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Evaluation of diets in relation to nutritional status

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In most parts of the world nutritional surveys amount to no more than a limited assessment of the food consumed, together with a clinical survey for overt signs of malnutrition. This state of affairs is not so serious as at first appears because impaired nutritional status in the developing countries is often gross and seldom requires subtle techniques for its detection. However, it is important to realize that much of the published information is approximate and is likely to remain so until more funds and more personnel are available for the work. WHO (1963) lists ten sources of information useful for the assessment of nutritional status (Table 1). This outline presents a formidable task seldom achieved even in developed countries.

The first half of Table 1 is directly concerned with the evaluation of diets. A gross estimate of the availability of food in most countries can be obtained from the annual publications of FAO, e.g. *The State of Food and Agriculture* (FAO, 1966), which present the balance of food production, imports and exports in terms of food supplies per head. Such information could be regarded as a 'meaningless mean' since it takes no account of the distribution of food by social and economic class, cultural and anthropological group, or by season of the year. But it does provide a valid comparison from year to year and indicates what might be achieved if it were possible to provide an optimum distribution of food along physiological lines. To measure the extent to which this is achieved it is necessary to complete time-consuming dietary surveys together with extensive laboratory tests.

The second half of Table 1 is concerned with the measurement of the effects of diets on the performance of individuals. Information on births and deaths is of use in evaluating nutritional status and can be collected by relatively unskilled labour, but the assessment of the prevalent disease patterns, particularly those such as infections and infestations that often lead to or are aggravated by malnutrition, requires skilled diagnosis. A similar skill is also required for the recognition of the physical signs of malnutrition, about which even the experts do not always agree.

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Table 1. *Assessment of nutritional status**

Sources of information	Nature of information obtained	Nutritional implications
(1) Agricultural data Food balance sheets	Gross estimates of agricultural production Agricultural methods Soil fertility Predominance of cash crops Overproduction of staples Food imports and exports	Approximate availability of food supplies to a population
(2) Socio-economic data information on marketing, distribution and storage	Purchasing power Distribution and storage of foodstuffs	Unequal distribution of available foods between the socio-economic groups in the community and within the family
(3) Food consumption patterns Cultural-anthropological data	Lack of knowledge, erroneous beliefs and prejudices, indifference	
(4) Dietary surveys	Food consumption Distribution within the family	Low, excessive or unbalanced nutrient intake
(5) Special studies on foods	Biological value of diets Presence of interfering factors (e.g. goitrogens) Effects of food processing	Special problems related to nutrient utilization
(6) Vital and health statistics	Morbidity and mortality data	Extent of risk to community Identification of high-risk groups
(7) Anthropometric studies	Physical development	Effect of nutrition on physical development
(8) Clinical nutritional surveys	Physical signs	Deviation from health due to malnutrition
(9) Biochemical studies	Levels of nutrients, metabolites and other components of body tissues and fluids	Nutrient supplies in the body Impairment of biochemical function
(10) Additional medical information	Prevalent disease patterns, including infections and infestations	Interrelationships of state of nutrition and disease

*Adapted by Jelliffe (1966) from WHO Expert Committee on Medical Assessment of Nutritional Status.

Probably the most objective measurements are anthropometric and biochemical but, as with the dietary surveys, these are both expensive and time-consuming. Also, one should not have a false sense of accuracy about even these measurements since their validity depends upon the standards against which they are judged. Physiological norms cover a range of values far greater than the precision of the techniques to measure individuals.

Food intakes

The assessment of any diet involves measurement of the consumption of food, the conversion of these values into nutrient intakes, and the comparison of these

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against standards for requirements. Stated simply in these terms, the procedure looks extremely easy, but in fact there are difficulties at every stage. In particular, it is difficult to measure the food intake of individuals since Heisenberg's 'principle of uncertainty', that you cannot measure anything without altering it, applies as much to dietary surveys as to atomic physics and, inevitably, patterns of food consumption change because measurements are being made. This is particularly true in measuring the food consumption of people in the developing countries, and probably the most reliable method, if the most laborious, is to reside with a group of people for long periods of time such that you are regarded as one of them (Culwick, 1951). This procedure also has the added advantage that variations in the consumption of food from day to day, from festival to festival and from season to season, are taken into account. In practice, however, extensive measurements of this type are extremely rare, particularly in the developing countries where the number of trained nutritionists is limited. Most investigators are faced with a choice between studying a small group of families in depth or larger numbers more superficially. The decision will largely depend upon the objectives of the survey, but in view of the possibility of obtaining gross dietary information from other sources the method of choice is one that gives individual food intakes.

The various techniques of dietary survey are shown in Table 2. Method 1 (a) provides the most accurate record that can be obtained, and is the most desirable if one is interested in the distribution of nutrients within a family, or indeed in the

Table 2. *Dietary survey techniques*

(1) Measurements as eaten:
By (a) Direct weighing
(b) Standard household measures
(c) Description of portion

(2) Estimations by recall, either from the immediate past (e.g. 24 h recall), or as the usual intake (i.e. 'customary diet'):
From (a) Description of portions of food
(b) Frequency of eating the foods
(c) Standard measures of key foods, e.g. bottles of milk, loaves of bread

(3) Estimations from consumption of groups, e.g. households, villages, regions:
From (a) Larder inventories and household purchases
(b) Family budgets and other socio-economic data
(c) Food production and marketing information
(d) National production, import and export of food

dietary intake of individuals. The recommendations for the International Biological Programme give a minimum of 3 d weighed intake of individuals at least twice a year from statistically selected households, but preceded by social (i.e. patterns of food intake) and economic (i.e. food availability) surveys to ensure the validity of the times chosen for measurement. However, the method is expensive in time and skilled personnel, and the investigator may be obliged to compromise some degree of accuracy, in which case diet histories may be obtained either by questionnaire or interview using one of the methods in (2). These techniques must be carefully validated on small samples before widespread use. Alternatively, an estimate may be obtained by a study of food moving into consumption using one of the methods in (3) but, as pointed out above, care must be used in interpreting such surveys since they give no indication of the distribution of food within the group.

Direct weighing is the most accurate, but causes the most disturbance. The use of standard household measures, e.g. cups, spoons, cigarette tins, is reasonably accurate, but estimates based on the description of portions is notoriously inaccurate even when made by skilled personnel. Some studies indicate that the amounts of foods consumed correlate well with the frequency with which they are eaten, but the method needs verification, particularly for any given social setting. Similarly, it has been shown that the intake of some nutrients may be estimated from a knowledge of the consumption of a few specific foods, e.g. calcium intake in Britain may be estimated from the consumption of loaves of bread and bottles of milk.

Nutrient intakes

People eat foods, not nutrients, but it is the nutrients that are important in the assessment of diets. There is no doubt that the most accurate way of determining nutrient content is to analyse a duplicate portion of everything eaten, and these standards were employed in the survey of diets in British hospitals (Platt, Eddy & Pellett, 1963). In this way not only can the more stable major nutrients be determined, but also the more labile vitamins are estimated on samples as eaten. In developing countries, variations between different samples of the same food make this principle more important, but the technique is unpractical in most cases. Analysis of similar foods, prepared in a similar way, is possible, but regrettably most workers use food tables which in the past were not always appropriate to tropical countries. One of the many contributions of the late Professor Platt was his analysis of tropical foods (Platt, 1945, 1962), which many groups now have on computer tapes and punched cards.

The need to work with diets as eaten by man rather than synthetic mixtures designed to simulate them is even more critical in microbial and biological assays. Often an imbalance or lack of availability of nutrients contradicts expectations from chemical analyses, which can only be resolved by studying the diet as a whole. For example, the determination of net dietary-protein value (Platt & Miller, 1959) is effectively more than the estimation of the amount of utilizable protein in a diet, since the value obtained is influenced by the way foods were prepared, the quantity and quality of the protein they contain, the dietary level of vitamins and minerals, the amount of food consumed, and whether the rats under assay were normal or infected with malaria (Dema, Miller & Platt, 1959) or hookworm (Orraca-Tetteh & Platt, 1964). The values obtained can, however, be compared direct with the requirements of the man who consumed the diet. An 'appeal to the rat' in this way is often a less laborious and more direct way of assessing diets, and has the added advantage that the presence of toxic factors may also be detected.

Nutrient requirements

The difficulties associated with the two stages of the assessment of diets can be overcome if there is a sufficiently large team of enthusiasts, but the statement of requirements involves difficulties of a different sort. An examination of tables of nutrient requirements as given by different sources shows a range of values larger than can be scientifically justified and which result at best from differences in the way they are intended to be used, and at worst from political interference. Foi example, the adult human requirement for protein ranges from 40 g/d as given by FAO to the 140 g/d as given by the USSR: similarly, the American vitamin C requirement is twice that for other countries. Inevitably, the controversy is often reduced to semantics. Thus 'minimum physiological requirement' (usually reduced to 'nutrient requirement') is not the same as 'recommended daily intake' (usually reduced to 'nutrient allowance'). For example, one might be able to get by with a miserable diet containing only 40 g/d protein, but one would hardly like to recommend that people should do so.

There is also debate about the meaning of minimum physiological requirements. Should these represent an intake necessary to eliminate overt signs of deficiency or one to provide optimal nutrition? Also, should the adopted values be the lowest ever recorded or the average for all measurements? (See Yudkin, 1968.) The present trend is for committees to base their figures statistically to cover 97% (i.e. mean+2 SD) of the population, and such standards can be used to judge the adequacy of individual diets.

Such considerations do not, nor can they, take into account that the requirements for several nutrients are affected by the rest of the diet. Thus the ratio of protein: fat:carbohydrate affects the requirements of riboflavine and thiamine, and the requirements of vitamin D and calcium are dependent on the amount of phytate in the diet. Similarly, the requirement of nicotinic acid is influenced by the level of tryptophan (an essential amino acid), from which it may be derived via a biochemical pathway requiring vitamins B_1, B_2 and B_6 as co-enzymes. Nor do accepted requirements allow for man's ability to adapt to undernutrition in its many forms, and one should not automatically expect classical signs of deficiency disease simply because survey results indicate that the intakes of many individuals are chronically sub-optimum.

Nutritional status

Nutritional status may be defined as the extent to which a customary diet meets requirements. On the assumption that one has available the required information listed in Table 1, there is still much room for individual judgement. I have chosen two examples from our International Biological Programme project in Ethiopia to illustrate some of the problems.

Vitamin A deficiency. It is well known that the incidence of clinical signs of vitamin A deficiency depends upon the observer. The classical eye signs (Bitot's spots, conjuctival and corneal xerosis, keratomalcia) are difficult to distinguish from those resulting from infections particularly trachoma (pingueculae, pterygium and

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pannus). Similarly, xerosis of the skin and follicular hyperkeratosis may be confused with ichthyosis, acne or even sunburn and scabies.

However, assuming that one is convinced that deficiency signs exist, it does not follow that they result from a deficiency of retinol or carotene or both. Platt and his colleagues (Friend, Heard, Platt, Stewart & Turner, 1961) have demonstrated that low plasma albumin resulting from protein or calorie deficiency, or both, reduces the transport of vitamin A. Similarly, it has been established that in areas where goitre is endemic, whether due to a lack of iodine in the diet or the presence of goitrogens, there is frequently a deficiency of vitamin A, probably due to the need for thyroxine to convert carotene into retinol. A chemical analysis of the diet does not always provide a solution to the problem because the source of carotene in the diet is sometimes also the source of the goitrogens.

Protein-calorie malnutrition. The early literature on this subject reveals a controversy concerning the clinical signs of kwashiorkor, marasmus and many intermediary and local conditions, e.g. marasmic kwashiorkor, hunger oedema. This was eventually resolved by the adoption of the term 'protein-calorie malnutrition' which covers the broad spectrum of symptoms, but the distinction between the two extremes is considered to rest primarily on the presence of oedema in kwashiorkor (Jelliffe, 1966). During this period there has developed a general concept that marasmus results from a deficiency of calories and kwashiorkor from a deficiency of protein. But there is no published dietary evidence to support this view. Briefly, children just do not eat enough of diets low in protein, and are thus concomitantly deficient in calories: similarly, those eating diets low in calories are forced to burn what protein there is for energy purposes. Surveys of diets derived from staples with little or no protein show that the mixtures consumed are either qualitatively adequate (Miller & Payne, 1969) or, as with semi-force-fed starchy paps, that the caloric density of the liquid is so low as to make an adequate caloric intake impossible on the grounds of stomach volume (Platt & Miller, 1958). Assays of the diets of Persian children said to be deficient in calories, demonstrate an impaired nitrogen utilization such that most of the protein consumed was used to meet the energy requirements of basal metabolism (Platt, Miller & Payne, 1961). The evaluation of diets indicates, therefore, that the primary cause of protein-calorie malnutrition is insufficient food, although the secondary causes may range from failure of breast-feeding to a gastro-intestinal infection. Also, it should be pointed out that the so-called protein-deficient experimental animals of Platt and others (McCance & Widdowson, 1968) were consuming only a fraction of the energy intake of normal animals. The reason for the presence or absence of oedema in the various forms of protein-calorie malnutrition remains to be demonstrated. Two corollaries follow from this reasoning. Firstly, if simple calorie deficiency does not exist, then the addition of empty calories in the form of sucrose or fat to the diet is unwarranted and secondly, if simple protein deficiency does not exist, the value of protein-rich foods has been overrated. What is required is enough of a balanced diet, which of course is the panacea for all nutritional problems.

In conclusion, I have tried to present an appraisal of the present state of knowledge in this field. Whether this is interpreted as indicating that nutrition is an imprecise science or a fascinating but complex multidiscipline depends upon one's point of view. Certainly in the evaluation of diets there are still many problems to be solved, but to quote Professor Platt, who initiated much of the work, 'the ability to ask the right questions is three parts of the way to solving them'.

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Interrelationship of the human intestinal flora and protein utilization

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Body size, physical fitness and functional performance of persons usually subsisting on rations well below formulated requirements often cannot be understood. In the poor cassava-eating regions of Java, periodic hunger-oedema is of common occurrence; in the sweet-potato-eating highlands of New Guinea, where the diet is essentially similar in macro-nutrients, it is a rarity, and, in addition, physique is often manifestly superior. Despite the fact that in this environment the small child is weaned from breast milk on to a nearly exclusive diet of cooked sweet-potato, protein malnutrition is not regularly observed even when it could reasonably be expected. Bailey (1963), one of the investigators who were struck by the paradoxical physical performance in sweet-potato eaters, remarked 'that we are in fact dealing with a highly specialized adaptation to a particular way of life'. This would mean a nutritional adaptation, a much more intrinsic mechanism than the enlargement of the thyroid in iodine deficiency, the increase in haemoglobin at low oxygen pressure or the regulation of peripheral circulation in heat or cold tolerance.