisters, domestic helpers, baby-sitters, etc.).

(*b*) *Control of infectious and diarrhoeal diseases*

(6) The expansion of immunization programmes, and the intensification of combined nutrition and mass immunization campaigns for infants under one year of age, are high priority measures. In some developing countries,

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[1] World Health Organization Regional Office for the Eastern Mediterranean (1969) *Report on the seminar on the nutritional problems in the weaning period, Addis Ababa, Ethiopia*, 3-15 March 1969 (unpublished document No. EM/NUTR/43).

[2] *Wld Hlth Org. techn. Rep. Ser.*, 1967, No. 377, p. 59 (*FAO Nutrition Meetings Report Series*, No. 42, p. 59).

compulsory immunization may be considered a prerequisite for the control of PCM in young children.

(7) The promotion of hygienic food preparation and good personal and domestic hygiene, and general sanitary measures.

(8) The promotion and provision of more suitable domestic utensils for the preparation of infant foods and for feeding infants.[1]

(*c*) *Minimizing the effects of infectious diseases*

(9) The development of programmes for the early rehydration of young children with diarrhoea ; the development of oral rehydration schemes and of ambulatory rehydration units may be very useful in some areas.

(10) The development of supplementary feeding programmes during epidemics, especially of measles, enteric fever, bacillary dysentery, and pertussis.

(11) The de-worming of heavily infested children and the effective treatment of lambliasis, amoebiasis, and other infestations. Selective chemoprophylaxis in countries with a high prevalence of tuberculosis or malaria or both.

(*d*) *Early detection and management of mild cases of malnutrition*

(12) Periodic surveillance of the population at risk, for the early detection and management of mild cases, especially in the weaning and post-weaning periods. Simple screening indicators (including growth curves), trained personnel, and mobile units to reach high-risk children in peri-urban, rural, and low-income areas are urgently needed.

(*e*) *Improved treatment, and early and complete rehabilitation, of moderate and severe cases of malnutrition*

(13) The improved ambulatory treatment and nutritional rehabilitation of moderate cases of PCM, to reduce the need for hospitalization and the occurrence of severe PCM.

(14) The improved hospital treatment of severe PCM should be given high priority in some areas. In many developing countries hospitals are constantly overcrowded with young children suffering from PCM, although only a proportion of such children are able to gain admission to hospital. In some instances mortality rates are 50% or more, and cases of PCM may be detained in hospital for 8–10 months. This situation imposes a tremendous financial burden on countries with limited resources.

(15) Follow-up care through supplementary feeding and intensive nutritional education, to prevent relapses or the occurrence of PCM in

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[1] Welbourne, H. F. & DeBeer, G. (1964) *J. trop. Med. Hyg.*, **67**, 155.

siblings, should receive high priority after ambulatory or hospital treatment.

9.3 Agricultural and socio-economic measures

The following general principles apply to the planning of agricultural and socio-economic measures for the prevention of PCM :

(1) Food production at the national level must take into account the special needs of vulnerable groups for food containing high-quality protein, e.g., milk, eggs, legumes, and oilseeds. National plans must therefore be devised that improve the nutrient value of diets according to ecological and regional conditions.

(2) Food distribution is uneven ; it varies between socio-economic groups and between children according to the family income and the parents' education. The distribution of free or subsidized food supplements is necessary in order to alleviate PCM. Such supplements must supply the amount of calories and nutrients that are lacking in the traditional home diet.

(3) In a subsistence economy, the family must be shown ways of improving the production, storage, and preparation of foods at home.

(4) In planning food production and applied nutrition programmes, priority must be given to those local foods or food varieties that are needed for the preparation of food mixtures suitable for the pre-school child.

(5) Special financial support or tax incentives may be required to encourage the production of processed weaning foods.

(6) The purchase of foods by governmental or non-governmental organizations may be needed when a new food industry begins, to help in reducing the cost of production and distribution, thereby keeping prices at a reasonable level.

(7) Purchasing power depends on employment and is influenced by economic development. However, some agricultural development programmes, e.g., of re-afforestation, irrigation, and drainage, assisted by the World Food Program, give priority to the employment of parents who are poor or have large families.

(8) Parents should be provided with education through all possible channels and services.

9.4 Priority services

The following community services should be developed preferentially as means of providing preventive care :

(1) Services whose organizational patterns make it possible for mothers, young children, and families to be reached for education on nutrition and child spacing, and for preventive care.

(2) Integrated preventive, curative, and rehabilitation services providing adequate follow-up care.

(3) Services that are provided to those most in need, through the selection of high-risk groups.

The following services meet most of the above requirements but urgently need strengthening and expanding:

(1) Maternal and child health services based on health centres and simple facilities.

(2) Nutritional rehabilitation services or mothercraft centres.

(3) Mobile units to reach low-income, high-risk groups in rural and peri-urban areas for immunization, periodic surveillance, nutritional education, follow-up, and referral.

(4) Outpatient services equipped with rehydration facilities and providing education on public health and nutrition.

(5) Applied nutrition; agricultural and home economics extension programmes; and social work.

9.5 Personnel

Shortage of manpower (health personnel, nutritionists, dieticians, home economists, etc.) at all levels, and inadequate training in nutrition, are obstacles to the planning, organization, and implementation of programmes for the prevention of PCM. These obstacles can be partly overcome by improved pre-service and in-service training and by the increasing use of auxiliary personnel.

9.6 Programme evaluation

The aim of programmes for the prevention of PCM is to secure the greatest efficiency per unit cost, i.e., the maximal result from the minimal cost. However, there are certain technical difficulties in the evaluation of cost effectiveness in this field. For example, one major variable that is impossible to quantify is the ability and motivation of those providing services. In comparing inpatient and outpatient treatment, it must be remembered that some ambulatory services, such as nutritional rehabilitation, have an educative value, so that the costs of prevention and cure cannot be separately assessed. Furthermore, some hospitals and many pilot projects attached to universities have elements of teaching and research,

the cost of which is difficult to isolate. Many preventive services, e.g., clinics for young children, are concerned with other diseases in addition to malnutrition, and the cost of the purely nutritional component cannot always be isolated. Variations between countries in the costs of transport and personnel restrict the comparability of results.

Indicators that can be used in the evaluation of public health programmes for the prevention of PCM are: (*a*) improved diets and their effect on the duration of hospitalization; (*b*) the use of inexpensive auxiliaries or volunteers in feeding hospitalized children; (*c*) the frequency of re-admission of children to hospital as a result of relapses; (*d*) the relative effectiveness of intensive education given to mothers admitted to hospital with their sick children, as compared to such education given after discharge by home visitors or through nutritional rehabilitation services; (*e*) changes in mortality rates and in the prevalence of PCM in the community; and (*f*) anthropometric studies on school-children before and after the institution of public health and feeding programmes.

A recent review was made by Cook [1] of the available literature on the cost-benefit analysis of treatment in hospital and outside (i.e., in nutritional rehabilitation centres or in clinics for young children) from several parts of Africa, Asia, and Latin America.

Cost must obviously be an important consideration in extending preventive programmes on a nation-wide scale. Further research on programme evaluation is therefore urgently needed, to compare not only hospital and other services providing treatment but, even more important, alternatives in the field of prevention.

Annex 1

PROPOSED CLASSIFICATION OF PROTEIN-CALORIE MALNUTRITION [2]

260 Kwashiorkor

Multiple deficiency syndrome
Nutritional oedema
Severe protein deficiency
Severe protein malnutrition

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[1] Cook, R. (1971) *J. trop. Pediat.*, **17**, 15.

[2] Adapted from the classification proposed by the Pan American Health Organization in 1970 (unpublished report) for the next revision of the WHO *Manual of the international statistical classification of diseases, injuries, and causes of death*, expected in 1975.

261 Nutritional marasmus
Athrepsia
Nutritional cachexia
Nutritional atrophy
Severe under-nutrition
Severe calorie malnutrition

262 Severe protein-calorie malnutrition, unqualified
Marasmus-kwashiorkor
Hunger oedema
Inanition
Severe malnutrition
Malnutrition of third degree

263 Moderate and unspecified protein-calorie malnutrition

263.0
Malnutrition of moderate degree
Malnutrition of second degree
Under-nutrition
Moderate dystrophy

263.8
Other protein-calorie malnutrition

263.9
Malnutrition, unspecified
Calorie malnutrition
Dystrophy

264 Lasting effects of protein-calorie malnutrition
Nutritional dwarfism

Annex 2

TREATMENT OF PROTEIN-CALORIE MALNUTRITION

Dietary treatment

A liquid diet, based on milk and supplemented with sugar and oil, is usually given at the beginning of treatment. It is often necessary to divide the diet into a number of small meals given by spoon ; this is time-consuming and may require the almost constant presence of nursing staff, whose devotion to the task has a direct bearing on the results that can be expected. If anorexia is severe, tube feeding is required ; after a few days, the child has generally regained sufficient appetite and strength to take nourishment

by himself, and tube feeding can be discontinued. In severe cases it is often advantageous to increase the quantities of protein and calories progressively, the rate of increase depending upon the clinical picture. The regimen should be supplemented with the ingredients of the traditional local diet as soon as the child has sufficiently recovered.

Vitamins should be given whenever there are signs of deficiency; in particular, signs of vitamin A deficiency should be watched for in regions where it is prevalent. An oral supplement of iron is also required after the first few days of treatment, to correct any iron deficiency that may exist or that may develop in the presence of intense erythropoiesis. Folic acid is indicated in the presence of macrocytosis. In most cases a supplement of potassium is necessary during the first days of treatment, owing to the rapid protein synthesis that is taking place. The administration of other minerals may also be necessary in severe cases of kwashiorkor, in regions where associated mineral deficiencies have been reported.

Treatment of complications

Hypothermia and shock

In severe cases of PCM, hypothermia and shock are frequently observed on admission. The child must be kept warm, and treated as promptly as possible for shock by the continuous intravenous infusion of an electrolyte-dextrose solution; in the most severe cases, plasma may also be required.

The administration of whole blood is indicated only when the child has severe anaemia; such cases are rare.

Intravenous dextrose-saline solution is also indicated if the child loses his oedema rapidly under treatment. As a working rule, administration should begin as soon as the child has lost more than 10% of his body weight in 24 hours.

Hypoglycaemia

This may develop without the typical signs of restlessness, shivering, and sweating. Glucose by the intragastric route or, better, by continuous intravenous infusion is indicated, but in some cases these measures are of no avail.

Pulmonary and gastrointestinal infections

Pulmonary infections can develop rapidly and can quickly prove fatal; therefore several authors administer antibiotics routinely during the first few days of hospitalization. Although good results have been reported, the advantages are difficult to assess accurately. As children with PCM are highly susceptible to infection, routine treatment with antibiotics

is probably advantageous when close surveillance is not feasible or when diagnostic facilities are inadequate.

The presence of a hidden infection, such as tuberculosis, should be suspected whenever a child fails to respond to treatment.

Diarrhoea is usually non-specific but occasionally is due to a specific infective enteritis or to intestinal sugar intolerance, particularly to lactose. It usually responds to dietary therapy alone.

In the great majority of cases diarrhoea is not a justification for postponing dietary treatment. Only if it is profuse, or if there is intense vomiting, may it be necessary to postpone dietary treatment by one or two days; the child should be given some liquid during this period, e.g., Darrow's solution in 2.5% glucose, by the intravenous or intragastric route.

Malaria, like bacterial infections, calls for immediate drug therapy. On the other hand, with intestinal parasitic infections it is preferable to wait until the child has recovered sufficiently before administering anthelmintics. Finally, the need must be emphasized for strict hygiene during hospitalization.

Results of treatment

With the above treatment and the levels of calorie and protein intakes indicated on p. 57 the child, after losing his oedema (in 7–10 days) may gain 10–15 g/kg/day; this rate of growth is 5 times that of a normal child of the same height, and 10 times that of a normal child of the same age. Nitrogen balance studies and measurements of total body potassium indicate that the tissue gained is of normal composition. It is of great importance to secure these rapid weight gains; a child can only be considered as nutritionally cured when he is symptom-free and has achieved the expected weight for his height, although he may still be below the normal height for his age.

PART III.

FUTURE RESEARCH AND ACTION

The Committee discussed other aspects of nutrition that, in its opinion, deserve immediate attention by FAO and WHO and that are relevant not only to food fortification and PCM but also to several other nutritional activities and programmes being developed by the two organizations.

1. THE INTERPRETATION OF NUTRITIONAL STANDARDS

Difficulties arise in interpreting dietary intakes and biochemical measurements in relation to nutritional status. Changes in dietary intake, biochemical measurements, and nutritional status according to the clinical picture do not necessarily occur simultaneously. More sensitive tests of deficiency would allow a better estimation of human requirements, while a more precise definition of human requirements might lead to a better interpretation of nutrient intakes.

The Committee considered that the problem of the interpretation of nutrient intakes and biochemical measurements should be kept constantly under review. Certain aspects of the problem are considered below.

1.1 Nutritional requirements: interpretation of nutrient intakes and planning of food supplies

The Joint FAO/WHO Expert Groups on the requirements for calcium,[1] protein,[2] vitamin A, thiamine, riboflavine, and niacin,[3] and ascorbic acid, vitamin D, vitamin B_{12}, folate, and iron [4] have adopted the concept of " recommended intake ", which is defined as " the amount considered sufficient for the maintenance of health in nearly all people ".[5] Whenever

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[1] *Wld Hlth Org. techn. Rep. Ser.*, 1962, No. 230 (*FAO Nutrition Meetings Report Series*, No. 30).

[2] *Wld Hlth Org. techn. Rep. Ser.*, 1965, No. 301 (*FAO Nutrition Meetings Report Series*, No. 37).

[3] *Wld Hlth Org. techn. Rep. Ser.*, 1967, No. 362, p. 73 (*FAO Nutrition Meetings Report Series*, No. 41, p. 73).

[4] *Wld Hlth Org. techn. Rep. Ser.*, 1970, No. 452 (*FAO Nutrition Meetings Report Series*, No. 47).

[5] The " recommended intakes " are not intended to be adequate under extreme environmental conditions, nor to cover any additional requirements that may result from abnormal conditions, such as infections, malabsorption syndromes, metabolic abnormalities, or the effects of food additives or other chemicals.

data permitted, the Groups predicted the average requirement of a population group and then estimated the variability of this requirement within subgroups of similar age, sex, and physiological state. They then recommended an intake that they felt would meet the requirements of all but a small proportion of individuals.

Thus an individual regularly ingesting the recommended intake of a nutrient must be considered at low risk of receiving less than his true requirement. As his intake falls, the risk of inadequate intake (i.e., of dietary deficiency) increases. Thus, it may be stated that :

(1) dietary intakes can be interpreted only in terms of the risk of deficiency to the individual that might be associated with a particular level of habitual intake ;

(2) the long-term objective of a nutrition programme is the maintenance of all individuals at as low a risk of deficiency as is consistent with national resources.

At the individual level dietary intakes can be assessed in relation to the " recommended intakes " as outlined above. However, other considerations must be taken into account in judging the adequacy of the average intake of a population. In a population, both the requirement for and the usual intake of a nutrient vary among individuals. In the case of calories, there is evidence that, if there are no limitations with regard to food supply or socio-economic or other factors, the intake is proportional to the requirements. Thus the average calorie intake of a population can be compared directly with the predicted average requirement. On the other hand, in the case of almost all nutrients there is no reason to believe that the intake parallels the requirements. In general, the distribution of intakes and of requirements for specific nutrients within a population are quite unrelated. Therefore, in assessing the risk of deficiency in a population (i.e., the proportion of persons who are predicted to ingest less than their true requirements) it is necessary to consider :

(1) the variation of nutrient requirements among individuals ; and

(2) the variation of habitual nutrient intake among individuals.

The Committee noted that FAO had attempted to investigate the variation of habitual intake of nutrients and hoped that these efforts would continue. However, it drew attention to the need for the further investigation of methods of dietary study that will provide reliable estimates of the usual intakes of individuals ; the variation of daily intakes depends upon the nutrient and probably also upon age or socio-economic group. It recommended that both FAO and WHO increase their efforts to obtain information about individual variation as regards nutrient requirements and habitual nutrient intakes, so that both factors can be considered simultaneously in interpreting the adequacy of reported nutrient supplies.

A joint FAO/WHO Expert Group recommended that " in order to ensure that nearly all individuals in the population are adequately nourished, it would be advisable for the average intakes of population groups to be in general higher than the weighted average recommended intake ".[1] The question of how much higher requires consideration of both the above independent variables (calorie intakes excepted) as well as of predicted wastage.

The predictions of the desirable calorie content of gross food supplies and of their quality in terms of nutrients must be based on different theoretical considerations.

1.2 The problem of " normal " in tests of nutritional status

In most biochemical and haematological measurements it is usual, for practical reasons, to specify ranges and " cut-off " points that distinguish " normal " individuals or groups from those who are " at risk " or " deficient ". This is an arbitrary procedure, since most parameters vary continuously.

It is usually assumed that the same criteria can be applied to all populations under all conditions ; an exception is the variation of " normal " haemoglobin levels with altitude.

The major difficulty arises from the concept that certain levels of measurement indicate a risk, and from the diagnoses made as a result, for example, a diagnosis of " subclinical rickets " based on a value of serum alkaline phosphatase above a certain level. In fact, it has been shown that a large proportion of children who do not have rickets but who are receiving regular supplements of vitamin D have serum alkaline phosphatase levels above the so-called limit of normal.[2] Conversely, children with PCM may have rickets without a raised level of serum alkaline phosphatase.

There are three possible conditions in which biochemical measurements indicate a deficiency or risk without any evidence of clinical disease or functional impairment. These are : a state of adaptation, without any impairment of health or function ; a state of compensation, with diminished reserve ; and a state of slow deterioration, leading to future breakdown. The classical way of distinguishing between these possibilities is by observing the natural evolution of the condition. In this way it has been established that certain levels of blood sugar may be regarded as pre-diabetic, and that certain levels of blood pressure are likely to end in hypertensive disease. In assessing the significance of biochemical and haematological indices of

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[1] *Wld Hlth Org. techn. Rep. Ser.*, 1970, No. 452, p. 68 (*FAO Nutrition Meetings Report Series*, No. 47, p. 68).

[2] Stephen, J. M. L. & Stephenson, P. (1971) *Arch. Dis. Childh.*, **46**, 185.

nutritional status, therefore, longitudinal studies are of the greatest importance.

A second approach is by statistical evaluation, but this cannot by itself distinguish between what is normal and abnormal in the biological sense. Nevertheless, as a first step it is desirable that data be expressed in such a way that the distribution patterns for different populations and groups can be compared.

The Committee recommended that FAO and WHO give high priority to supporting research on this general problem.

2. NUTRITIONAL VALUE AND PHYSIOLOGICAL EFFECTS OF FATS

During the last decade there have been great advances in knowledge of the nutritional value and physiological effects of different fats. Some of these advances may soon lead to a revision of current views about the quality of fats and to a more precise approach to the problem of lipid requirements, thereby influencing recommendations on the kinds of fat suitable for use in human diets and on the conditions governing their use.

Current research on dietary fats includes research on the nutritional value and physiological effects of (*a*) erucic acid and other long-chain fatty acids, (*b*) fats containing a high proportion of linolenic acid, and (*c*) heated and oxidized fats.

For example, investigations have shown that rape oil, which is rich in erucic acid, is poorly utilized in various species of animals and may in some cases cause an accumulation of lipids in cardiac tissues, followed by myocardial lesions. It is not known whether similar effects are produced in man. However, on the basis of findings in animals, some countries are aiming to produce new varieties of rape seed, the oil from which is expected not to have these harmful effects.

The Committee recommended that the existing knowledge on this subject be reviewed, that the possible practical implications for agriculture and for health be considered, and that it be determined what aspects require more thorough research, including epidemiological studies, in animals and man.

3. IMPACT OF FAMILY PLANNING PROGRAMMES ON FETAL AND MATERNAL NUTRITION

Recognizing (*a*) the advantages of incorporating nutrition and family planning into the basic health services, and (*b*) the increased opportunity for education in nutrition and family life, and for investigations into fetal

and maternal nutrition, offered by such incorporation,[1, 2] the Committee recommended:

(1) that guidelines be prepared to orient health personnel, nutritionists, and home economists to the above-mentioned advantages;

(2) that existing and anticipated family planning services be utilized for collecting data on lactation, maternal metabolism, reproductive efficiency, and the possible side effects of contraception;

(3) that consideration be given to maternal and infant nutrition in programmes already initiated by FAO to study the impact of child spacing on the nutrition of families and on their general economic and social development.

4. TRAINING AND EDUCATION IN NUTRITION

4.1 Training of professional and para-professional personnel in food and nutrition

The science of nutrition is concerned primarily with the part played by nutrients in body growth, development, and maintenance. Foods are the prime source of these nutrients. In many colleges and universities, nutrition is taught by biochemists, as a part of biochemistry. Because physiology, endocrinology, and other biomedical sciences, as well as a special knowledge of foods, are also basic to nutritional education, a teacher of broad training and experience, such as a nutritional biochemist, is needed for this task.

In universities where nutrition is taught well, the subject is presented in courses on basic, clinical, applied, and comparative nutrition. Various aspects of human nutrition should be included in the training of nutritional biochemists, nutritional physiologists, clinical nutritionists, public health nutritionists, and dietitians, because nutrition is their primary professional concern. The broader aspects of human nutrition and food science should receive greater emphasis in the curricula of physicians, dentists, food scientists, agriculturists, home economists, and nurses, because this subject is basic to their professional practice.

Throughout the world the nutritional education of professional and para-professional personnel is seldom good, often fair, and frequently poor. This is because (*a*) those who teach this subject are inadequately prepared or too narrow in their approach, or their knowledge is obsolete, and (*b*)

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[1] *Wld Hlth Org. techn. Rep. Ser.*, 1969, No. 428.

[2] *Maternal nutrition and family planning in the Americas. Report of a PAHO Technical Group meeting, Washington, D.C., 20–24 October 1969*, Washington, Pan American Health Organization, 1970 (Scientific Publication No. 204).

students have insufficient time allocated to nutrition to obtain the knowledge and understanding required.

The amount and quality of education in food and nutrition given to professional personnel is fundamental to the solution of the food and nutritional problems of the world's population. This problem is not new; FAO and WHO, as well as other organizations, have been concerned with it for many years, and yet little progress has been made towards its solution. Today, nutrition is inadequately taught in medical, dental, and veterinary schools throughout the world and to students of food science and technology, agriculture (especially agronomy and plant breeding), dietetics, and home economics.

The Committee recommended that FAO and WHO study again the problem of nutritional education, identify those attempts to solve it that are succeeding, and decide what new approaches should be made. The problem is serious throughout the world; inadequate training is probably an important reason why nutritional efforts have failed in the past.

4.2 Evaluation of nutritional education of the community

Education in nutrition is a major strategic method for the prevention of malnutrition and must receive emphasis in community nutrition programmes. Yet there is surprisingly little evidence that existing techniques of nutritional education are effective or represent a good utilization of limited resources, and it appears that some conventional programmes of nutritional education have not succeeded in influencing food habits in the desired manner.

The Fourth Joint FAO/WHO Expert Committee on Nutrition [1] recommended that governments be helped in developing methods and materials suitable for the teaching of nutrition in schools and community and health centres, in training personnel, and in convening conferences on the subject. Nutritional education was discussed also by the fifth [2] and sixth [3] Committees.

The present Committee recommended the investigation of whether nutritional education in its present form is as effective as is generally assumed, and of whether additional techniques could be employed to improve its effectiveness and the evaluation of its results.

The effectiveness of educational approaches using the mass media and peer groups of volunteers should be compared with that of such traditional

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[1] *Wld Hlth Org. techn. Rep. Ser.*, 1955, No. 97 (*FAO Nutritional Meetings Report Series*, No. 9).

[2] *Wld Hlth Org. techn. Rep. Ser.*, 1958, No. 149 (*FAO Nutritional Meetings Report Series*, No. 19).

[3] *Wld Hlth Org. techn. Rep. Ser.*, 1962, No. 245 (*FAO Nutritional Meetings Report Series*, No. 32).

approaches as group conferences, demonstrations, and individual counselling. The results of using various types of graphic presentation of nutritional information also need critical evaluation.

In evaluating the nutritional education of the community and in developing guidelines for the future, the adequacy of the teaching methods used, of the content of the programme, and of the methods used for evaluation must be considered. In judging the response to a nutritional education programme, due consideration must be given to the economic and other constraints upon the response of individuals to advice on food habits.

There is also a need to review the nature and effectiveness of educational material on nutrition presented to children in primary and secondary schools.

Future expert groups on various nutritional problems should be provided with a realistic appraisal of the effectiveness of nutritional education as a preventive measure, of the time scale involved, and of the resources required.

The need to evaluate the results and methodology of nutritional education programmes does not detract from the value of such programmes as a major approach to community nutritional problems ; on the contrary, they deserve more vigorous support.