6 Special Problems in Different Groups

YOUNG CHILDREN

In developing regions of the world malnutrition makes its principal impact on young children. These children are at a stage of life when growth is rapid, nutrient requirements are high, and the diets likely to be given are inadequate, because of poverty, lack of suitable foods, parental ignorance or fallacies in the form of food prejudices and restrictive taboos. It is also a period of continuous stress from bacterial, viral and parasitic infections.

Malnutrition in Early Childhood

Although there is no precise dividing-point, it is helpful to consider the types of malnutrition seen in young children in developing countries in the two usual age-groups—infants and pre-school-age children (1-4 years).

Infants

The nutritional status of children in the first year of life depends on the local methods of infant feeding and, through the foetal stores, on the maternal diet in pregnancy and on the mother's own nutritional status. However, the principal practical determinant is often whether the baby is breast-fed, as is traditional, or whether, as is increasingly the case in urban areas, attempts are made to feed it artificially.

Breast-fed infants

While it is difficult to generalize, the nutritional status of the breast-fed baby is usually excellent in the first 5-6 months. Growth is well sustained as sufficient protein, calories and vitamins are supplied by breast-milk. The only common exception to this is infantile beriberi, which usually occurs in exclusively breast-fed babies of mothers in areas of Asia where diets are largely composed of thiamine-deficient polished rice, the peak incidence being at 2-5 months of age (Aykroyd & Krishnan, 1941). It is essentially maternal malnutrition " transmitted " to the suckling by the mother's

thiamine-deficient breast-milk. The condition is difficult to diagnose before the full clinical picture has developed, since the mother may appear healthy and the infant well-nourished, as judged by weight and development of muscle and subcutaneous fat. Neither incidence nor prevalence of the condition can be ascertained by survey methods. It can be gauged approximately by the age-specific 2-5 month mortality rate (if such can be obtained), or by hospital data concerning acute cases of infantile beriberi responding dramatically to parenteral thiamine.

Generally, in traditional rural circumstances in developing tropical regions, infants in the second half of the first year of life will continue to be breast-fed, usually with inadequate supplements of largely carbohydrate gruels or pastes. Severe malnutrition is usually not seen at this stage, although avitaminosis A (as with keratomalacia in Indonesia), or early rickets (as in Ethiopia) may occur, where for dietary and social reasons these forms of malnutrition are prevalent.

More commonly, the second semester of infancy is characterized only by an inadequate weight gain, as shown by a somewhat flattened growth curve, and sometimes by a degree of iron-deficiency anaemia.

Artificially fed infants

At the present time, there is a world-wide trend towards urbanization, partly planned, but largely haphazard. Among these new townspeople, there is an increasing decline in breast-feeding, partly because mothers have to seek employment in jobs where breast-feeding is no longer culturally acceptable, and, to an increasing extent, because of the unfortunate influence of advertised infant foods and the example of socio-economic " superiors ".

For the majority of families in tropical regions, artificial bottle-feeding is not practical—economically, educationally or hygienically.

Specially imported animal milks and processed products designed for babies are too expensive for parents to be able to buy in sufficient amounts, so that token, homeopathic doses are normally used. Mothers ordinarily have not had sufficient education to follow the necessary routine of preparation, dilution and protection from contamination. Lastly, conditions in the home with regard to supplies of water and fuel, kitchen facilities, and the means for storage protected from insects and dust make the preparation of uncontaminated feeds an impossibility.

In these circumstances, the majority of non-breast-fed infants reared artificially on the bottle receive very dilute, highly infective feeds, resulting in most cases in protein-calorie malnutrition, sometimes associated with infective diarrhoea, and often leading to death.

The type of resulting malnutrition depends on the artificial feeds the child has received. Usually, this will be over-diluted milk, supplying wholly inadequate protein and calories. Infective diarrhoea occurs frequently, and ultimately nutritional marasmus develops.

If the baby is fed on liquid, largely carbohydrate preparations, instead of diluted animal milk, and avoids severe diarrhoea, infantile kwashiorkor is likely. This situation has already developed in Trinidad, where poorer, less educated mothers may use a gruel of arrowroot starch as the sole food, so that the peak incidence of kwashiorkor is found to be at 5 to 7 months of age (Jelliffe, Symonds & Jelliffe, 1960). A lowering of the age-incidence of kwashiorkor is also found, though in lesser degree, in many areas of developing countries in the process of urbanization.

Furthermore, because of the increasing use of prepared animal-milk products, certain vitamin deficiencies may be expected to occur more frequently. A rise in the incidence of infantile scurvy is likely, whereas, at present, this condition is rare among breast-fed, traditionally reared infants, who receive adequate ascorbic acid through breast-milk.

If, as is probable, cheaper milk preparations will often be used, including skim-milk in powdered or condensed form, severe avitaminosis A, including keratomalacia, will occur more frequently and become a nutritional public-health problem of increasing importance.

Pre-school children (1-4 years)

This period of childhood, especially the second year of life, is notoriously fraught with risk. The young child is " transitional " as regards diet, immunity to infections and psychological dependence. This is a period of rapid growth with high nutrient needs, particularly of protein for swiftly increasing muscle tissue. It is a time when several meals a day are required and when foods should be easily masticable and digestible.

It is at this time also that the non-immune child comes in contact with a succession, or more often an accumulation, of bacterial, viral and parasitic infections. Lastly, it is often the occasion for the psychological trauma that occurs as a result of the sudden separation from the mother—after a prolonged period of continuous intimate contact and permissive breast-feeding—frequently caused by a further pregnancy.

Certain vitamin- and mineral-deficiency diseases occur with varying frequency in pre-school-age children in different parts of the world, including, for example, avitaminosis A, rickets and iron-deficiency anaemia. The incidence varies greatly from place to place, depending upon the local dietary and social factors. Thus, rickets in sunnier parts of the world may be related to lack of exposure to available ultraviolet light due to overcrowding in urban dwellings, as in old-style walled cities or in slums, or to a deliberate sheltering of young children from the sun for various cultural reasons, e.g., to prevent their acquiring a darker complexion or to escape the " evil eye ".

However, the principal forms of malnutrition seen during this transitional period are those now termed " protein-calorie malnutrition of early child-

hood ", including kwashiorkor. In one form or another, these are common in most developing countries, and represent the principal nutritional public-health problem in the world. Thus, in Haiti in 1960, it was found that 7 000 per 100 000 of the pre-school-age population in the country as a whole were suffering from kwashiorkor (Jelliffe & Jelliffe, 1960), while in Kampala, Uganda, 10% of admissions to the children's wards at Mulago Hospital demonstrated this advanced syndrome (Musoke, 1961), and more than 50% of those attending local child-welfare clinics showed clinical and anthropometric evidence suggestive of mild to moderate malnutrition of this type (Welbourn, 1954).

Owing to the important and wide prevalence of this type of malnutrition, the present section deals mainly with current views on nomenclature, etiology, clinical features and appropriate survey methods.

Protein-Calorie Malnutrition of Early Childhood

The nutritional status of young children as regards protein and calories may be viewed as an uninterrupted downward gradient running from " normal ", through mild and moderate degrees of malnutrition, to severe syndromes, including kwashiorkor and nutritional marasmus (Jelliffe, 1959).

Suggested terminology

The label " protein-calorie malnutrition of early childhood " (PCM) has been suggested as a generic term to cover the whole range of mild to severe, classifiable and unclassifiable manifestations, including the two main severe clinical syndromes of kwashiorkor and nutritional marasmus.

The reasons advanced in favour of this term are:

(*a*) It emphasizes that kwashiorkor is *not* the only clinical end-result associated with protein-shortage in young children. In fact, lesser manifestations of protein-calorie malnutrition are at all times far more frequent, while in some countries nutritional marasmus is the most common severe form (Graham & Morales, 1963; McLaren, Ammoun & Houri, 1964; Mönckeburg, 1966).

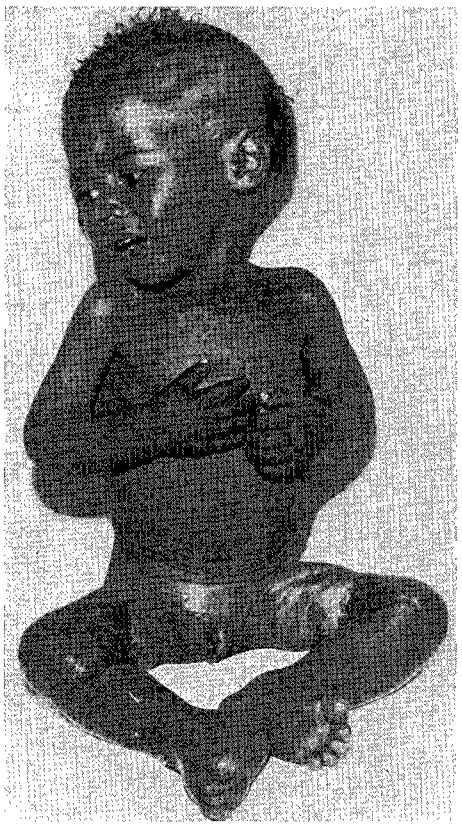
(*b*) It stresses the need for consideration of calorie intake as well as protein, not only in infant-feeding in tropical regions, but in the treatment of all syndromes, including kwashiorkor (Dean & Skinner, 1957).

(*c*) All the syndromes can be related to a diet low in protein, but with different levels of intake of calories in the form of largely carbohydrate foods.

(*d*) The term " early childhood " is appropriate, as the various syndromes may occur commonly from the early months of life up to late pre-school age.

The two major, severe syndromes of protein-calorie malnutrition of early childhood are kwashiorkor and nutritional marasmus, and any

FIG. 49. KWASHIORKOR, SHOWING OEDEMA, MISERY, WASTED MUSCLES WITH PRESENCE OF SUBCUTANEOUS FAT, FLAKY-PAINT RASH AND HAIR CHANGES



attempt to assess the signs found in less severely affected children will be based on a clear definition of the clinical picture in these advanced cases.

Kwashiorkor (Fig. 49)

Nomenclature

Williams (1933) introduced the socially descriptive West African word "kwashiorkor"[1] to scientific medical literature, but a variety of other terms have been used for this dramatic, severe malnutrition syndrome.

Some of these terms are listed below:

(*a*) Clinically descriptive: enfants rouges, culebrilla,[2] bouffissure d'Annam, syndrome dépigmentation oedème

(*b*) Pathologically descriptive: fatty liver disease

(*c*) Suggested nutritional etiology: dystrofia pluricarencial, syndrome pluricarencial (multiple-deficiency disease); mehlnährschaden (flour malnutrition), nutritional oedema syndrome, malignant malnutrition

(*d*) Vernacular name: *obwosi*[3] (in Luganda).

Terms previously used are listed in various publications (Trowell, Davis & Dean, 1954; Waterlow & Scrimshaw, 1957; De Silva, 1964), but today these are largely of historical interest, since, by unofficial international agreement, the term kwashiorkor is currently used almost universally for this particular extreme form of protein-calorie malnutrition of early childhood, even though there is disagreement about minimum diagnostic criteria.

[1] Meaning a disease occurring in a young child displaced from his mother by a subsequent pregnancy.

[2] "Snakeskin", referring to the flaky-paint rash sometimes found.

[3] As with many vernacular names for the condition in African languages, *obwosi* has the same meaning as kwashiorkor.

Etiology

Kwashiorkor can occur in infancy or in later childhood, and even, though rarely, in adult life. However, in classical circumstances, it has its main incidence in the second year of life. Thus, of 1141 cases analysed by Trowell, Davis & Dean (1954), 45% were between 1 and 2 years of age, and 69% between 1 and 3 years of age.

Kwashiorkor is never exclusively dietary in etiology. Infective, psychological, cultural and other conditioning factors, either singly or in combination, are also operative. Nevertheless, the principal cause is always a nutritional imbalance in early childhood, that is, a diet that is low in protein, but that contains carbohydrate calories. A similar syndrome can be produced experimentally by feeding a low-protein, mainly carbohydrate diet to piglets (Platt, 1958).

Descriptions of the clinical features of kwashiorkor have been much confused by workers in one country or region arbitrarily assuming that the clinical picture with which they are familiar is necessarily identical in detail in other parts of the world. Kwashiorkor is a variable syndrome with certain constant features. Details of the clinical picture will vary with the following factors:

(*a*) the degree of deficiency and the ratio of carbohydrate calories to protein intake;

(*b*) the velocity of onset;

(*c*) the age at which the patient is affected; [1]

(*d*) the duration;

(*e*) conditioning factors—e.g., infections, psychological trauma; and

(*f*) genetic characteristics—e.g., skin colour, type of hair.

Thus, the infantile kwashiorkor of Trinidad, with its peak incidence between 5 and 7 months of age, almost never shows hair changes and consistently has an enlarged liver (Jelliffe, Symonds & Jelliffe, 1960). This contrasts markedly with the usual classical textbook tropical African case (Trowell, Davis & Dean, 1954).

In addition, Gopalan (1961) has shown that in two parts of India the clinical picture of kwashiorkor varies. In Hyderabad, affected children are much lighter in weight than those observed in Coonoor, because of a lower-calorie staple food and because of a later introduction of semi-solids. Similarly, obese variants of kwashiorkor are well recognised in Jamaica, where they are known as " sugar-babies " (Waterlow, 1948; Jelliffe, Bras & Stuart, 1954).

[1] The importance of the age at which malnutrition occurs has been emphasized in experimental malnutrition by Widdowson & McCance (1963), who have shown that different species have their own vulnerable periods in so far as the potential for subsequent recovery is concerned.

Despite these variations of detail in different parts of the world, it seems justifiable to divide the clinical features of kwashiorkor into three categories: constant, usual, and occasional (Jelliffe & Dean, 1959).

Constant signs of kwashiorkor

There are four constant features in kwashiorkor, which, though normally accompanied by other signs, can be regarded as diagnostic if found in early childhood in regions where the diet in infancy is predominantly carbohydrate. These are oedema, growth failure, muscle wasting with retention of some subcutaneous fat, and psychomotor change.

(*a*) *Oedema.* This is the cardinal sign of kwashiorkor and the syndrome should not be diagnosed in its absence. It can be detected initially in the pretibial region by the production of a definite pit as a result of moderate pressure for three seconds with a finger or thumb over the lower end of the tibia.

In tropical circumstances, the oedema occurring in hookworm disease, which is associated with severe anaemia, or in beriberi, or in the nephrotic syndrome, when it is accompanied by a heavy albuminuria, may require differentiation. Particular difficulty may be encountered with hookworm disease, as it can itself be a conditioning factor in the development of kwashiorkor.

(*b*) *Growth retardation.* The growth retardation of kwashiorkor has been demonstrated in an analysis of certain anthropometric measurements of a large group of affected children admitted to the Infant Malnutrition Research Unit (IMRU), Kampala (Table 18). A low body weight (68% of the standard) and a low mid-arm circumference (77%) are the main abnormal features, with body length (91%) much less affected. The fact that weight is proportionally much more affected than length has also been shown by Sénécal & Aubry (1958), McFie & Welbourn (1962), and Moncada (1963).

The interpretation of weight in untreated kwashiorkor is complicated by the presence of oedema fluid and, especially in the so-called " sugar baby " variants in some parts of the world, by a relatively thick layer of subcutaneous fat. Also, as Dean (1960) has shown, in Kampala, the severity of kwashiorkor, as measured by the clinical picture or by the mortality rate, is not always proportional to the degree of weight loss, even if the weight is taken after oedema has subsided.

(*c*) *Muscle wasting with retention of some subcutaneous fat.* Muscle wasting is a constant feature of kwashiorkor, both clinically and at autopsy, and a reduction in the circumference of the upper arm is usually particularly evident. It is much less obscured by oedema than the forearm or leg, although minimal oedema may occasionally be detectable, especially over the dependent triceps. However, even when none can be found, there is a

further decrease in arm circumference when body oedema subsides, indicating the constant presence of subclinical oedema and an increased water content of muscle and skin (Frenk et al., 1957). Nevertheless the mid-arm circumference has the advantage of being both simply measured and roughly circular.

This reduction in arm circumference has been confirmed as one of the main features of the syndrome by anthropometric measurements on a large series of children with kwashiorkor (Table 18). Clinical palpation suggests

TABLE 18. CERTAIN ANTHROPOMETRIC MEASUREMENTS IN CHILDREN WITH KWASHIORKOR, EXPRESSED AS PERCENTAGES OF LOCAL STANDARDS *

Measurement	Proportion of locally accepted standard value (%)
Weight	68
Arm circumference	77
Calf circumference	78
Length	91
Sitting height	92

* Data supplied by the Infant Malnutrition Research Unit, Kampala.

that it is principally due to muscle wasting, and this can be demonstrated both at autopsy and during life by surface measurements and radiology (Jelliffe & Jelliffe, 1960; McFie & Welbourn, 1962).

Muscle wasting can also be demonstrated functionally by testing the infant's ability to hold up his head when gently pulled from a lying to a sitting position (Smythe, 1958).

The relatively thick layer of subcutaneous fat can also be observed on both the body and the limbs. It can be palpated during clinical examination, and confirmed by using skin-fold calipers. Its presence in part reflects the child's calorie intake in the form of largely carbohydrate foods.

(*d*) *Psychomotor change.* The child with kwashiorkor is apathetic, miserable, inert, withdrawn and anorexic. His motor development is retarded and has usually regressed in recent weeks.

The causation of this psychomotor change is complex. In some cultures the psychological trauma due to the maternal withdrawal associated with "weaning" from the breast, sometimes including actual geographical

separation from the mother, often plays a part. The possibility of biochemical change affecting the brain is suggested by changes in the electroencephalogram (Nelson & Dean, 1959), while physical components include a lowered basal metabolic rate, and the weakness and hypotonicity due to severe muscle wasting.

Usual signs of kwashiorkor

Certain signs, though not necessary for diagnosis, are common and are usually present either singly or in any combination:

(*a*) *Hair changes.* Although varying greatly from one part of the world to another, some degree of hair abnormality is usually found, although kwashiorkor can occur with wholly normal hair. The hair changes may comprise lightening in colour (dyspigmentation), straightness (if the normal hair is curly, as in African children), silkiness, and loosely attached roots, as shown by sparseness and " easy pluckability ".

Of the hair changes, dyspigmentation, if present, can be the most striking. It appears to occur most readily in African children. It is absent in cases of acute onset and, conversely, most marked in chronic syndromes of gradual evolution, such as with some of the " sugar baby " cases in Jamaica.

Dyspigmentation of the hair can occur from non-nutritional environmental and genetic causes. In some regions it is not uncommonly found in children without kwashiorkor.

However, if genetic and environmental causes can be excluded, the correlation of dyspigmentation of the hair in pre-school children with a community diet, for this group, of largely carbohydrate, low-protein foods is suggested by (*a*) its absence in African children who are not protein-deficient (as among the Hadza hunters of Tanganyika) (Jelliffe et al., 1962b), as compared with the very high incidence among the children of the Baganda, whose diet is based on steamed plantain (Welbourn, 1954); (*b*) its maximal occurrence at age 1-3 years, when, in most tropical regions, the child's diet is low in protein and high in carbohydrate calories (Jelliffe, 1955a); and (*c*) the fact that African children in the Congo with dyspigmentation of the hair have been shown to have a lower weight curve, especially in the second year of life, than children with normal black hair (André & Holemans, 1955).

However, this subject calls for further investigation; its complexity is indicated by the range of abnormal hair colours that can be found in kwashiorkor—light brown, reddish-brown, blonde, etc.

(*b*) *Diffuse depigmentation of the skin.* Probably with the same pathogenesis as dyspigmented hair, and usually paralleling it, light-coloured skin is a common feature of kwashiorkor, although with the genetic range of coloration found in any population, it may be difficult to gauge with certainty. It is most easily seen in darker pigmented groups, especially children

of African descent, and, in the same way as dyspigmented hair, it is often most pronounced in chronic cases of gradual onset.

(*c*) *Moon-face.* The full, well-rounded, somewhat pendulous and blubbery cheeks, known as moon-face, are often present in kwashiorkor. The pathogenesis of moon-face is uncertain. It occurs particularly in obese variants of kwashiorkor, and is presumably the result of increased fat, with possibly some degree of oedema. However, in addition to its probable relationship to the intake of carbohydrate calories, the effect of endocrine dysfunction also merits consideration, as the appearance can be similar to the Cushingoid face of pathological or steroid-induced hyperadrenalism.

(*d*) *Anaemia.* Again, this varies in commonness, and even more in precise etiology from country to country; thus in Jordan, some cases are vitamin-E responsive (Majaj et al., 1963). It is usually not severe unless other causes, such as a heavy hookworm infection, malaria or kala-azar, are also present.

Occasional signs of kwashiorkor

The various signs that are occasionally present include the following:

(*a*) *Flaky-paint rash.* This well-known lesion has been described elsewhere (Trowell, Davis & Dean, 1954; Jelliffe, 1955b) as occurring in advanced cases. It varies in commonness in different parts of the world. If present, it is virtually pathognomonic.

(*b*) *Hepatomegaly.* Although extreme fatty infiltration is a constant pathological finding, a considerably enlarged liver, sometimes extending down to the level of the umbilicus, is a feature of the kwashiorkor syndrome in only certain parts of the world, especially in the infantile cases of the West Indies (Waterlow, 1948; Jelliffe, Bras & Stuart, 1954), and in parts of Indonesia (Oomen, 1957b; Blankhart, 1958). From a world standpoint, hepatomegaly should be viewed as an occasional manifestation, and in some tropical communities the large livers found in late infancy and in the preschool age-group are often associated with splenomegaly and are principally the result of malaria (Walters & McGregor, 1960).

(*c*) *Other skin lesions.* Children with kwashiorkor may sometimes show indolent sores, fissures (as behind the ears), and a " moist groin rash " (Trowell, Davis & Dean, 1954).

(*e*) *Associated vitamin deficiency.* A variety of signs possibly due to associated vitamin deficiency may be found, including keratomalacia and angular stomatitis. Their commonness varies from one part of the world to another.

(*f*) *Associated conditioning infections.* These may include chest signs of tuberculosis, severe anaemia in hookworm infection, and dehydration, even when peripheral oedema is present, from diarrhoea.

Nutritional marasmus (inanition) (Fig. 50, 51 and 52)

Nomenclature

The term at present used for this second severe syndrome of protein-calorie malnutrition is imprecise, but clinically descriptive, referring to a person, usually a young child, showing severe wasting, principally due to a grossly inadequate diet. Older terms include athrepsia, cachexia, decomposition, infantile atrophy, denutrition, and inanition.

Etiology

Nutritional marasmus is principally due to severe under-nutrition, that is, a diet very low in both protein and calories—so-called " balanced starvation ". While it can occur at all ages, including adulthood, it is seen most commonly in the first year of life—in contrast to kwashiorkor, which occurs mainly in the age-group 1-3 years—frequently as a result of attempted artificial feeding with very dilute milk, and also often associated with infective diarrhoea and sometimes with tuberculosis. A late form of childhood nutritional marasmus can occur in the pre-school period as a result of prolonged breast-feeding not supplemented with other foods, so-called " breast starvation ".

Once again a clinical picture similar to nutritional marasmus can be produced in piglets by feeding them a diet low in both protein and carbohydrate calories (Platt, 1958).

The clinical signs of nutritional marasmus can be divided into two groups: constant and occasional.

Constant signs of nutritional marasmus

The two constant features of nutritional marasmus are growth retardation and wasting of muscle and of subcutaneous fat.

(*a*) *Growth retardation.* This is extreme. Weight retardation is much more marked than that of length: the child is usually below 60% of the standard weight.

(*b*) *Wasting of muscle and of subcutaneous fat.* This can be detected by clinical inspection and by palpation. The arm feels thin and the skin is loose (Gongora & McFie, 1959), and measurements of the circumference and the skin-folds of the upper arm, and subsequent calculation of muscle circumference are all very low. It is also clinically apparent in the wizened " little old man " or " monkey " face.

Occasional signs of nutritional marasmus

(*a*) *Hair changes.* Minor abnormalities of the hair may be seen occasionally. These are never marked, although light-brown, somewhat sparse hair may be found. The conspicuously dyspigmented hair occurring in many children with kwashiorkor never occurs.

FIG. 50. NUTRITIONAL MARASMUS, SHOWING EXTREME WASTING OF MUSCLE AND FAT

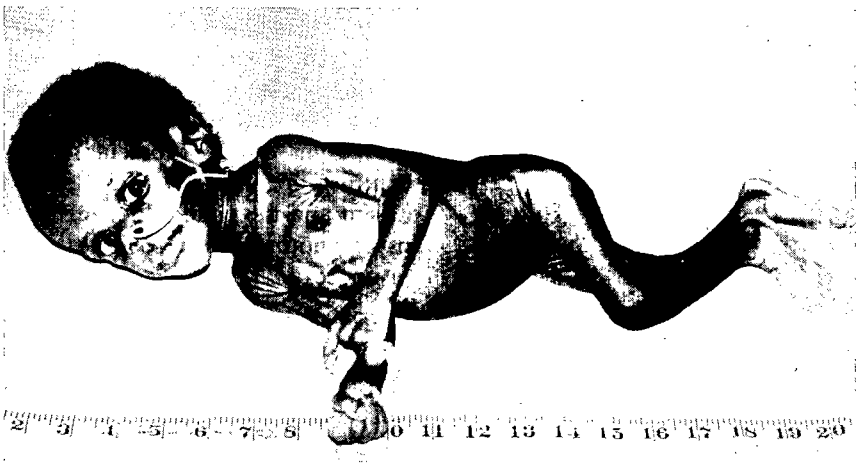


FIG. 51. NUTRITIONAL MARASMUS AND RECOVERY

(*a*) Nutritional marasmus, showing extreme wasting of muscle and fat, large-seeming head and small chest

(*b*) Same child after nutritional recovery. Note change in body proportions

FIG. 52. NUTRITIONAL MARASMUS IN YOUNG SCHOOL-AGE CHILD, SHOWING SEVERE WASTING OF MUSCLE AND FAT

The condition is more common in infants but can occur in older children and adults

(*b*) *Associated vitamin deficiency.* In particular, angular stomatitis and keratomalacia may be present.

(*c*) *Associated conditioning diseases.* These may include the dehydration resulting from infective diarrhoea, oral moniliasis (thrush), and chest signs due to tuberculosis. In contrast to kwashiorkor, oedema is absent and the child seldom exhibits psychomotor change, such as apathy or anorexia.

Intermediate severe syndromes

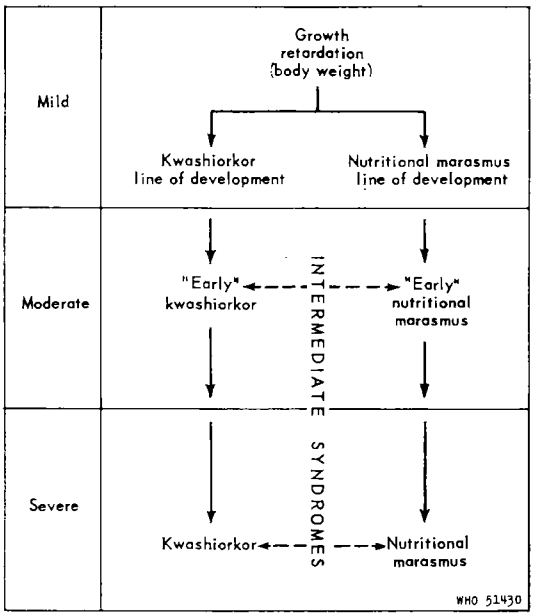
The term " protein-calorie malnutrition of early childhood " has been introduced in an attempt to attach a tentative etiologically helpful label to the group as a whole. Yet even with advanced forms there will be frequent cases which are intermediate between the two clinical " mountain-peaks " of kwashiorkor and of nutritional marasmus, and which cannot be defined in precise terms.

In addition, the interrelationships between the two major syndromes are such that changing circumstances may result in a transition from one clinical picture to another. A child with early kwashiorkor can be forced into nutritional marasmus by severe infective diarrhoea and ill-advised, prolonged " therapeutic " starvation, or an infant with nutritional marasmus due to inadequate breast-feeding may fall ill with kwashiorkor during the second year of life when carbohydrate foods are given.

Mild-moderate protein-calorie malnutrition

Lesser degrees of protein-calorie malnutrition of early childhood,

FIG. 53. LINES OF DEVELOPMENT IN PROTEIN-CALORIE MALNUTRITION OF EARLY CHILDHOOD



The diagram is a schematic attempt to correlate the development of mild, moderate and severe protein-calorie malnutrition in the two main lines of development—i.e., leading to kwashiorkor and to nutritional marasmus as well as to indeterminate, atypical, intermediate syndromes. The dotted lines stress the potential convertibility from one line of development to the other (Jelliffe & Welbourn, 1963).

sometimes termed " latent ", " hidden " or " marginal ", are far more common than the advanced syndromes, and in order to assess the full extent of the problem, these mild-moderate forms must also be enumerated in a nutritional assessment of the community (Jelliffe, 1963).

The problem is complicated by the variability of the clinical picture, by difficulties in regard to the objective definition of some of the signs, such as psychomotor change, and by the fact that a continuous gradient exists between the obvious severe case and the well-nourished, healthy child (Fig. 53 and 54 (*a*), (*b*), (*c*)).

As judged by the records of children attending clinics who subsequently develop kwashiorkor, and by the common flattening of weight curves in the second year of life in regions where kwashiorkor is widespread, the first clinical indication of protein-calorie malnutrition appears to be growth failure, attested in particular by a low body weight or an inadequate weight gain.

In general terms, the clinical picture of mild-moderate protein-calorie malnutrition (Fig. 54 (*b*), (*c*)), is of an underweight disproportionate child, with a long-seeming body, thin limbs, a head that appears too large (Dean,

FIG. 54. DEGREES OF PROTEIN-CALORIE DEFICIENCY IN EARLY CHILDHOOD

(*a*) Normal healthy well-fed child

1960; Hassan, 1960; Moncada, 1963), and feet that seem unduly elongated (Thomson, 1960).[1] The buttocks are flattened and the scapulae appear " winged ". The chest is small, especially in contrast with the abdomen, which is often somewhat distended because of thin abdominal muscles, a bulky, fermentable, largely carbohydrate diet, sometimes associated with heavy burdens of roundworms and enlargement of the liver and spleen, often on a malarial basis.

Other signs in the grouping suggestive of protein-calorie malnutrition will be present in varying combinations, depending, among other things, on whether the child is in the kwashiorkor or marasmus " line of development " (Fig. 53).

In the kwashiorkor " line of development ", hair changes, including dyspigmentation, straightness, sparseness and easy pluckability, moon-face, psychomotor change and other signs in the suggestive grouping will be found in different combinations, together with a clinically obvious layer of subcutaneous fat. These cases—when marked—have been termed: " prekwashiorkor ", " early kwashiorkor ", " subclinical kwashiorkor ", or " latent kwashiorkor ".

By contrast, in the marasmus " line of development ", the principal clinical signs will be low weight and diminished subcutaneous fat and muscle, sometimes with minor hair changes.

As with severe syndromes, children with less advanced protein-calorie malnutrition may fall intermediately between these two " lines of development ".

[1] Historically, the characteristically lesser effect of malnutrition on skeletal growth has been recognized for many years, resulting in " the body being elongated and the head large " (Jackson, 1925). Similar results are also found in piglets experimentally subjected to severe undernourishment, which develop heads that are too large, legs that are too long and bodies that are too small (McCance, 1964).

FIG. 54. DEGREES OF PROTEIN-CALORIE DEFICIENCY IN EARLY CHILDHOOD *(continued)*

(b) Mild protein-calorie malnutrition. The child on the left is 18 months old and weighs the same as the 6-month-old baby on the right

From the anthropometric point of view, mild to moderate cases show abnormal measurements that might be expected from findings in the advanced syndromes of kwashiorkor and nutritional marasmus and are suggested by the clinical picture described above (Fig. 54 (*b*), (*c*)).

The principal anthropometric abnormality is a low weight for age, approximately paralleling the severity of the malnutrition. Despite early interference with bone metabolism (Jones & Dean, 1956), there is much less interference with linear growth, as indicated by measurement of body length (Dean, 1964), unless mild-to-moderate protein-calorie malnutrition is prolonged, when stunting, or " nutritional dwarfing " can result, with children both undersized as well as underweight.

The head circumference, though affected, is much less so than the weight, especially if malnutrition occurs in the second year of life. This is because 50% of extra-uterine skull growth occurs in the first year of life. The apparent largeness of the head is due to the contrast between a relatively normal-sized skull with the thin limbs, the wasted face—in children in the marasmus " line of development ", and especially with the small chest,

FIG. 54. DEGREES OF PROTEIN-CALORIE DEFICIENCY IN EARLY CHILDHOOD (*continued*)

(c) Moderate protein-calorie malnutrition in a pre-school-age child, showing body disproportion (large-seeming head, small chest, thin limbs, long-seeming body and feet)

which is due in large part to wasted or poorly developed pectoral muscles, a finding which can be confirmed by a below-standard chest circumference.

Muscle wasting is clinically evident and can be calculated approximately from the measurement of arm circumference and of the triceps skin-fold. Recent field studies also suggest that the simply measured arm circumference *alone* parallels the underlying muscle wasting in the great majority of young children with all degrees of protein-calorie malnutrition (Robinow & Jelliffe—in preparation).

Attempts to classify the severity or degree of protein-calorie malnutrition have been made, on the basis of combined assessment of certain signs and measurements. Examples are the Oomen Malnutrition Index (Oomen, 1955; Trimmer, 1965) and the PCM Score (Jelliffe & Welbourn, 1963). The value of these classifications requires further investigation.

Nutritional dwarfing

In as yet ill-defined dietary circumstances, protein-calorie malnutrition—probably when mild-moderate and prolonged—results in nutritional dwarfing—that is, in children who are "considerably underweight and undersized, while at the same time appearing to have relatively normal body proportions" (Jelliffe, 1959). As Downs (1964) remarks, children with nutritional dwarfing are light in weight, short in stature, with

relatively normal body proportions and subcutaneous fat appropriate to their weight; they are likely to be taken for healthy younger children.

This condition has received inadequate attention, but appears to be not uncommon in Peru (Graham, 1966) and in Arab refugee children in the Lebanon (Puyet, Downs & Budeir, 1963; Downs, 1964).

One important reason for knowing whether nutritional dwarfing is common or not lies in the lesser usefulness of weight-for-length measurements in community assessment, if this is the case.

Assessment in the community

An assessment of the prevalence of protein-calorie malnutrition of early childhood may form part of an over-all nutrition survey of a community. However, in view of its importance as a public health problem and the lack of factual knowledge,[1] it is suggested that specific surveys of this vulnerable age-group will often be indicated, both in rural and in urban areas, despite the recognized difficulties of collecting young children for examination.

Assessment will be directed at children from birth to 4 years (i.e., 59 months), using all available methods locally practicable. The data obtained from all sources are complementary and help to describe the situation from a different aspect.

All results should be reported for the entire young-child group (0-59 months). They should also be broken down into figures: (*a*) for infants (0-11 months); (*b*) for the pre-school-age group (12-59 months); and (*c*) for each year.

Direct assessment of prevalence in the community

Clinical signs

Signs in the grouping " suggestive " of protein-calorie malnutrition (see page 43) will be recorded, and the proportion presenting each individual sign calculated for each age-group. However, as noted earlier, they are difficult to define objectively and are variable in occurrence, so that their usefulness is limited, especially in some communities (Standard, Lovell & Garrow, 1966).

Percentages of children showing a combination of three or more signs in the " suggestive " grouping will be more helpful. Likewise the percentage in the different age-groups suffering from the two major syndromes—kwashiorkor and nutritional marasmus—should be analysed.

[1] Relatively few community surveys for protein-calorie malnutrition of early childhood have been carried out: New Guinea (Oomen & Malcolm, 1958); South India (Rao et al., 1959); Haiti (Jelliffe & Jelliffe, 1960, 1961); Trinidad (Jelliffe, Symonds & Jelliffe, 1960); the San Blas Indians (Jelliffe et al., 1961b); Ethiopia (Woodruff & Hoerman, 1960); Malaya (Dean, 1961); Java (Oomen, Prawirowinoto & Latuasan, 1954; Bailey, 1962); Nigeria (Collis, Dema & Omolulu, 1962b); and in the East African community child health surveys: among the Bachiga (Jelliffe et al., 1961a); the Lugbara (Jelliffe et al., 1962a); the Hadza (Jelliffe et al., 1962b); the Acholi (Jelliffe et al., 1963); the Karamojong (Jelliffe et al., 1964).

Nutritional anthropometry

Basic measurements will consist of weight, length, triceps skin-fold, and the circumferences of the head, chest and mid-upper arm. The results should be reported in two ways: (*a*) mathematically, showing the mean (average) values and two standard deviations; and (*b*) compared with both the local standards, if available, and the general standards of reference. They can then be expressed as percentages of children in the four 10% levels below the standard—that is, 90-81%; 80-71%; 70-61%; 60% and below.

Single weight measurements

(*a*) *Weight for age.* For children seen only once in a field survey, the prevalence of malnutrition in the community has to be estimated from a single examination.

The significance of children with weight below the standard is complicated by the fact that this group will also include some who were born underweight, such as premature babies and twins, as well as some genetically in a low weight percentile. Moreover, it is not possible, on the basis of a single examination, to separate children recovering from infections or malnutrition from those who are deteriorating and in critical need of treatment.

The weights of actual clinical cases of kwashiorkor seen will be masked by oedema, and these children should be excluded from the weight classification.

However, these shortcomings are mitigated if single weight measurements are made on large numbers of children in a survey as part of the assessment of the approximate nutritional profile of a community.

If ages are known with certainty, the number of children in different degrees of " below-standard weight " for age are calculated.

Various methods have been suggested or used to express these findings. The Gomez system termed young children between 90% and 75% of the standard as first-degree malnutrition, between 75% and 61% as second-degree, and 60% and below as third-degree (Gomez et al., 1955). This classification has been used quite widely, especially in South America, and has proved extremely useful. However, the selection of levels below standard was based largely on clinical hospital experience in Mexico City.

Ford (1964) has suggested that 66% of the standard weight should be regarded as the " malnutrition line " but this has the disadvantage of including only obvious advanced cases.

Continental European schools of paediatrics have long used the general terms " dystrophia " or " dysthrepsia " for protein-calorie malnutrition of early childhood, and have, in fact, based the diagnosis of *degrees* of involvement on the percentage of standard weight—e.g., hypothrepsia 1, 90%-80%; hypothrepsia 2, 80%-60%, and athrepsia, below 60%.

The system here suggested, whereby weights are expressed in relation to the four 10% levels below standard, is thought to be more useful in that it does not draw diagnostic conclusions that may not be warranted in every case, and because it avoids labels that may be used in different ways by different authorities.

Should descriptive labels be needed for public health purposes, the following are suggested: 1st level underweight, 90%-81%; 2nd level underweight, 80%-71%; 3rd level underweight, 70%-61%; 4th level underweight, 60% and below.

(*b*) *Weight for length or for head circumference.* While age assessment must be attempted by all practicable means, an accurate estimate is often not possible. In such cases, as has been suggested, the weight may be expressed in relation to two measurements that are usually much less affected by malnutrition at that age—length and head circumference.[1]

As with other measurements, the weight-for-length and weight-for-head circumference should be expressed in percentages in the four 10% levels below the local and general standards of reference.

Such findings are plainly approximations, as both length and head circumference are, in fact, affected to some degree (Stoch & Smythe, 1963). They will probably be of most use in severe, relatively acute protein-calorie malnutrition, often seen in the second year of life, and less so in more chronically affected children in the later pre-school age when stunted height is also likely to be found.

Serial weight measurements

Where a more prolonged observation is feasible, failure to gain " significant " weight over an adequate period of observation may be an important indicator of protein-calorie malnutrition, although other factors must also be taken into account.

This method is only possible in special circumstances—for example in child health clinics or in longitudinal studies. It has the great advantage of not calling for accurate age assessment; but the measurements must be taken with care since the increments are small and the possibility of error greatly increased.

Because rates of growth vary, different periods of observation are needed for different age-groups (Table 19).[2]

If reliable records or graphic growth charts are available in child welfare clinics, it is suggested that the percentages in the various age-groups with different levels of " insufficient weight gain " should be recorded.

[1] In a survey of African pre-school children in Busoga, Uganda, whose ages were known, it was found that the weight for age correlated very strongly with the weight for length and with the weight for head circumference (Robinow & Jelliffe—in preparation).

[2] Marsden (1964) has introduced the more rigorous concept of " faltering ", which he defines as failure to gain ½ lb (226 g) over a period of three months during infancy.

TABLE 19. WEIGHT GAIN DURING THE FIRST TWO YEARS OF LIFE

Age (months)	Approximate average monthly weight gain	Minimum length of observation (months)	Weight gain that would be regarded as insufficient
0-6	1½ lb (679 g)	1	¾ lb (340 g) per month
7-12	1 lb (453 g)	2	1 lb (453 g) per 2 months
12-24	½ lb (226 g)	4	1 lb (453 g) per 4 months

Single length measurements

Although, as noted earlier, linear growth is usually much less affected than weight, it is desirable, if practicable, to compare length for age with standards.

This is particularly important in order to detect whether " nutritional dwarfing " is common in a community—in which event, weight-for-length measurements will not be so helpful, as both weight and length are reduced proportionately.

Muscle depletion

This may be calculated from measurements of the upper-arm circumference and of the triceps skin-fold. Results can be expressed in relation to the four 10% levels below the standard.

In a field study of young African children in Busoga, Uganda, the arm circumference correlated very strongly with the calculated muscle circumference, as well as with weight for age (Robinow & Jelliffe—in preparation). It has also been found useful in field studies in rural Greece (X. G. Kondakis —personal communication, 1966), in Haiti (I. Beghin, W. Fougère & K. W. King—personal communication, 1966), and in Ankole, Uganda (R. Cook—personal communication, 1966).

As a simple approximation, therefore, the actual arm circumference can be used as a general anthropometric index of protein-calorie malnutrition and should also be expressed in relation to four 10% levels below the standard.

If precise age assessment is not possible, a further useful approximation, for both boys and girls, is that between 1 and 2 years of age the mid-upper arm circumference [1] is about 16 cm and the triceps skin-fold about 10 mm.

Chest/head circumference ratio

In well-nourished children, the circumference of the chest becomes larger than that of the head after the first six months of life. In protein-

[1] 100% 16 cm; 90% 14.4 cm; 80% 12.8 cm; 70% 11.2 cm; 60% 9.6 cm.

calorie malnutrition, the chest does not develop well, probably mainly because of wasting or poor growth of the pectoral muscles, and the head measurement is the larger of the two circumferences. The result is that the chest/head ratio is less than one (Hassan, 1960; Moncada, 1963; Dean, 1965). This simple test is of value for children between 6 months and 5 years of age, and does not need a tape measure; a piece of string will serve. It is suggested that the percentage of children in the different age-groups who have a chest/head ratio of below one should be calculated and reported.

Biochemical tests

Serum-albumin levels warrant reinvestigation in the field, in correlation with anthropometric measurements and clinical assessment, although the majority opinion at the moment is that they are not of value in identifying mild-to-moderate cases.

Tests of the urine may be carried out to measure creatinine excreted in a timed period as an index of muscle mass, or urea excreted, expressed per gram of creatinine, as a measure of protein intake. They are, however, inadequately evaluated as practical field methods. " Standards " are uncertain, and there arise the usual difficulties of urine collection from young children under field conditions.

The amino-acid imbalance test (Whitehead & Dean, 1964) holds out great promise, since it requires only a small amount of blood obtained by finger-prick, and the results are independent of age. It does, however, require the facilities of a well-organized central laboratory. Likewise, the hydroxyproline excretion test, carried out on a random sample of urine, may prove of value in survey work (Whitehead, 1965).

The buccal-mucosa test of Squires (1965) appears to be simple to carry out, but needs further evaluation in the field.

Indirect assessment of prevalence in the community

Age-specific mortality rates

As noted earlier, age-specific mortality rates for 1-4 years of age, and in many regions for 1-2 years of age, should be sought. They can be expressed in various ways, but most simply as percentages of total mortality. They should always be interpreted in relation to the local setting. However, in many developing regions, such information will not be available or will be so inaccurate as to be meaningless.

Cause-of-death records

The specific death rates from malnutrition in ages 1-4 years should be collected, provided that sufficiently accurate local records exist, which is not usually the case.

Health-service statistics

Statistics concerning the major syndromes—kwashiorkor and nutritional marasmus—seen in out-patients and admitted to adjacent hospitals and health centres in the preceding year should be assembled, as well as the reported incidence of potential conditioning infections, including whooping cough, tuberculosis, measles, infective diarrhoea, intestinal helminths and malaria.

Assessment of ecological factors

Data relevant to the local epidemiology of protein-calorie malnutrition to be collected on the survey include the following:

(*a*) feeding practices with regard to young children, by detailed food consumption or rapid questionnaire;

(*b*) cultural influences;

(*c*) socio-economic factors;

(*d*) local food production and availability;

(*e*) incidence of conditioning infections, including the incidence of malaria and intestinal helminths as shown by laboratory tests, and of tuberculous infection, as indicated by the tuberculin test; and

(*f*) medical and educational services.

Priorities

While information has to be sought from as many useful sources as possible, relatively simple, practical surveys can be carried out, with limited personnel, on the basis of clinical assessment, anthropometry, available statistics from local health services and a largely qualitative investigation of causative ecological factors.

The apparent value of various methods of field assessment of protein-calorie malnutrition is given in Table 20, together with their probable feasibility in relation to the collection of samples or statistics, to laboratory services available and to age-estimation.

Methods for use in " direct assessment " in field prevalence surveys are given in Table 21 (where ages known) and Table 22 (where ages unknown).

Presentation

Although this topic is discussed in general terms elsewhere, further comments are pertinent at this point on the presentation of data likely to be collected in rapid prevalence surveys of young children (0-5 years).

Clinical assessment

A composite table will be required showing (*a*) single clinical signs (in the suggestive grouping); (*b*) combinations of three or more signs; and

TABLE 20. PROBABLE VALUE AND FEASIBILITY OF SUGGESTED INDICATORS FOR THE COMMUNITY ASSESSMENT OF PROTEIN-CALORIE MALNUTRITION IN YOUNG CHILDREN *

Indicators	Value of indicators			Feasibility of obtaining accurate data in developing countries	
	High	Medium	Low	Easy	Difficult
1. Specific mortality rate from malnutrition	*				*
2. Infant mortality rate			*		*
3. Mortality rate in children 1-4 years		*			*
4. Percentage of deaths of children below 5 years of age in relation to total mortality			*		*
5. Wills-Waterlow index (p. 100)		*			*
6. Specific mortality rate from diarrhoea and some infectious diseases (measles)			*		*
7. Prevalence of protein-calorie deficiencies					
(*a*) Clinical signs (grouped)				*	
(*b*) Weight for age	*				*
(*c*) Weight for length				*	
(*d*) Weight for head circumference		*		*	
(*e*) Arm circumference	*			*	
(*f*) Chest/head circumference ratio		*		*	
(*g*) Serum albumin		*		*	
(*h*) Urinary urea, expressed per gram of creatinine		*			*
(*i*) Amino-acid imbalance test	*				*
(*j*) Hydroxyproline excretion test	*				*

* Adapted by permission from Bengoa (personal communication, 1965).

(*c*) the major syndromes of kwashiorkor and nutritional marasmus (Table 23).

Nutritional anthropometry

Results should be presented showing percentages in different age-groups in four levels below standard: 90%-81%; 80%-71%; 70%-61%; and 60% and below.

The most important of these will be the weight for age (Table 24) (excluding kwashiorkor cases), but other anthropometric measurements, especially the arm circumference (Table 25), should be reported in the same tabular form, if ages are known in sufficient detail.

TABLE 21. TENTATIVE METHODS OF DIRECT ASSESSMENT OF PROTEIN-CALORIE MALNUTRITION OF EARLY CHILDHOOD AS A COMMUNITY PROBLEM (WHERE AGES ARE KNOWN)

Method of assessment	Remarks
Clinical signs	" Suggestive " group for protein-calorie malnutrition (single signs, combination of three or more signs)
	Major syndromes (kwashiorkor, nutritional marasmus)
Anthropometry:	
Weight for age	Using percentage of accepted standard [a] (e.g., 90 %-81 %, 80 %-71 %, 70 %-61 %, 60 % and below)
Height for age	Using percentage of accepted standard [a]
Mid-arm-muscle circumference for age	Using percentage of accepted standard [a] (calculated from mid-arm circumference and triceps skin-fold)
Mid-arm circumference for age	Using percentage of accepted standard [a]
Chest/head circumference ratio	One or above in well-nourished child over a year old
Biochemical:	
Amino-acid imbalance test	
Hydroxyproline excretion test	
Cytological:	
Buccal mucosa smear	

[a] Comparison should be made with both the general standards of reference and the local standards, if available.

TABLE 22. METHODS OF DIRECT ASSESSMENT OF PROTEIN-CALORIE MALNUTRITION OF EARLY CHILDHOOD AS A COMMUNITY PROBLEM (WHERE AGES ARE UNKNOWN)

Method of assessment	Remarks
Clinical signs	" Suggestive " group for protein-calorie malnutrition (single signs; combination of three or more signs)
	Major syndromes (kwashiorkor, nutritional marasmus)
Anthropometry:	
Weight for length [a]	Using percentage of accepted standard [b]
Weight for head circumference [a]	Using percentage of accepted standard [b]
Mid-arm circumference [a]	Using percentage of 16 cm (for 1-2-year-old children)
Chest/head circumference ratio	One or above in well-nourished child over a year old
Biochemical:	
Amino-acid imbalance test	
Hydroxyproline excretion test	
Cytological:	
Buccal mucosa smear	

[a] Probably most valuable at age 1-2 years.

[b] Comparison should be made with both the general standards of reference and the local standards, if available.

TABLE 23. METHOD OF REPORTING RESULTS OF CLINICAL ASSESSMENT IN PREVALENCE SURVEY FOR PROTEIN-CALORIE MALNUTRITION OF EARLY CHILDHOOD, SHOWING PERCENTAGES IN DIFFERENT AGE-GROUPS WITH (a) SINGLE CLINICAL SIGNS, (b) COMBINATIONS OF THREE OR MORE SIGNS, AND (c) MAJOR SYNDROMES

Age (months)	Number examined	Oedema	Dyspigmented hair	Easily pluckable hair	Thin, sparse hair	Straight hair	Muscle wasting	Depigmented skin	Psychomotor change	Moon-face	Hepatomegaly	Flaky-paint dermatosis	Combination of three or more signs	Severe syndromes	
														Kwashiorkor	Nutritional marasmus
0-3															
4-6															
7-11															
Total 0-11															
12-23															
24-35															
36-47															
48-59															
Total 12-59															
Total 0-59															

WHO 51481

If ages are not known, appropriate data (Table 22) can be reported in similar tables using broad groupings of " infants " and " pre-school children ", instead of small precise age-groups. These will particularly include clinical signs (single signs, combinations of three or more, major syndromes), weight for length, and arm circumference.

Statistics from local health services

Recorded attendances at hospitals and health centres are reported in the manner shown in Table 26. Again, if ages are not known with precision, the percentage attendances with both kwashiorkor and nutritional marasmus can be given for 0-11 months (or for " infants "), 12-59 months (or for " pre-school children "), and for 0-4 years (0-59 months) (or for " young children ").

Key findings in prevalence surveys

While detailed investigations of all possible sources are necessary and should be tabulated and documented, it is suggested that the simplest " key

TABLE 24. METHOD OF REPORTING RESULTS OF WEIGHTS FOR AGE IN PREVALENCE SURVEYS FOR PROTEIN-CALORIE MALNUTRITION OF EARLY CHILDHOOD, SHOWING PERCENTAGES IN FOUR LEVELS UNDERWEIGHT FOR AGE

Age (months)	Number examined	Levels underweight for age[a]			
		Percentage in 1st level (90%-81% standard)	Percentage in 2nd level (80%-71% standard)	Percentage in 3rd level (70%-61% standard)	Percentage in 4th level (60% standard & below)
0-3					
4-6					
7-11					
Total 0-11					
12-23					
24-35					
36-47					
48-59					
Total 12-59					
Total 0-59					

WHO 51482

[a] Oedematous children with kwashiorkor should be excluded from this classification.

findings " gathered in rapid surveys for protein-calorie malnutrition of early childhood are those permitting of a rough assessment of the percentages in the community of (*a*) mild-moderate cases and (*b*) severe cases.

According to present evidence, the most useful practical definition of these two groups is as follows:

(*a*) *mild-moderate PCM:* total of 1st, 2nd and 3rd levels underweight for age (i.e., between 90% and 61% of standard weight);

(*b*) *severe PCM:* total of cases of kwashiorkor and 4th level underweight for age (which will include nutritional marasmus).

These can be tabulated according to age-group (Table 27), and in a more condensed, simplified form—with data reported for the groups 0-1 year, 1-4 years, and 0-4 years—may be regarded as the most fundamental community data for purposes of public health comparison, in the same way that the splenic index is used by the malariologist.

TABLE 25. METHOD OF REPORTING RESULTS OF ARM-CIRCUMFERENCE MEASUREMENTS FOR AGE IN PREVALENCE SURVEYS FOR PROTEIN-CALORIE MALNUTRITION IN EARLY CHILDHOOD, SHOWING PERCENTAGES IN FOUR LEVELS UNDER STANDARD FOR AGE

Age (months)	Number examined	Levels below standard arm circumference for age			
		Percentage in 1st level (90%-81% standard)	Percentage in 2nd level (80%-71% standard)	Percentage in 3rd level (70%-61% standard)	Percentage in 4th level (60% standard & below)
0-3					
4-6					
7-11					
Total 0-11					
12-23					
24-35					
36-47					
48-59					
Total 12-59					
Total 0-59					

WHO 51482

TABLE 26. METHOD OF REPORTING TWO MAIN SYNDROMES OF PROTEIN-CALORIE MALNUTRITION IN YOUNG CHILDREN ATTENDING HOSPITAL OR HEALTH CENTRE

Age (months)	Number attending	Severe syndromes	
		Kwashiorkor	Nutritional marasmus
0-3			
4-6			
7-11			
Total 0-11			
12-23			
24-35			
36-47			
48-59			
Total 12-59			
Total 0-59			

WHO 51483

TABLE 27. METHOD OF REPORTING PERCENTAGES POSITIVE WITH (a) MILD-MODERATE AND (b) SEVERE PROTEIN-CALORIE MALNUTRITION OF EARLY CHILDHOOD FROM DATA COLLECTED ON A PREVALENCE SURVEY

Age (months)	Number examined	Mild - moderate [a] protein - calorie malnutrition (%)	Severe [b] protein - calorie malnutrition (%)
0-3			
4-6			
7-11			
Total 0-11			
12-23			
24-35			
36-47			
48-59			
Total 12-59			
Total 0-59			

WHO 51484

[a] Total of children in 1st, 2nd and 3rd levels underweight for age.
[b] Total of children with clinical kwashiorkor and children in 4th level underweight for age.

By these means, it will be possible to compare the prevalence of protein-calorie malnutrition in early childhood in communities in two regions or countries, as in the following example:

	0-1 year		*1-4 years*		*0-4 years*	
	Severe	*Mild-moderate*	*Severe*	*Mild-moderate*	*Severe*	*Mild-moderate*
Country A	1%	8%	3%	40%	2%	32%
Country B	0%	5%	1%	7%	0.5%	4%

Where the ages in only 50% or less of the children surveyed can be obtained, a similar classification can be used with weight-for-length in lieu of weight-for-age measurements, despite the greater difficulties in interpreting results (pages 193-195):

(*a*) *mild-moderate PCM :* total of 1st, 2nd and 3rd levels underweight for length;

(*b*) *severe PCM :* total of cases of kwashiorkor and 4th level underweight for length.

Avitaminosis A

Severe manifestations of vitamin-A deficiency are widespread in young children in some parts of the world, including Indonesia (Oomen, 1957b), while in other regions eye damage and blindness from avitaminosis A are public health problems at present unrecognized (McLaren, 1963; Oomen, McLaren & Escapini, 1964).

Etiology

The most dangerous manifestation, keratomalacia, principally affects young pre-school children, and is often associated with moderate or severe protein-calorie malnutrition. It is a disease of poverty and ignorance, with a diet economically and culturally restricted to exclude sources of vitamin A (e.g., milk, fish) and sources of carotene (e.g., green vegetables, papaya). In some communities, it may be precipitated by too early a cessation of breast-feeding (McLaren, 1956), and in urban areas, even among young infants, by artificial feeding with vitamin-deficient dried skimmed milk, in powdered or condensed form.

Poor storage may play a part, particularly in twins or premature infants, while infections—e.g., diarrhoeal disease and measles—act at times as the final conditioning factor (Oomen, McLaren & Escapini, 1964; McLaren, Oomen & Escapini, 1966).

Assessment in the community

Direct assessment. This may be gauged by the prevalence of clinical signs in the " suggestive " grouping, by low levels of serum vitamin A (after correction for low plasma proteins), and by dietary survey.

In addition, the presence of typically damaged eyes in older children and adults, showing phthisis bulbi, leucoma or staphyloma, may provide retrospective evidence of severe avitaminosis A in early childhood (Oomen, McLaren & Escapini, 1964; McLaren, Oomen & Escapini, 1966).

Indirect assessment. Hospital figures, both in the children's and ophthalmic wards, may furnish useful statistics concerning admissions with keratomalacia. However, these may represent an underestimate, because many classically trained paediatricians and ophthalmologists have not had much experience in diagnosing the ocular manifestations of vitamin-A deficiency.

Keratomalacia is so frequently a disease of the toddler that " weanling blindness " is an age-specific epidemiological phenomenon. Local records of age-incidence of blindness, if available, may disclose suggestive data (McLaren, Oomen & Escapini, 1966).

Ecological assessment. Cultural evidence suggesting that avitaminosis A is common may be indicated by vernacular names for various eye signs. Thus, in Indonesian, Bitot's spots are known as *sisikan* (" scaly like a fish "),

and night blindness is termed *mata ajam* (" chicken's eyes "), referring to the inability of chickens to see well at night (Oomen, McLaren & Escapini, 1964).

Infantile Beriberi

Infantile beriberi is unquestionably a public health problem in parts of South-East Asia, where the diet consists mainly of polished rice. It is the only common form of malnutrition occurring in young breast-fed infants that is attributable to maternal dietary inadequacy, the mother's thiamine-deficient diet being matched by a low thiamine level in her milk.

Assessment in the community

Direct assessment. This is not possible in the course of a prevalence survey because the illness is usually an acute one—rapidly fatal if not treated with thiamine—or with rather non-specific features in the less frequent chronic cases. It is in connexion with this type of acute condition that long-term incidence surveys are particularly revealing.

Examination of pregnant women for " suggestive " clinical signs and for urinary thiamine levels will enable areas where infantile beriberi is a high risk to be defined, as may the estimation of thiamine in breast milk (Simpson & Chow, 1956).

Indirect assessment. If available, the age-specific mortality from 2 to 5 months will be helpful, as will statistics based on hospital admissions of typically affected infants responding dramatically to parenteral thiamine.

Ecological assessment. Knowledge of the local pattern of the feeding of infants and mothers will be suggestive.

Rickets

Rickets is common in some tropical and subtropical countries, where young children are given no vitamin D, either as food or as supplement, and where they are not exposed to sunlight because of crowded urban conditions or are purposely kept indoors for various cultural reasons—for example, to keep the skin fair or to avoid the " evil eye ".

Assessment in the community

Direct assessment. In view of the lack of specificity of many of the signs found in rickets (Winter, 1954), direct assessment is best based principally on the prevalence in young children of at least three of the " suggestive " groups of signs, preferably supported by high serum-alkaline-phosphatase levels and by radiological examination of the wrists in samples of those examined clinically.

Indirect assessment. Statistics of out-patient attendances and admissions of children with rickets may be useful, although the criteria used for diagnosis should be scrutinized.

Ecological assessment. Dietary patterns and cultural practices excluding children and women from irradiation with the ultraviolet light of sunshine may be relevant to the etiology of rickets in some areas.

Iron Deficiency

Anaemia is extremely common in young children in many developing countries. It is often due to a number of concurrent factors, including nutritional deficiencies (Wadsworth, 1959), bacterial and parasitic infections and genetic abnormalities, especially sickle-cell anaemia in children of African ancestry.

Iron needs are high in early childhood because of the rapid increases in the total number of red blood cells and in muscle mass which occur with normal development. Iron deficiency results when these needs are not met, as a result of dietary inadequacy (e.g., human and cow's milk; iron-poor staples) and iron loss (e.g., infection with hookworm or bilharziasis), often associated with suboptimal liver stores (e.g., twins, prematures, babies of iron-deficient mothers), and possibly with malabsorption.

Assessment in the community

Direct assessment. Haemoglobin estimations are the most useful screening test. Low levels must be investigated by (*a*) tests for iron-deficiency anaemia, e.g., thin blood films for cell morphology, microhaematocrit readings of packed cell volume; and (*b*) tests for common associated causes of anaemia, e.g., stools for hookworm ova and occult blood, thick blood film for malarial parasites, test for sickling in African children. Standards for the results of these investigations have already been indicated. Special research techniques for more-detailed haematological surveys may be required (Annex 2).

Indirect assessment. The number of children with iron-deficiency anaemia in the hospitals of the area must be investigated. Findings may be difficult to evaluate, as anaemia in young children in tropical regions is often due to multiple causes at a given time, and the necessary haematological laboratory facilities to ensure correct etiological diagnoses are not normally available.

Ecological assessment. Dietary studies are, of course, relevant, but they should also take account of the availability and absorption of iron present in the diet and also of iron ingested with food from the water supply, from the soil—as with laterite dust—and from ferrous cooking pots.

SCHOOLCHILDREN

Children of school age (usually 5-15 years) in developing regions do not normally show significant serious illness, still less mortality, from malnutrition. They have passed through the dangerous years of early childhood. They are growing more slowly, and are able to compete for, and digest, the full range of the adult diet. In rural areas, they may be able to supplement their diets with wild fruits, berries, insects and small animals. Ordinarily, they will have achieved a substantial immunity against at least some of the prevalent infections and parasites, particularly malaria.

On the other hand, schoolchildren in tropical regions are often undernourished, with positive clinical signs and subnormal anthropometric measurements, such as a low weight for height and thin subcutaneous fat, but without sufficient symptoms to warrant attendance at hospital or health centre. This is particularly likely to happen when children walk long distances to school with little, if any, breakfast, when no school meal is provided, and when assistance with heavy manual household chores, such as chopping wood or herding domestic animals, is expected of them when they return home in the evening.

Thus, while school-age children should be included in the total population sample examined in the course of a cross-sectional nutrition survey, it may be useful to carry out a survey of schoolchildren as such, since the planning of a school health service, in particular a school meals programme adapted to the local problems—nutritional, financial and practical—may thereby be expedited.

A survey of schoolchildren offers the advantage that the subjects are easily accessible, often in buildings equipped with tables and chairs that can readily be adapted to survey purposes. They can also be followed longitudinally, with the object of assessing growth. In fact, in the school health services, serial measurements of weight and height should be included in the pupil's health record. If such measurements are already available and are reliable, their analysis may yield valuable data.

The disadvantages of this type of survey are that it is directed at an age-group not markedly vulnerable nutritionally, and which may not even be representative of the school-age population as such. Often only a limited proportion of children will be attending school, with the remainder taking part in more traditional activities in the village, with somewhat different nutritional consequences.

Results must be assessed in relation to possible seasonal food variations and to the nutritional consequences of school holidays.

Nutritional assessment of schoolchildren

Methods of direct assessment are similar to those described by earlier workers (Patwardhan, 1961). However, certain features call for special attention.

Clinical assessment. While varying in different parts of the world, the following signs are likely to occur in this age-group and must be looked for carefully: Bitot's spots, conjunctival xerosis, anaemia, parotid enlargement, angular cheilosis, fluorosis, caries, goitre, tropical ulcers, hepatomegaly and splenomegaly.

Nutritional anthropometry. That the physique of schoolchildren is related to nutrition is suggested, for example, by the improvement in the heights and weights of well-to-do Indian children in South Africa as compared with those of the same genetic stock in India (Abramson, 1959). Likewise, Bakwin & McLaughlin (1964) have shown that the weights and heights of " privileged " American schoolchildren in 1936 are today matched by the measurements of children in the lower socio-economic groups.

Basic measurements recommended for schoolchildren are weight, height, triceps skin-fold and arm circumference.

Results are expressed separately for each sex and for age to the nearest year. In accordance with ICNND practice, results should be compared with Baldwin-Wood weight-for-height-for-age tables. Space does not permit of the inclusion in the tables of percentage levels under the standard for each of these, and results must be calculated for each individual as a percentage of the standard, so that results may ultimately be entered in the four usual 10% groups—90%-81%, 80%-71%, 70%-61%, and 60% and below.

With the assistance of parents or teachers, age assessment may be possible from documentary evidence, or the use of a local-events calendar, linked to the eruption of the permanent dentition (Table 5). While ages should ideally be determined to the nearest three months, the nearest year will, in fact, be adequate.

Where ages are unknown, it will be necessary to use weight-for-height figures alone. The disadvantage of this procedure is that it merely indicates whether the child is underweight for height; it does not reveal which children are both underweight and stunted (De Wijin, 1952). As the Baldwin-Wood data are not available in this form, figures derived from Harvard weight-for-height standards should be employed, although these are somewhat higher than the Baldwin-Wood measurements.

Low skin-fold measurements have been found in schoolchildren in developing regions (Wadsworth, 1963; Ferro-Luzzi & Ferro-Luzzi, 1962; Ferro-Luzzi, 1962a, b, c; Potgieter—personal communication, 1964; Robson, 1964b), possibly related to four factors—a lower calorie intake, greater physical exercise, genetic variation, and perhaps an adaptation to a warmer climate.

The arm circumference, as a measurement by itself, or as a means of calculating the muscle circumference, has not been much used, although Luyken & Luyken-Koning (1959, 1961), Kondakis, Maraelle & Kazungu

(1964), and Potgieter (personal communication, 1964) comment on its possible usefulness.

Malnutrition can also be assessed in a school-age population by repeated measurements to test the rate of growth. This can be done with individual children or with groups. As growth is relatively slow, a fairly prolonged interval is needed between weighings to allow for a significant and measureable increment. Probably the optimum time interval is one year, since this will also eliminate the effect of seasonal variations in growth and nutrition (Robson, 1964a). As an approximate index, it may be noted that between 5 and 10 years of age the weight increases by 10% and the height by 5 cm (2 in) annually.

Problems connected with the interpretation of growth in older schoolchildren include variations between early and late maturers, the physiologically earlier puberty in girls, and the slowed growth that may precede the pubertal spurt. Also, in some less-well-fed parts of the world, growth is related to the availability of food and decreases during the hungry season.

Biochemical tests

Examination of the blood for haemoglobin levels should be included, together with stool examinations for ova and for occult blood, and a thick blood film for malaria, if relevant for the particular community.

Other biochemical tests may be carried out to cover a wide range of investigations or may be selected because of known or probable local problems.

Biophysical methods

Although usually not applicable, dark-adaptation tests or dynamometry may sometimes be practicable and indicated.

PREGNANT AND LACTATING WOMEN

Next to young children, pregnant and lactating women are nutritionally the most vulnerable group, especially in developing regions of the world, and yet comparatively little is known of their special nutritional needs (WHO Expert Committee on Nutrition in Pregnancy and Lactation, 1965).

In some areas, women may be in a constant state of nutritional stress from the time of an early marriage, before growth has ceased, until a premature death in their thirties. The whole of adult life may be continuously reproductive, as pregnancies and prolonged lactation follow one another without pause (Gopalan & Belvady, 1961).

Nutritional needs are high, particularly since, in some cultures, women may be responsible for much heavy work carried out with inefficient, clumsy tools (Phillips, 1954) and continued throughout pregnancy. Cultivation, carrying food to market, collecting water and wood, and pounding or

hand-milling foods, as well as cooking for the family and carrying young children are commonly women's tasks.

Furthermore their nutritional status is frequently aggravated by food customs specifically applying to women, especially during pregnancy and the puerperium. For example, in some East African communities women are prohibited from eating chicken, eggs, mutton and certain types of fish, which are the main local sources of animal protein. It is rare for any dietary improvement to be made during pregnancy.

In such circumstances of continuous, cumulative nutritional drain, various types of what may be termed " maternal depletion syndrome " occur (Jelliffe & Maddocks, 1964). Probably the most common is protein-calorie malnutrition. This is usually insidious and undramatic, although oedema of nutritional origin can develop in extreme circumstances (Bailey, 1962). Even a kwashiorkor-like picture has—in rare cases—been described.

Lesser degrees of protein-calorie malnutrition in women of child-bearing age probably contribute to the low birth-weight of their neonates, to a failure to make the expected weight gain during pregnancy, and to a decrease in subcutaneous fat and muscle tissue. Ultimately, this cumulative process undoubtedly plays a part in the premature ageing and early death often seen among women in developing regions.

Specific maternal depletion syndromes can also occur, often becoming more marked with recurring pregnancies. These syndromes, which vary in different parts of the world, include osteomalacia, iron-deficiency (and megaloblastic) anaemias, and iodine-deficiency goitre.[1]

Surveys of pregnant women therefore have a place in public health activities because of the nutritional vulnerability of this group, because at least a sample are accessible at prenatal clinics, which are popular in many parts of the world, and because of the consequences of maternal malnutrition not only for the mother, but in relation to the health, nutrition and survival of her child. All prenatal clinical examinations in developing regions should give as much emphasis to the early detection of malnutrition and its prevention by dietary advice as to the more classical, mechanical aspects of pregnancy. While serial observations are ideal, from the nutritional viewpoint the optimum *single* time for examination is the sixth month, particularly since dietary correction is still feasible for the mother and hence for the foetus.

Nutritional assessment of pregnant and lactating women

Direct assessment

Clinical signs. Certain signs have a special importance in particular regions, depending upon the local nutritional problems. They include

[1] The interpretation of goitre in pregnancy in relation to dietary iodine lack is complicated by recent work showing that this occurs commonly in well-fed women, probably as a physiological response to a low plasma-inorganic-iodine level, attributable mainly to renal loss of iodine (Crooks et al., 1964).

angular cheilosis, pre-tibial oedema, conjunctival pallor, goitre, the bone pains of osteomalacia, and the " suggestive " signs of beriberi.

Nutritional anthropometry. In women seen at prenatal clinics, nutritional status, as regards protein-calorie malnutrition, can be assessed by weighing at intervals throughout pregnancy. Well-fed, healthy women gain about 15%-25% of their pre-gravid body-weight as a result of the developing foetus, placenta, uterus and amniotic fluid, together with breast enlargement and some increase in subcutaneous fat (Standard & Passmore, 1940; Leitch, 1957; Fish et al., 1960; Hytten & Leitch, 1964).

In poorly-fed communities, it is a common occurrence for weight gains in pregnancy to be inadequate, while in Ceylon 5% of a group of women studied showed a loss of weight (Clements, 1961).

It is suggested tentatively that, pending more precise information, a weight gain of less than 10% between " early pregnancy " and full-term pregnancy should be regarded as an indicator of protein-calorie malnutrition, and that low weights should be expressed according to the following grouping: more than 10%; 10%-5%; less than 5%-no gain; loss of weight.

If accurate prenatal records are available for past years, the incidence of progressive decrease of weight with successive pregnancies should be determined (Venkatachalam, 1962a).

The suggested use of serial measurements of triceps skin-fold and arm circumference as indicators of calorie and protein reserves in pregnancy requires further investigation.

Biochemical tests. The nutritional problems of local importance determine the nature and usefulness of these tests. Special standards are required for pregnant women, but since these are not usually available, ordinary adult standards must be used tentatively,

Biochemical tests may be helpful, as in India, where Venkatachalam, Belavady & Gopalan (1962) found that women of the lower socio-economic group had low serum-vitamin-A levels, which were less during pregnancy. Sometimes, however, little change occurs, as in Guatemala, where Beaton, Arroyave & Flores (1964) found no evidence of lower serum-protein levels in poorer women as a result of multiple pregnancies and prolonged lactation. As they point out, this may be due to unknown processes of adaptation, to unexpected dietary adequacy, or to lack of sensitivity of present methods.

Haemoglobin levels are of great practical value in the nutritional assessment of pregnant women, especially in regions where maternal deaths occur from anaemia alone, or combined with normal blood-loss during delivery. Haemoglobin determinations should be made at each prenatal attendance, above all at the sixth month of pregnancy.

The interpretation of haemoglobin levels in pregnancy must take into account the normal physiological fall in level of about 2 g/100 ml due to

haemodilution. This pseudo-anaemia is associated with a decreased haematocrit reading, but no hypochromia.

Nutritional anaemia in pregnancy is sometimes caused by iron deficiency, or it may be megaloblastic, owing to an inadequate intake of folic acid and vitamin B_{12}, or possibly to increased excretion. Anaemia due to combined iron and folic-acid deficiency can occur.

If levels of haemoglobin are found below the standard for pregnant women, initial laboratory tests should include a haematocrit reading, a thin blood film (for cell morphology), a stool examination (for occult blood and hookworm ova), and a thick blood film for malarial parasites. If a diagnosis cannot be made with these simple tests, special investigations, such as bone-marrow and serum levels of iron, folic acid or vitamin B_{12}, are indicated (Annex 2).

Indirect assessment

For a number of complex reasons, maternal mortality and perinatal mortality are affected by the mother's socio-economic level, and figures should be collected, if practicable. A common source of these data is the biased samples attending prenatal clinics or admitted to hospital. Similar information should be sought concerning women seen in wards and clinics with various forms of maternal malnutrition, such as anaemia of pregnancy, osteomalacia, and beriberi.

Maternal malnutrition is among the causes of low birth-weights in both man (Wigglesworth, 1966) and livestock (Blaxter, 1957). In many parts of the world, the birth-weight in lower socio-economic groups is lower than in the well-to-do groups of the same genetic stock (Gopalan, 1957; Venkatachalam, 1962a; Udani, 1963).[1] At the same time, any study of birth-weights must also take account of a diversity of other factors (Jelliffe, 1966; Wigglesworth, 1966): genetic influences, maternal ill-health and overwork, smoking habits, placental malarial infection (E.F.P. Jelliffe, in preparation), frequency of multiple births,[2] lack of prenatal supervision, obstetrical abnormalities.

As approximate indicators of maternal malnutrition, birth-weights of singleton neonates may be usefully compared (*a*) with the usual " general standard of reference " (2.5 kg or 5½ lb), the so-called " prematurity " or " low birth weight " level (WHO Expert Committee on Maternal and Child Health, 1961); (*b*) with whatever has been calculated to be the local " special-care weight level " (e.g., in Kampala, 2 kg or 4½ lb) (Jelliffe, 1966); and (*c*) with the birth-weights of the newborn of the well-fed, modern-living

[1] Low-birth-weight neonates are not a homogeneous group, but include at least two overlapping entities: the gestationally premature, expelled from the uterus before term, and the underweight full-term baby (Jelliffe, 1966).

[2] The incidence of dizygous twinning varies greatly. In Japan, it is 2.7 per 1000 births; in Ibadan, Nigeria, 39.9 per 1000 births. The reason for the difference is not clear: though presumed to be genetic, it may be connected with other factors, including nutrition.

élite of the same genetic stock, which may be expressed as a " socio-economic birth-weight quotient " (Bengoa, Jelliffe & Perez, 1959).

Hospital figures of birth-weights should be used with caution as they are often made by junior midwives with ill-checked scales and with variations in techniques, such as taking the measurement with large artery forceps still clamped to the cord.

Birth-weight figures must be based on large samples, preferably numbering at least 1000 of careful weighings of naked singleton babies, and made within 6 hours of delivery.

Attention will also have to be paid to minimizing sampling errors, since there is a likelihood of hospitals admitting a high proportion of primiparae (Morley & Knox, 1960).

ADULTS

With the exception of pregnant and lactating women, adults are the least vulnerable segment of a population in so far as undernutrition is concerned. Nevertheless, certain groups need special consideration—for example, old people and persons engaged in heavy labour. In any event, healthy well-nourished adults are important as productive supporters of the family and as actual or potential parents.

In adulthood, growth has ceased, and the only physiological changes in body dimensions are those that result from ageing or that are associated with constant physical exercise. Consequently, selected anthropometric measurements in adults have a useful place in assessing past or present protein-calorie malnutrition, or overnutrition from an excessive intake of calories, presenting clinically as obesity. They can be useful, if repeated in a community in successive generations, in revealing a positive or negative secular trend.

Standards

As stressed earlier, anthropometric data should, if possible, be compared both with local and with general standards of reference. Data on subcutaneous skin-folds and arm circumference are based on average measurements made on large samples of apparently healthy, well-fed Caucasian adults, and may therefore be inappropriate, for genetic reasons, in other ethnic groups.

The cited weight-for-height standards are not based on average figures, but derived mathematically from " desirable " levels calculated by American insurance companies on the basis of a large-scale study of body build, blood pressure, and other factors affecting longevity (Society of Actuaries, 1959; ICNND, 1963). The figures have been adjusted for people of average frame measured nude (E. Bridgforth—personal communication, 1965).[1]

[1] A system of applying different standards for men and women of " large ", " medium " and " small " frame-sizes suggested by the Society of Actuaries (1959) has not been followed, since, although it would be desirable to take due notice of the lateral aspect of human physique as a factor affecting body weight, no definition of the different frame-sizes exists at present.

Standards are given for each sex for " 25 years and over ", because it is currently considered that the increase in weight in middle age commonly seen in well-fed communities is probably undesirable from the viewpoint of health.

Undernutrition in adults

Surveys to assess the nutritional status of adults in poorly-fed communities are normally carried out by a combination of methods previously described. Anthropometric measurements should, as a matter of routine, include the weight, height, triceps skin-fold and arm circumference: jointly these give a useful guide to the general state of protein-calorie nutrition of adults (Fig. 55).

The clinical picture and anthropometric changes in adult protein-calorie malnutrition vary with its duration—classified as brief, prolonged, chronic and lifelong (World Health Organization, 1951)—the degree of deprivation, associated deficiences (e.g., vitamin B complex) and the presence of complicating infections. The malnutrition may also be seasonal, as in the endemic, recurring oedema seen in some regions during the " hungry season ".

Investigations of extreme cases of protein-calorie malnutrition seen in starvation during famines, in volunteer experiments (Keys et al., 1950) and among victims of concentration camps

FIG. 55.

MODERATE PROTEIN-CALORIE MALNUTRITION IN AN ADULT, SHOWING BODY DISPROPORTION

(Helweg-Larsen et al., 1952) have all shown severe weight loss with no alteration in height save for that produced by stooping. Body weights more than 50% below the original level were observed, and must, in fact, have been still lower, as water retention is a well-recognized feature, even in the absence of oedema. The skin in such circumstances is loose and inelastic. Muscle and fat wasting are strikingly obvious, and demonstrable quantitatively by the decrease in limb measurements, including the arm circumference. The head and the bony prominences appear to be enlarged because of the disappearance of muscle and fat " padding ". The general appearance is that of a person twenty or thirty years older than the real age.

To the paediatrician, the clinical picture, with the exception of the " famine oedema " of advanced cases, is identical with that of nutritional marasmus (inanition) in young children, even to the " little old man " faces. Accordingly—more particularly in view of the lack of a clinical label for this type of severe protein-calorie malnutrition in adults—the use of the same generic term, adult nutritional marasmus,[1] seems justified. The age-specificity normally attached to the word " marasmus " is not implicit in its original derivation; in fact, the term has been used for adult cases by previous workers (Helweg-Larsen et al., 1952).

Examples of severe adult marasmus are not common, except in famines and analogous disasters. However, less advanced protein-calorie malnutrition occurs among adults, particularly during the " hungry season ", and among women as a result of continuous maternal depletion.

Throughout the world, the elderly are susceptible to lesser degrees of protein-calorie malnutrition, as well as to vitamin deficiencies, because of lack of teeth, diminished earning power, solitude, inability to cultivate the land and collect or cook foods, diminished appetite, and apathy. The assessment of protein-calorie malnutrition in the elderly is complicated by uncertainty as to the " physiological " range of changes in weight, muscle atrophy, skin changes, and the decline in height associated with ageing (Trotter & Gleser, 1951).

Degrees of undernutrition can be expressed in four levels underweight (90%-80%, 80%-71%, 70%-61%, and 60% and lower), with recorded weights compared with " desirable " standards, or with previous weight levels in health, if these are known.

Meaning of measurements. Low body weights for heights may be related to a number of factors, e.g., a light bone structure. For practical purposes, however, they are principally a reflection of body thinness due to subnormal amounts of subcutaneous fat and muscle, the result either of poor development, or tissue wasting, or a combination of the two. Correction may be

[1] A clinical picture similar to that of kwashiorkor can be seen in adults, including oedema, dyspigmented hair and lightening in colour of the body skin, and can occur in association with chronic pancreatic damage, including calcification.

necessary to account for oedema or for grossly enlarged viscera (e.g., hepatomegaly) if present.

Calorie reserves are indicated by thickness of subcutaneous fat, usually measured, for convenience, at the triceps skin-fold (Skerlj, Brozek & Hunt, 1953); protein inadequacy is best reflected by thin musculature, due either to poor development or to wasting. This may be assessed by calculation of the arm-muscle circumference (Mason, Mundkur & Jacob, 1963).

The arm circumference is a simple measurement, requires no calculation, and provides a rough index of both protein and calorie reserves, probably with especial emphasis on protein stores as reflected by muscle tissue. This measurement has not been much used in nutritional assessment work among adults in developing regions, although it has been found to be of value in New Guinea (Bailey, 1963b). In the USA, Ohlson et al. (1956) found a relation between arm circumference and under-weightness in Michigan.

Overnutrition in adults

Certain diseases, including obesity, diabetes, hypertension, atheroma and caries, are associated with dietary patterns characterized by high intakes of calories, fat and cane sugar, although other factors undoubtedly come into play, such as genetic constitution, the psychological stress of urban life, amount of exercise, etc. Certainly it is in these communities that probably unphysiological increases in weight, subcutaneous fat, serum cholesterol and blood pressure occur with age.

Obesity, mainly associated with an excessive calorie intake, is widespread in children and adults in more privileged parts of the world. It affects a very small proportion of well-to-do persons in most countries. The cause is primarily over-eating. It results mainly from easy accessibility to foods, especially high-calorie fats, together with insufficient exercise. In some countries, obesity is culturally desired—in women as a mark of beauty, for example, among the Zulus (Abramson et al., 1961), or in either sex as a symbol of wealth and prestige, as in the rulers of ancient Hawaii (Jelliffe & Jelliffe, 1964).

Community surveys can use the chest/abdomen circumference ratio in males (Welham & Behnke, 1942), the weight-for-height measurements and the skin-fold thicknesses as screening tests. Abnormal levels are difficult to define, but Jolliffe (1962) suggests 10% over the "desirable" weight standard as a rough guide, if taken in conjunction with skin-fold measurements. Where subcutaneous fat is concerned, many authorities prefer a composite fat thickness, calculated by adding together results obtained at several sites. Jolliffe (1962) gives figures for combined readings from the triceps, subscapular and lateral chest sites. As a useful approximation, Mayer (1959) suggests that men should be considered obese if the triceps skin-fold exceeds 15 mm, and women if it exceeds 25 mm.

Obesity appears to be associated with a reduced expectation of life, as well as with a higher risk of hypertension and diabetes (Society of Actuaries, 1959). Screening tests for these conditions in field studies consist of blood-pressure measurements carefully taken under standard conditions, and urine examinations for sugar with easily transportable, chemically impregnated paper test-strips.

The etiology of atheroma is complex. Multiple factors are undoubtedly present, and they differ from one community to another. Field surveys are usually based on estimations of serum-cholesterol levels and electro-cardiographic tracings taken with a portable machine from men between 40 and 60 years of age. Results have to be correlated with height, weight and blood-pressure determinations, and considered together with the incidence figures of coronary-thrombosis cases in the area and such autopsy findings from adult hearts as may be available in adjacent hospitals.

The interpretation of serum-cholesterol levels is difficult, even though methods for comparing data from observers employing different techniques have been established. Levels can be raised or lowered in a short period by diets high in animal fat without in any way reflecting the presence or absence of any associated atheromatous deposits in the coronary arteries. However, on these premises, and subject to the reservation that the incidence of atheroma in a population has to be related to various aspects of the whole way of life, the probability of a community having a high rate of atheroma is greater if serum-cholesterol levels are " high " (250 ± 30 mg/100 ml) rather than " low " (120 ± 30 mg/100 ml).

Caries is also a disease of multiple causation, including the fluoride content of the drinking-water, genetic susceptibility, nutritional status and the oral effect of the diet itself. In particular, studies based on methods of geographical pathology have disclosed, among different peoples, a considerable incidence in groups whose diet is high in refined sugars and flours, as distinct from communities subsisting on unprocessed, natural animal and vegetable foods containing little free sugar and considerable cellulose fibre and roughage.

Caries is currently a major problem in technically developed parts of the world. It is also increasingly prevalent in children and adults in every part of the world, mainly because of dietary changes so often associated with urbanization and the cultural modifications it entails.

Caries should receive attention in general nutrition surveys, at least to the extent of determining its prevalence. The procedures recommended by the WHO Expert Committee on Dental Health (1962) and Wilson et al. (1964) are guides to more intensive, specialized community surveys.

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Annex 1

GENERAL ANTHROPOMETRIC STANDARDS OF REFERENCE

(1) WEIGHT FOR AGE, BIRTH TO 60 MONTHS, SEXES COMBINED *

Age (months)	Weight (kg)				
	Standard	90 % standard	80 % standard	70 % standard	60 % standard
0	3.4	3.0	2.7	2.4	2.0
1	4.3	3.7	3.4	2.9	2.5
2	5.0	4.4	4.0	3.4	2.9
3	5.7	5.1	4.5	4.0	3.4
4	6.3	5.7	5.0	4.5	3.8
5	6.9	6.2	5.5	4.9	4.2
6	7.4	6.7	5.9	5.2	4.5
7	8.0	7.1	6.3	5.5	4.9
8	8.4	7.6	6.7	5.9	5.1
9	8.9	8.0	7.1	6.2	5.3
10	9.3	8.4	7.4	6.5	5.5
11	9.6	8.7	7.7	6.7	5.8
12	9.9	8.9	7.9	6.9	6.0
13	10.2	9.1	8.1	7.1	6.2
14	10.4	9.35	8.3	7.3	6.3
15	10.6	9.5	8.5	7.4	6.4
16	10.8	9.7	8.7	7.6	6.6
17	11.0	9.9	8.9	7.8	6.7
18	11.3	10.1	9.0	7.9	6.8
19	11.5	10.3	9.2	8.1	7.0
20	11.7	10.5	9.4	8.2	7.1
21	11.9	10.7	9.6	8.3	7.2
22	12.05	10.9	9.7	8.4	7.3
23	12.2	11.1	9.8	8.6	7.4
24	12.4	11.2	9.9	8.7	7.5
25	12.6	11.4	10.1	8.9	7.6
26	12.7	11.6	10.3	9.0	7.7
27	12.9	11.8	10.5	9.2	7.8
28	13.1	12.0	10.6	9.3	7.9
29	13.3	12.1	10.7	9.4	8.0
30	13.5	12.2	10.8	9.5	8.1
31	13.7	12.4	11.0	9.7	8.2
32	13.8	12.5	11.1	9.8	8.3
33	14.0	12.65	11.2	9.9	8.4
34	14.2	12.8	11.3	10.0	8.5
35	14.4	12.9	11.5	10.1	8.6
36	14.5	13.1	11.6	10.2	8.7
37	14.7	13.2	11.8	10.3	8.8
38	14.85	13.4	11.9	10.4	8.9
39	15.0	13.5	12.05	10.5	9.0
40	15.2	13.6	12.2	10.6	9.1
41	15.35	13.75	12.3	10.7	9.2
42	15.5	13.9	12.4	10.8	9.3
43	15.7	14.0	12.6	10.9	9.4
44	15.85	14.2	12.7	11.05	9.5
45	16.0	14.4	12.9	11.2	9.6
46	16.2	14.6	12.95	11.3	9.7
47	16.35	14.7	13.1	11.4	9.8
18	16.5	14.8	13.2	11.5	9.9
49	16.65	15.0	13.35	11.6	10.0
50	16.8	15.2	13.5	11.75	10.1
51	16.95	15.3	13.65	11.9	10.2
52	17.1	15.45	13.8	12.0	10.3
53	17.25	15.6	13.9	12.1	10.4
54	17.4	15.7	14.0	12.2	10.5
55	17.6	15.85	14.2	12.3	00.6
56	17.7	16.0	14.3	12.4	10.7
57	17.9	16.15	14.4	12.6	10.75
58	18.05	16.3	14.5	12.7	10.8
59	18.25	16.4	14.6	12.8	10.9
60	18.4	16.5	14.7	12.9	11.0

* Values derived from Harvard Standards—Stuart & Stevenson (1959).

(2) LENGTH FOR AGE, BIRTH TO 60 MONTHS SEXES COMBINED *

Age (months)	Length (cm)				
	Standard	90 % standard	80 % standard	70 % standard	60 % standard
0	50.4	45.4	40.3	35.3	30.2
1	54.8	48.7	43.3	38.3	32.5
2	58.0	51.7	46.2	40.5	34.5
3	60.0	54.0	48.0	42.0	36.0
4	62.3	56.3	49.5	43.3	37.3
5	64.4	58.1	51.1	44.8	38.5
6	65.8	59.2	52.6	46.1	39.5
7	67.6	60.7	54.1	47.2	40.5
8	69.2	62.0	55.3	48.3	41.5
9	70.7	63.6	56.5	49.5	42.4
10	72.2	64.9	57.7	50.4	43.2
11	73.5	66.0	58.8	51.3	44.1
12	74.7	67.2	59.8	52.3	44.8
13	76.0	68.3	60.7	53.1	45.4
14	77.1	69.3	61.6	54.0	46.2
15	78.1	70.3	62.4	54.6	46.8
16	79.3	71.3	63.3	55.4	47.5
17	80.5	72.3	64.2	56.3	48.2
18	81.4	73.2	65.1	57.0	48.8
19	82.7	74.2	65.8	57.7	49.4
20	83.5	75.1	66.9	58.4	50.0
21	84.4	76.0	67.4	59.0	50.7
22	85.4	76.9	68.3	59.7	51.3
23	86.3	77.7	68.9	60.2	51.8
24	87.1	78.4	69.6	60.9	52.2
25	88.0	79.1	70.3	61.2	52.7
26	88.8	80.0	71.0	62.0	53.3
27	89.7	80.7	71.5	62.7	53.8
28	90.4	81.3	72.2	63.2	54.2
29	91.3	82.0	72.8	63.7	54.7
30	91.8	82.6	73.4	64.2	55.1
31	92.6	83.2	74.0	64.7	55.5
32	93.3	83.7	74.6	65.2	56.0

(2) LENGTH FOR AGE, BIRTH TO 60 MONTHS, SEXES COMBINED *(continued)*

Age (months)	Length (cm)				
	Standard	90 % standard	80 % standard	70 % standard	60 % standard
33	94.0	84.4	75.1	65.7	56.3
34	94.7	85.0	75.7	66.2	56.7
35	95.3	85.7	76.3	66.7	57.2
36	96.0	86.4	76.8	67.2	57.6
37	96.6	87.0	77.3	67.6	58.0
38	97.3	87.5	78.0	68.1	58.3
39	97.9	88.0	78.4	68.6	58.7
40	98.4	88.5	78.9	69.0	59.2
41	99.1	89.1	79.3	69.4	59.5
42	99.7	89.7	79.7	69.8	59.8
43	100.3	90.3	80.2	70.3	60.2
44	101.0	90.9	80.7	70.7	60.5
45	101.6	91.5	81.3	71.1	60.9
46	102.1	92.0	81.7	71.5	61.2
47	102.7	92.6	82.1	72.0	61.7
48	103.3	93.0	82.6	72.3	62.0
49	103.8	93.6	83.2	72.7	62.3
50	104.5	94.0	83.6	73.1	62.7
51	105.2	94.5	84.0	73.4	63.1
52	105.7	95.1	84.4	73.8	63.5
53	106.2	95.6	84.9	74.3	63.8
54	106.8	96.1	85.4	74.7	64.1
55	107.3	96.5	85.7	75.0	64.4
56	107.9	96.8	86.0	75.3	64.7
57	108.2	97.2	86.3	75.7	64.9
58	108.5	97.5	86.7	75.9	65.1
59	108.7	97.7	86.9	76.1	65.2
60	109.0	98.0	87.1	76.2	65.3

* Values derived from Harvard Standards—Stuart & Stevenson (1959).

(3) WEIGHT FOR LENGTH, YOUNG CHILDREN, SEXES COMBINED. 52-108 cm IN LENGTH*

Length (cm)	Weight (kg)				
	Standard	90 % standard	80 % standard	70 % standard	60 % standard
52	3.8	3.4	3.0	2.7	2.3
53	4.0	3.6	3.2	2.8	2.4
54	4.3	3.9	3.4	3.0	2.6
55	4.6	4.1	3.6	3.2	2.7
56	4.8	4.3	3.8	3.4	2.9
57	5.0	4.5	3.9	3.5	3.0
58	5.2	4.7	4.2	3.6	3.1
59	5.5	4.9	4.4	3.8	3.3
60	5.7	5.1	4.6	4.0	3.4
61	6.0	5.4	4.8	4.2	3.6
62	6.3	5.7	5.0	4.4	3.8
63	6.6	5.9	5.3	4.6	3.9
64	6.9	6.2	5.5	4.8	4.1
65	7.2	6.5	5.8	5.0	4.3
66	7.5	6.8	6.0	5.3	4.5
67	7.8	7.0	6.2	5.5	4.7
68	8.1	7.3	6.5	5.7	4.9
69	8.4	7.6	6.7	5.9	5.0
70	8.7	7.8	7.0	6.1	5.2
71	9.0	8.1	7.2	6.2	5.3
72	9.2	8.3	7.4	6.4	5.5
73	9.5	8.5	7.6	6.6	5.6
74	9.7	8.7	7.8	6.8	5.8
75	9.9	9.0	8.0	6.9	5.9
76	10.2	9.2	8.3	7.1	6.1
77	10.4	9.4	8.3	7.2	6.2
78	10.6	9.5	8.5	7.4	6.4
79	10.8	9.7	8.6	7.5	6.5
80	11.0	9.9	8.8	7.7	6.6
81	11.2	10.1	9.0	7.8	6.7
82	11.4	10.3	9.1	8.0	6.8
83	11.6	10.4	9.2	8.1	6.9
84	11.8	10.6	9.4	8.3	7.1

(3) WEIGHT FOR LENGTH, YOUNG CHILDREN, SEXES COMBINED, 52-108 cm IN LENGTH
(continued)

Length (cm)	Weight (kg)				
	Standard	90 % standard	80 % standard	70 % standard	60 % standard
85	12.0	10.7	9.6	8.4	7.2
86	12.2	11.0	9.8	8.5	7.3
87	12.4	11.1	9.9	8.6	7.4
88	12.6	11.3	10.1	8.8	7.6
89	12.8	11.5	10.2	9.0	7.7
90	13.1	11.8	10.5	9.2	7.9
91	13.4	11.9	10.7	9.3	8.0
92	13.6	12.2	10.9	9.5	8.2
93	13.8	12.4	11.0	9.6	8.3
94	14.0	12.6	11.2	9.8	8.4
95	14.3	12.8	11.4	10.0	8.5
96	14.5	13.1	11.6	10.2	8.7
97	14.7	13.3	11.8	10.3	8.8
98	15.0	13.5	12.0	10.5	9.0
99	15.3	13.7	12.3	10.7	9.2
100	15.6	14.0	12.5	10.9	9.4
101	15.8	14.2	12.6	11.1	9.5
102	16.1	14.5	12.9	11.3	9.7
103	16.4	14.7	13.2	11.5	9.8
104	16.7	15.0	13.4	11.7	10.0
105	17.0	15.3	13.6	11.9	10.1
106	17.3	15.6	13.8	12.1	10.4
107	17.6	15.9	14.0	12.3	10.5
108	18.0	16.2	14.4	12.6	10.8

* Values derived from Harvard Standards—Stuart & Stevenson (1959).

(4) WEIGHT FOR HEAD CIRCUMFERENCE, YOUNG CHILDREN, SEXES COMBINED *

Head circumference (cm)	Weight (kg)				
	Standard	90 % standard	80 % standard	70 % standard	60 % standard
35.0	3.4	3.1	2.7	2.6	2.0
35.5	3.6	3.3	2.9	2.6	2.1
36.0	3.8	3.4	3.0	2.7	2.3
36.5	4.0	3.6	3.2	2.8	2.4
37.0	4.2	3.8	3.4	2.9	2.5
37.5	4.4	3.9	3.5	3.1	2.6
38.0	4.6	4.1	3.7	3.2	2.8
38.5	4.8	4.3	3.8	3.3	2.9
39.0	5.0	4.5	4.0	3.5	3.0
39.5	5.2	4.7	4.2	3.7	3.1
40.0	5.5	5.0	4.4	3.9	3.3
40.5	5.7	5.2	4.6	4.0	3.4
41.0	6.0	5.4	4.8	4.2	3.6
41.5	6.3	5.6	5.0	4.4	3.8
42.0	6.6	5.9	5.3	4.6	4.0
42.5	6.9	6.2	5.5	4.8	4.2
43.0	7.2	6.5	5.8	5.0	4.3
43.5	7.5	6.8	6.0	5.2	4.5
44.0	7.9	7.1	6.3	5.5	4.7
44.5	8.2	7.4	6.6	5.7	5.0
45.0	8.6	7.7	6.9	6.0	5.2
45.5	9.0	8.1	7.2	6.3	5.4
46.0	9.4	8.5	7.5	6.6	5.6
46.5	9.8	8.9	7.8	6.9	5.9
47.0	10.3	9.3	8.2	7.2	6.2
47.5	10.9	9.8	8.7	7.6	6.5
48.0	11.4	10.3	9.1	8.0	6.8
48.5	11.9	10.7	9.5	8.3	7.1
49.0	12.6	11.3	10.1	8.8	7.6
49.5	13.6	12.3	10.9	9.5	8.2
50.0	15.1	13.6	12.1	10.6	9.1

* Calculated from Table (1) of this Annex and Table 6 of the text.

(5) TRICEPS SKIN-FOLD, BIRTH TO 60 MONTHS, SEXES SEPARATE*

Age (months)	Triceps skin-fold (mm)									
	Standard		90 % standard		80 % standard		70 % standard		60 % standard	
	M	F	M	F	M	F	M	F	M	F
Birth	6.0	6.5	5.4	5.9	4.8	5.2	4.2	4.6	3.6	3.9
6	10.0	10.0	9.0	9.0	8.0	8.0	7.0	7.0	6.0	6.0
12	10.3	10.2	9.3	9.2	8.2	8.2	7.2	7.1	6.2	6.1
18	10.3	10.2	9.3	9.2	8.2	8.2	7.2	7.1	6.2	6.1
24	10.0	10.1	9.0	9.1	8.0	8.1	7.0	7.1	6.0	6.1
36	9.3	9.7	8.4	8.7	7.5	7.8	6.5	6.8	5.6	5.8
48	9.3	10.2	8.4	9.2	7.5	8.2	6.5	7.2	5.6	6.1
60	9.1	9.4	8.2	8.5	7.3	7.5	6.4	6.6	5.5	5.7

* Adapted from Hammond (1955a); Tanner & Whitehouse (1962).

(6) ARM CIRCUMFERENCE, 1-60 MONTHS, SEXES SEPARATE*

Age (months)	Arm circumference (cm)									
	Standard		90 % standard		80 % standard		70 % standard		60 % standard	
	M	F	M	F	M	F	M	F	M	F
1	11.5	11.1	10.3	10.0	9.2	8.9	8.0	7.8	6.9	6.7
2	12.5	12.0	11.2	10.8	10.0	9.6	8.7	8.4	7.5	7.2
3	12.7	13.3	11.4	12.0	10.2	10.6	8.9	9.3	7.6	8.0
4	14.6	13.5	13.2	12.1	11.7	10.8	10.2	9.4	8.8	8.1
5	14.7	13.9	13.2	12.5	11.7	11.1	10.3	9.7	8.8	8.3
6	14.5	14.3	13.1	12.9	11.6	11.5	10.2	10.0	8.7	8.6
7	15.0	14.6	13.5	13.2	12.0	11.7	10.5	10.2	9.0	8.8
8	15.5	15.0	14.0	13.5	12.4	12.0	10.9	10.5	9.3	9.0
9	15.8	15.3	14.2	13.7	12.6	12.2	11.0	10.7	9.5	9.2
10	15.8	15.4	14.2	13.8	12.6	12.3	11.1	10.8	9.5	9.2
11	15.8	15.5	14.3	14.0	12.7	12.4	11.1	10.9	9.5	9.3
12	16.0	15.6	14.4	14.0	12.8	12.5	11.2	10.9	9.6	9.4
15	16.1	15.7	14.5	14.1	12.9	12.5	11.3	11.0	9.7	9.4
18	15.7	16.1	14.1	14.5	12.5	12.9	11.0	11.3	9.4	9.7
21	16.2	15.9	14.6	14.3	13.0	12.7	11.4	11.1	9.7	9.6
24	16.3	15.9	14.7	14.4	13.0	12.8	11.4	11.2	9.8	9.6
27	16.6	16.4	15.0	14.7	13.3	13.1	11.7	11.5	10.0	9.8
30	16.4	16.4	14.8	14.8	13.1	13.1	11.5	11.5	9.9	9.8
33	16.4	16.1	14.8	14.5	13.1	12.9	11.5	11.3	9.8	9.7
36	16.2	15.9	14.6	14.3	13.0	12.7	11.3	11.1	9.7	9.6
39	16.9	17.4	15.2	15.7	13.5	14.0	11.8	12.2	10.1	10.5
42	16.5	16.3	15.0	14.7	13.2	13.1	11.6	11.4	9.9	9.8
45	16.7	16.8	15.0	15.1	13.4	13.5	11.7	11.8	10.0	10.1
48	16.9	16.9	15.2	15.2	13.5	13.5	11.8	11.8	10.1	10.2
51	17.2	16.8	15.5	15.1	13.8	13.4	12.0	11.7	10.3	10.1
54	17.5	16.6	15.7	15.0	14.0	13.3	12.2	11.7	10.5	10.0
57	17.2	16.8	15.5	15.1	13.8	13.4	12.1	11.7	10.4	10.1
60	17.0	16.9	15.3	15.2	13.6	13.5	11.9	11.8	10.2	10.1

* From Wolanski (personal communication, 1964).

(7) MID-ARM-MUSCLE CIRCUMFERENCE, 6-60 MONTHS, SEXES SEPARATE *

Age (months)	Mid-arm-muscle circumference (cm)									
	Standard		90 % standard		80 % standard		70 % standard		60 % standard	
	M	F	M	F	M	F	M	F	M	F
6	11.4	11.2	10.3	10.1	9.1	9.0	8.0	7.8	6.8	6.7
12	12.7	12.4	11.4	11.2	10.2	9.9	8.9	8.7	7.6	7.4
18	12.9	12.5	11.6	11.3	10.3	10.1	9.0	8.8	7.7	7.6
24	13.1	12.8	11.8	11.5	10.5	10.2	9.2	9.0	7.9	7.7
36	13.3	12.9	12.0	11.6	10.3	10.3	9.3	9.0	8.0	7.7
48	14.0	13.7	12.6	12.3	11.2	11.0	9.8	9.6	8.4	8.2
60	14.1	13.9	12.7	12.5	11.3	11.1	9.9	9.7	8.5	8.3

* Calculated from Tables (5) and (6) of this Annex.

(8) WEIGHT FOR HEIGHT FOR AGE, 6-19 YEARS, BOYS

Translated and extended from the Baldwin-Wood tables in the English system of measurement by B. T. Baldwin.
Issued by the Iowa Child Welfare Research Station, State University of Iowa, September 1924 (Baldwin, 1925; Baldwin & Wood, 1923)

Height (cm)	Weight (kg)														Height (cm)
	6 years	7 years	8 years	9 years	10 years	11 years	12 years	13 years	14 years	15 years	16 years	17 years	18 years	19 years	
97	*15.0														97
98	*15.1														98
99	*15.3														99
100	*15.5														100
101	*15.7														101
102	*15.9														102
103	*16.1														103
104	16.6														104
105	16.8	*16.8													105
106	17.0	*17.0													106
107	17.2	*17.2	*17.2												107
108	17.5	*17.6	*17.4												108
109	17.8	*17.9	*17.7												109
110	18.3	*18.4	*18.2												110
111	18.9	*18.9	*18.8												111
112	19.4	19.4	*19.4												112
113	19.7	19.7	*19.7												113
114	20.0	20.0	*20.0												114
115	20.4	20.4	*20.4	*20.3											115
116	20.7	20.8	20.7	*20.6											116
117	21.1	21.5	21.1	*21.2											117
118	21.5	21.8	21.4	*21.4											118
119	21.9	21.9	21.8	*21.7											119
120	22.3	22.4	22.2	*22.2	*22.2										120
121	22.5	22.8	22.7	*22.7	*22.7										121
122	22.9	23.2	23.1	23.2	*23.2										122
123	23.4	23.5	23.6	23.6	*23.5										123
124	23.9	23.8	24.1	24.0	*23.8										124
125	24.3	24.3	24.5	24.4	24.2	*24.4									125
126	*24.6	24.9	24.9	24.9	24.8	*24.9									126
127	*25.0	25.3	25.3	25.3	25.4	*25.4	*25.4								127
128		25.9	25.9	25.7	25.9	*25.9	*25.9								128
129		26.4	26.5	26.2	26.4	*26.4	*26.4								129
130		26.9	27.0	26.7	26.8	27.0	*26.9								130
131		27.2	27.4	27.3	27.3	27.5	*27.3								131
132		27.5	27.9	27.8	27.8	28.0	27.7								132
133		*28.0	28.4	28.4	28.3	28.5	28.3	*28.5							133
134		*28.5	28.9	28.9	28.8	28.9	29.0	*29.3							134
135			29.4	29.4	29.3	29.4	29.6	*29.9							135
136			30.0	29.9	29.7	29.8	30.3	*30.3							136
137			30.6	30.4	30.2	30.2	30.9	*30.7							137
138			*30.9	30.8	30.9	30.8	31.3	31.2	*31.7						138
139			*31.2	31.1	31.5	31.5	31.9	31.8	*32.0						139

140			*31.6	31.6	32.2	32.2	32.4	32.4	*32.5							140
141			*32.1	32.3	32.9	32.8	32.9	33.2	*33.1							141
142			*32.6	33.1	33.7	33.5	33.4	34.0	*33.7							142
143				*33.6	34.1	34.2	34.1	34.7	34.5	*35.3						143
144				*34.1	34.4	35.0	34.7	35.2	35.5	*35.8						144
145				*34.6	34.9	35.7	35.4	35.8	36.3	*36.3						145
146				*35.3	35.7	36.2	36.2	36.5	36.9	*37.0						146
147				*36.0	36.5	36.7	36.9	37.1	37.4	*37.7						147
148					37.0	37.2	37.6	37.8	38.0	38.2						148
149					37.5	37.8	38.2	38.4	38.6	38.7						149
150					38.1	38.5	39.0	39.1	39.3	39.3	39.2					150
151					*38.7	39.2	39.5	39.7	40.0	40.3	40.3					151
152					*39.4	39.9	40.0	40.3	40.7	41.3	41.5					152
153						40.5	40.6	41.1	41.6	42.1	42.6					153
154						41.0	41.4	41.9	42.5	42.8	43.7					154
155						41.5	42.1	42.7	43.4	43.5	44.8	*46.3				155
156						*42.3	42.9	43.4	44.0	44.2	45.5	*47.2				156
157						*43.2	43.8	44.1	44.7	44.9	46.3	48.1				157
158						*44.0	44.6	44.9	45.5	45.8	47.3	49.2	*51.3			158
159						*44.9	45.4	45.8	46.4	46.9	48.6	50.3	*52.6			159
160						*45.8	46.2	46.7	47.4	48.0	49.8	51.5	53.9	*55.4		160
161							47.4	47.3	48.1	48.8	50.2	52.0	54.4	*55.9		161
162							48.7	48.0	48.8	49.6	50.6	52.5	54.9	*56.4		162
163							49.4	48.8	49.6	50.5	51.2	53.2	55.5	*57.0		163
164							*49.6	49.9	50.5	51.4	52.1	54.1	56.3	*57.7		164
165							*49.7	50.9	51.4	52.3	53.1	55.1	57.1	58.3		165
166								51.4	52.1	53.2	54.1	56.1	57.9	59.3		166
167								51.8	52.9	54.0	55.1	57.0	58.7	60.3		167
168								52.3	53.7	54.8	56.1	57.8	59.4	61.0		168
169								*53.1	54.7	55.7	57.1	58.5	60.0	61.4		169
170								*53.9	55.6	56.5	58.1	59.1	60.5	61.7		170
171									56.7	57.3	58.8	59.9	61.2	62.5		171
172									57.8	58.0	59.5	60.9	62.0	63.4		172
173									58.7	58.7	60.2	61.8	62.8	64.2		173
174									59.2	59.6	61.1	62.7	63.8	65.1		174
175									59.7	60.4	61.9	63.5	64.7	65.9		175
176									60.5	61.2	62.5	64.0	65.3	66.5		176
177									61.4	62.0	62.9	64.3	65.7	67.2		177
178									62.4	62.8	63.4	64.7	66.1	67.8		178
179									*63.3	63.9	64.5	65.4	66.6	68.4		179
180									*64.2	65.1	65.7	66.1	67.1	68.8		180
181										65.8	66.4	66.7	67.7	69.6		181
182										66.3	67.0	67.3	68.3	70.4		182
183										66.9	67.6	68.0	69.0	71.2		183
184										*67.5	68.6	69.1	70.1	71.8		184
185										*68.2	69.5	70.3	71.3	72.5		185
186										*68.8	70.3	71.3	72.2	73.2		186
187										*69.3	71.0	72.3	73.1	73.8		187
188										*69.8	71.7	73.3	73.9	74.4		188

Starred (*) figures represent values based on theoretical computations rather than on exact averages. Age is taken at the nearest birthday, height at the nearest centimetre, weight at the nearest tenth of a kilogramme.

(9) WEIGHT FOR HEIGHT FOR AGE, 6-18 YEARS, GIRLS

Translated and extended from the Baldwin-Wood tables in the English system of measurement by B. T. Baldwin.
Issued by the Iowa Child Welfare Research Station, State University of Iowa, September 1924 (Baldwin, 1925; Baldwin & Wood, 1923)

Height (cm)	Weight (kg)													Height (cm)
	6 years	7 years	8 years	9 years	10 years	11 years	12 years	13 years	14 years	15 years	16 years	17 years	18 years	
100	15.3													100
101	15.7													101
102	16.0	*16.0												102
103	16.1	*16.1												103
104	16.3	*16.3												104
105	16.6	*16.6												105
106	16.8	*16.8												106
107	17.1	17.1												107
108	17.6	17.5												108
109	18.0	17.8												109
110	18.2	18.1	*18.2											110
111	18.4	18.5	*18.4											111
112	18.6	18.8	*18.6											112
113	19.2	19.3	*19.1											113
114	19.7	19.8	*19.7											114
115	20.2	20.1	20.2											115
116	20.6	20.3	20.8											116
117	21.0	20.5	21.3	*21.2	*21.2									117
118	21.4	21.1	21.5	*21.5	*21.5									118
119	21.8	21.8	21.8	*21.9	*21.9									119
120	22.3	22.3	22.2	*22.3	*22.3									120
121	22.7	22.7	22.7	*22.7	*22.9									121
122	23.1	23.1	23.1	23.2	23.4	*23.4								122
123	23.3	23.4	23.5	23.6	23.8	*23.7								123
124	23.4	23.7	23.8	24.2	24.1	*24.0								124
125	23.7	24.1	24.3	24.7	24.6	*24.7								125
126	*24.2	24.4	24.8	25.2	25.3	*25.8								126
127	*24.7	24.8	25.4	25.8	26.0	26.9	26.9							127
128		25.2	25.8	26.2	26.4	27.2	*27.1							128
129		25.7	26.2	26.6	26.7	27.5	*27.3							129
130		*26.3	26.7	27.0	27.1	27.9	27.3							130
131		*27.1	27.4	27.5	27.7	28.2	28.4							131
132		*27.8	28.1	28.0	28.2	28.6	29.5							132
133		*28.4	28.6	28.6	28.8	29.1	29.9							133
134		*28.9	29.1	29.2	29.5	29.6	30.3							134
135			29.6	29.8	30.1	30.1	30.7	*31.5						135
136			30.0	30.4	30.5	30.7	31.0	*31.9						136
137			30.4	31.0	31.0	31.3	31.4	*32.2						137

| | | |

(10) WEIGHT FOR HEIGHT, BOYS *

Height (cm)	Weight (kg)				
	Standard	90 % standard	80 % standard	70 % standard	60 % standard
112	19.7	17.7	15.8	13.8	11.8
114	20.6	18.5	16.5	14.4	12.4
116	21.3	19.2	17.0	14.9	12.8
118	22.1	19.9	17.7	15.5	13.3
120	22.9	20.6	18.3	16.0	13.7
122	23.7	21.3	19.0	16.6	14.2
124	24.5	22.1	19.6	17.2	14.7
126	25.4	22.9	20.3	17.8	15.2
128	26.4	23.8	21.1	18.5	15.8
130	27.3	24.6	21.8	19.1	16.4
132	28.2	25.4	22.6	19.7	16.9
134	29.2	26.3	23.4	20.4	17.5
136	30.2	27.2	24.2	21.1	18.1
138	31.4	28.3	25.1	22.0	18.8
140	32.5	29.3	26.0	22.8	19.5
142	33.7	30.3	27.0	23.6	20.2
144	35.1	31.6	28.1	24.6	21.1
146	36.2	32.6	29.0	25.3	21.7
148	37.4	33.7	29.9	26.2	22.4
150	38.6	34.7	30.9	27.0	23.2
152	40.0	36.0	32.0	28.0	24.0
154	41.4	37.4	33.1	29.0	24.8
156	43.1	38.8	34.5	30.2	25.9
158	44.7	40.2	35.8	31.3	26.8
160	46.5	41.9	37.2	32.6	27.9
162	48.2	43.4	38.6	33.7	28.9
164	50.2	45.2	40.2	35.1	30.1
166	52.5	47.3	42.0	36.8	31.5
168	54.8	49.3	43.8	38.4	32.9
170	57.0	51.3	45.6	40.0	34.2
172	59.4	53.5	47.5	41.6	35.6
174	62.2	56.0	49.8	43.6	37.3

* Values derived from Harvard Standards—Stuart & Stevenson (1959).

(11) WEIGHT FOR HEIGHT, GIRLS *

Height (cm)	Weight (kg)				
	Standard	90 % standard	80 % standard	70 % standard	60 % standard
110	18.8	16.9	15.0	13.2	11.3
112	19.6	17.6	15.7	13.7	11.8
114	20.4	18.4	16.3	14.3	12.2
116	21.2	19.1	17.0	14.8	12.7
118	22.0	19.8	17.6	15.4	13.2
120	22.8	20.5	18.2	16.0	13.7
122	23.6	21.2	18.9	16.5	14.2
124	24.5	22.1	19.6	17.2	14.7
126	25.4	22.9	20.3	17.8	15.3
128	26.4	23.8	21.1	18.5	15.8
130	27.4	24.7	21.9	19.2	16.4
132	28.5	25.7	22.8	20.0	17.1
134	29.5	26.6	23.6	20.7	17.7
136	30.6	27.5	24.5	21.4	18.4
138	31.6	28.4	25.3	22.1	19.0
140	32.8	29.5	26.2	23.0	19.7
142	34.0	30.6	27.2	23.8	20.4
144	35.3	31.8	28.2	24.7	21.2
146	36.5	32.9	29.2	25.6	21.9
148	37.7	33.9	30.2	26.4	22.6
150	38.7	34.8	31.0	27.1	23.2
152	39.8	35.8	31.8	27.9	23.9
154	42.0	37.8	33.6	29.4	25.2
156	43.9	39.5	35.1	30.7	26.3
158	46.4	41.8	37.1	32.5	27.8
160	49.7	44.7	39.8	34.8	29.8
162	52.7	47.4	42.2	36.9	31.6

* Values derived from Harvard Standards—Stuart & Stevenson (1959).

(12) TRICEPS SKIN-FOLD, 5-15 YEARS, SEXES SEPARATE *

Age (years)	Triceps skin-fold (mm)									
	Standard		90 % standard		80 % standard		70 % standard		60 % standard	
	M	F	M	F	M	F	M	F	M	F
5	9.1	9.4	8.2	8.5	7.3	7.5	6.4	6.6	5.5	5.7
6	8.2	9.6	7.4	8.6	6.6	7.7	5.8	6.7	4.9	5.8
7	7.9	9.4	7.1	8.5	6.3	7.5	5.5	6.6	4.7	5.7
8	7.6	10.1	6.8	9.1	6.1	8.1	5.3	7.1	4.5	6.1
9	8.2	10.3	7.4	9.2	6.6	8.2	5.8	7.2	4.9	6.2
10	8.2	10.4	7.4	9.3	6.6	8.3	5.7	7.3	4.9	6.2
11	8.9	10.6	8.1	9.6	7.2	8.5	6.3	7.5	5.4	6.4
12	8.5	10.1	7.6	9.1	6.8	8.1	5.9	7.0	5.1	6.0
13	8.1	10.4	7.3	9.4	6.5	8.3	5.7	7.3	4.9	6.2
14	7.9	11.3	7.1	10.1	6.3	9.0	5.5	7.9	4.8	6.8
15	6.3	11.4	5.7	10.2	5.0	9.1	4.4	8.0	3.8	6.8

* Adapted from Hammond (1955a).

(13) ARM CIRCUMFERENCE, 6-17 YEARS, SEXES SEPARATE *

Age (years)	Arm circumference (cm)									
	Standard		90 % standard		80 % standard		70 % standard		60 % standard	
	M	F	M	F	M	F	M	F	M	F
6	17.3	17.3	15.6	15.5	13.8	13.8	12.1	12.1	10.4	10.4
7	17.8	17.8	16.0	16.0	14.2	14.2	12.5	12.5	10.7	10.7
8	18.4	18.4	16.5	16.6	14.7	14.7	12.9	12.9	11.0	11.1
9	19.0	19.1	17.1	17.2	15.2	15.3	13.3	13.4	11.4	11.5
10	19.7	19.9	17.7	17.9	15.8	15.9	13.8	13.9	11.8	11.9
11	20.4	20.7	18.4	18.6	16.3	16.5	14.3	14.5	12.2	12.4
12	21.2	21.5	19.1	19.3	16.9	17.2	14.8	15.0	12.7	12.9
13	22.2	22.4	20.0	20.2	17.7	17.9	15.5	15.7	13.3	13.4
14	23.2	23.2	20.9	20.9	18.6	18.5	16.3	16.2	13.9	13.9
15	25.0	24.4	22.5	22.0	20.0	19.5	17.5	17.1	15.0	14.6
16	26.0	24.7	23.4	22.2	20.8	19.7	18.2	17.3	15.6	14.8
17	26.8	24.9	24.1	22.3	21.4	19.9	18.8	17.4	16.1	14.9

* Adapted from O'Brien, Girshik & Hunt (1941).

(14) MUSCLE CIRCUMFERENCE, 6-15 YEARS, SEXES SEPARATE*

Age (years)	Muscle circumference (cm)									
	Standard		90 % standard		80 % standard		70 % standard		60 % standard	
	M	F	M	F	M	F	M	F	M	F
6	14.7	14.2	13.2	12.8	11.8	11.4	10.3	9.9	8.8	8.5
7	15.3	14.8	13.8	13.3	12.2	11.8	10.7	10.4	9.2	8.9
8	16.0	15.3	14.4	13.8	12.8	12.2	11.2	10.7	9.6	9.2
9	16.5	15.9	14.9	14.3	13.2	12.7	11.6	11.1	9.9	9.5
10	17.1	16.6	15.4	14.9	13.7	13.3	12.0	11.6	10.3	10.0
11	17.6	17.3	15.8	15.6	14.1	14.1	12.3	12.1	10.6	10.4
12	18.5	18.3	16.6	16.5	14.8	14.6	12.9	12.8	11.1	11.0
13	19.6	19.1	17.6	17.2	15.7	15.3	13.7	13.4	11.8	11.5
14	20.8	19.6	18.7	17.6	16.6	15.7	14.6	13.7	12.5	11.8
15	23.0	20.8	20.7	18.7	18.4	16.6	16.1	14.6	13.8	12.5

* Calculated from Tables (12) and (13) of this Annex.

(15) WEIGHT FOR HEIGHT, ADULT MALES *

Percentage of standard weight	Weight ranges (kg), corresponding to the percentages given in the first column, for the heights shown										
	145 cm	146 cm	147 cm	148 cm	149 cm	150 cm	151 cm	152 cm	153 cm	154 cm	155 cm
50-54	26.0-28.5	26.2-28.7	26.5-29.0	26.8-29.4	27.0-29.6	27.3-29.9	27.5-30.2	27.8-30.5	28.1-30.8	28.3-31.1	28.6-31.4
55-59	28.6-31.1	28.8-31.4	29.1-31.7	29.5-32.0	29.7-32.3	30.0-32.6	30.3-32.9	30.6-33.3	30.9-33.6	31.2-33.9	31.5-34.3
60-64	31.2-33.7	31.5-34.0	31.8-34.3	32.1-34.7	32.4-35.0	32.7-35.4	33.0-35.7	33.4-36.1	33.7-36.4	34.0-36.7	34.4-37.1
65-69	33.8-36.3	34.1-36.6	34.4-37.0	34.8-37.4	35.1-37.7	35.5-38.1	35.8-38.4	36.2-38.9	36.5-39.2	36.8-39.6	37.2-40.0
70-74	36.4-38.9	36.7-39.2	37.1-39.6	37.5-40.1	37.8-40.4	38.2-40.8	38.5-41.2	39.0-41.6	39.3-42.0	39.7-42.4	40.1-42.8
75-79	39.0-41.5	39.3-41.9	39.7-42.3	40.2-42.7	40.5-43.1	40.9-43.5	41.3-43.9	41.7-44.4	42.1-44.8	42.5-45.2	42.9-45.7
80-84	41.6-44.1	42.0-44.5	42.4-44.9	42.8-45.4	43.2-45.8	43.6-46.3	44.0-46.7	44.5-47.2	44.9-47.6	45.3-48.1	45.8-48.6
85-89	44.2-46.7	44.6-47.1	45.0-47.6	45.5-48.1	45.9-48.5	46.4-49.0	46.8-49.4	47.3-50.0	47.7-50.4	48.2-50.9	48.7-51.4
90-94	46.8-49.3	47.2-49.7	47.7-50.2	48.2-50.8	48.6-51.2	49.1-51.7	49.5-52.2	50.1-52.8	50.5-53.2	51.0-53.7	51.5-54.3
95-99	49.4-51.8	49.8-52.3	50.3-52.8	50.9-53.4	51.3-53.9	51.8-54.4	52.3-54.9	52.9-55.5	53.3-56.0	53.8-56.5	54.4-57.1
100-104	**51.9**-54.4	**52.4**-55.0	**52.9**-55.5	**53.5**-56.1	**54.0**-56.7	**54.5**-57.2	**55.0**-57.7	**55.6**-58.3	**56.1**-58.9	**56.6**-59.4	**57.2**-60.0
105-109	54.5-57.0	55.1-57.6	55.6-58.1	56.2-58.8	56.8-59.3	57.3-59.9	57.8-60.5	58.4-61.1	59.0-61.7	59.5-62.2	60.1-62.9
110-114	57.1-59.6	57.7-60.2	58.2-60.8	58.9-61.5	59.4-62.1	60.0-62.6	60.6-63.2	61.2-63.9	61.8-64.5	62.3-65.0	63.0-65.7
	156 cm	157 cm	158 cm	159 cm	160 cm	161 cm	162 cm	163 cm	164 cm	165 cm	166 cm
50-54	29.0-31.8	29.3-32.2	29.7-32.5	30.0-32.9	30.3-33.2	30.6-33.5	30.9-33.9	31.2-34.2	31.5-34.5	31.8-34.9	32.0-35.1
55-59	31.9-34.7	32.3-35.1	32.6-35.5	33.0-35.9	33.3-36.2	33.6-36.6	34.0-36.9	34.3-37.3	34.6-37.7	35.0-38.0	35.2-38.3
60-64	34.8-37.6	35.2-38.0	35.6-38.5	36.0-38.9	36.3-39.3	36.7-39.6	37.0-40.0	37.4-40.4	37.8-40.8	38.1-41.2	38.4-41.5
65-69	37.7-40.5	38.1-41.0	38.6-41.4	39.0-41.9	39.4-42.3	39.7-42.7	40.1-43.1	40.5-43.5	40.9-44.0	41.3-44.4	41.6-44.7
70-74	40.6-43.4	41.1-43.9	41.5-44.4	42.0-44.9	42.4-45.3	42.8-45.8	43.2-46.2	43.6-46.7	44.1-47.1	44.5-47.6	44.8-47.9
75-79	43.5-46.3	44.0-46.8	44.5-47.4	45.0-47.9	45.4-48.3	45.9-48.8	46.3-49.3	46.8-49.8	47.2-50.3	47.7-50.7	48.0-51.1
80-84	46.4-49.1	46.9-49.7	47.5-50.3	48.0-50.9	48.4-51.4	48.9-51.9	49.4-52.4	49.9-52.9	50.4-53.4	50.8-53.9	51.2-54.3
85-89	49.2-52.1	49.8-52.7	50.4-53.3	51.0-53.9	51.5-54.4	52.0-54.9	52.5-55.5	53.0-56.0	53.5-56.5	54.0-57.1	54.4-57.5
90-94	52.2-54.9	52.8-55.6	53.4-56.3	54.0-56.9	54.5-57.4	55.0-58.0	55.6-58.8	56.1-59.1	56.6-59.7	57.2-60.3	57.6-60.7
95-99	55.0-57.8	55.7-58.5	56.4-59.2	57.0-59.8	57.5-60.4	58.1-61.0	58.9-61.6	59.2-62.2	59.8-62.8	60.4-63.4	60.8-63.9
100-104	**57.9**-60.7	**58.6**-61.5	**59.3**-62.2	**59.9**-62.8	**60.5**-63.5	**61.1**-64.1	**61.7**-64.7	**62.3**-65.4	**62.9**-66.0	**63.5**-66.6	**64.0**-67.1
105-109	60.8-63.6	61.6-64.4	62.3-65.2	62.9-65.8	63.6-66.5	64.2-67.2	64.8-67.8	65.5-68.5	66.1-69.1	66.7-69.8	67.2-70.3
110-114	63.7-66.5	64.5-67.3	65.3-68.1	65.9-68.8	66.6-69.5	67.3-70.2	67.9-70.9	68.6-71.6	69.2-72.3	69.9-73.0	70.4-73.6

	167 cm	168 cm	169 cm	170 cm	171 cm	172 cm	173 cm	174 cm	175 cm	176 cm
50-54	32.3-35.5	32.6-35.8	33.0-36.2	33.3-36.5	33.7-36.9	34.0-37.3	34.4-37.7	34.7-38.1	35.1-38.5	35.4-38.9
55-59	35.6-38.7	35.9-39.1	36.3-39.5	36.6-39.9	37.0-40.3	37.4-40.7	37.8-41.1	38.2-41.6	38.6-42.0	39.0-42.4
60-64	38.8-41.9	39.2-42.3	39.6-42.8	40.0-43.2	40.4-43.7	40.8-44.1	41.2-44.6	41.7-45.0	42.1-45.5	42.5-45.9
65-69	42.0-45.2	42.4-45.6	42.9-46.1	43.3-46.5	43.8-47.0	44.2-47.5	44.7-48.0	45.1-48.5	45.6-49.0	46.0-49.5
70-74	45.3-48.4	45.7-48.8	46.2-49.4	46.6-49.9	47.1-50.4	47.6-50.9	48.1-51.5	48.6-52.0	49.1-52.5	49.6-53.0
75-79	48.5-51.6	48.9-52.1	49.5-52.7	50.0-53.2	50.5-53.8	51.0-54.3	51.6-54.9	52.1-55.5	52.6-56.0	53.1-56.6
80-84	51.7-54.9	52.2-55.4	52.8-56.0	53.3-56.5	53.9-57.1	54.4-57.7	55.0-58.3	55.6-58.9	56.1-59.5	56.7-60.1
85-89	55.0-58.1	55.5-58.6	56.1-59.3	56.6-59.9	57.2-60.5	57.8-61.1	58.4-61.8	59.0-62.4	59.6-63.0	60.2-63.7
90-94	58.2-61.3	58.7-61.9	59.4-62.5	60.0-63.2	60.6-63.9	61.2-64.5	61.9-65.2	62.5-65.9	63.1-66.5	63.8-67.2
95-99	61.4-64.5	62.0-65.1	62.6-65.8	63.3-66.5	64.0-67.2	64.6-67.9	65.3-68.6	66.0-69.3	66.6-70.0	67.3-70.7
100-104	**64.6**-67.8	**65.2**-68.4	**65.9**-69.1	**66.6**-69.9	**67.3**-70.6	**68.0**-71.3	**68.7**-72.1	**69.4**-72.8	**70.1**-73.6	**70.8**-74.3
105-109	67.9-71.0	68.5-71.7	69.2-72.4	70.0-73.2	70.7-74.0	71.4-74.7	72.2-75.5	72.9-76.3	73.7-77.1	74.4-77.8
110-114	71.1-74.2	71.8-74.9	72.5-75.7	73.3-76.5	74.1-77.3	74.8-78.2	75.6-79.0	76.4-79.8	77.2-80.6	77.9-81.4

	177 cm	178 cm	179 cm	180 cm	181 cm	182 cm	183 cm	184 cm	185 cm	186 cm
50-54	35.8-39.3	36.2-39.7	36.7-40.2	37.1-40.7	37.5-41.2	37.9-41.6	38.3-42.0	38.9-42.4	39.1-42.9	39.5-43.3
55-59	39.4-42.9	39.8-43.4	40.3-43.9	40.8-44.5	41.3-44.9	41.7-45.4	42.1-45.8	42.5-46.3	43.0-46.8	43.4-47.3
60-64	43.0-46.5	43.5-47.0	44.0-47.6	44.6-48.2	45.0-48.7	45.5-49.2	45.9-49.7	46.4-50.2	46.9-50.7	47.4-51.2
65-69	46.6-50.1	47.1-50.6	47.7-51.2	48.3-51.9	48.8-52.4	49.3-53.0	49.8-53.5	50.3-54.0	50.8-54.6	51.3-55.2
70-74	50.2-53.6	50.7-54.2	51.3-54.9	52.0-55.6	52.5-56.2	53.1-56.8	53.6-57.3	54.1-57.9	54.7-58.5	55.3-59.1
75-79	53.7-57.2	54.3-57.9	55.0-58.6	55.7-59.3	56.3-59.9	56.9-60.6	57.4-61.1	58.0-61.8	58.6-62.4	59.2-63.1
80-84	57.3-60.8	58.0-61.5	58.7-62.2	59.4-63.0	60.0-63.7	60.7-64.4	61.2-65.0	61.9-65.6	62.5-66.3	63.2-67.0
85-89	60.9-64.4	61.6-65.1	62.3-65.9	63.1-66.7	63.8-67.4	64.5-68.2	65.1-68.8	65.7-69.5	66.4-70.2	67.1-70.9
90-94	64.5-68.0	65.2-68.7	66.0-69.6	66.8-70.4	67.5-71.2	68.3-71.9	68.9-72.6	69.6-73.4	70.3-74.1	71.0-74.9
95-99	68.1-71.5	68.8-72.3	69.7-73.2	70.5-74.1	71.3-74.9	72.0-75.7	72.7-76.4	73.5-77.2	74.2-78.0	75.0-78.8
100-104	**71.6**-75.1	**72.4**-76.0	**73.3**-76.9	**74.2**-77.9	**75.0**-78.7	**75.8**-79.5	**76.5**-80.3	**77.3**-81.1	**78.1**-81.9	**78.9**-82.8
105-109	75.2-78.7	76.1-79.6	77.0-80.6	78.0-81.6	78.8-82.5	79.6-83.3	80.4-84.1	81.2-84.9	82.0-85.9	82.9-86.7
110-114	78.8-82.3	79.7-83.2	80.7-84.3	81.7-85.3	82.6-86.2	83.4-87.1	84.2-87.9	85.0-88.9	86.0-89.8	86.8-90.7

* Adapted by permission from Society of Actuaries (1959)—modified for average frame size and nude measurements (ICNND, 1963; Bridgforth—personal communication, 1965).

(16) WEIGHT FOR HEIGHT, ADULT FEMALES *

Percentage of standard weight	Weight ranges (kg), corresponding to the percentages given in the first column, for the heights shown									
	140 cm	141 cm	142 cm	143 cm	144 cm	145 cm	146 cm	147 cm	148 cm	149 cm
50-54	22.5-24.6	22.7-24.9	23.0-25.2	23.2-25.4	23.5-25.8	23.8-26.1	24.0-26.3	24.3-26.7	24.6-27.0	24.9-27.3
55-59	24.7-26.9	25.0-27.2	25.3-27.5	25.5-27.8	25.9-28.1	26.2-28.4	26.4-28.7	26.8-29.1	27.1-29.5	27.4-29.8
60-64	27.0-29.1	27.3-29.4	27.6-29.8	27.9-30.1	28.2-30.5	28.5-30.8	28.8-31.1	29.2-31.5	29.6-31.9	29.9-32.3
65-69	29.2-31.4	29.5-31.7	29.9-32.1	30.2-32.4	30.6-32.8	30.9-33.2	31.2-33.5	31.6-33.9	32.0-34.4	32.4-34.8
70-74	31.5-33.6	31.8-34.0	32.2-34.4	32.5-34.7	32.9-35.2	33.3-35.6	33.6-35.9	34.0-36.4	34.5-36.8	34.9-37.3
75-79	33.7-35.9	34.1-36.3	34.5-36.7	34.8-37.1	35.3-37.5	35.7-37.9	36.0-38.3	36.5-38.8	36.9-39.3	37.4-39.8
80-84	36.0-38.1	36.4-38.5	36.8-39.0	37.2-39.4	37.6-39.9	38.0-40.3	38.4-40.7	38.9-41.3	39.4-41.8	39.9-42.3
85-89	38.2-40.3	38.6-40.8	39.1-41.3	39.5-41.7	40.0-42.2	40.4-42.7	40.8-43.1	41.4-43.7	41.9-44.2	42.4-44.8
90-94	40.4-42.6	40.9-43.1	41.4-43.5	41.8-44.0	42.3-44.6	42.8-45.1	43.2-45.5	43.8-46.1	44.3-46.7	44.9-47.3
95-99	42.7-44.8	43.2-45.3	43.6-45.8	44.1-46.3	44.7-46.9	45.2-47.4	45.6-47.9	46.2-48.5	46.8-49.1	47.4-49.7
100-104	**44.9**-47.1	**45.4**-47.6	**45.9**-48.1	**46.4**-48.7	**47.0**-49.3	**47.5**-49.8	**48.0**-50.3	**48.6**-51.0	**49.2**-51.6	**49.8**-52.2
105-109	47.2-49.3	47.7-49.9	48.2-50.4	48.8-51.0	49.4-51.7	49.9-52.2	50.4-52.7	51.1-53.4	51.7-54.1	52.3-54.7
110-114	49.4-51.6	50.0-52.2	50.5-52.7	51.1-53.3	51.8-54.0	52.3-54.6	52.8-55.2	53.5-55.8	54.2-56.5	54.8-57.2
	150 cm	151 cm	152 cm	153 cm	154 cm	155 cm	156 cm	157 cm	158 cm	159 cm
50-54	25.2-27.6	25.5-28.0	25.8-28.3	26.0-28.5	26.3-28.8	26.6-29.1	26.9-29.5	27.7-29.8	27.5-30.1	27.8-30.5
55-59	27.7-30.2	28.1-30.5	28.4-30.8	28.6-31.1	28.9-31.4	29.2-31.8	29.6-32.1	29.9-32.5	30.2-32.9	30.6-33.2
60-64	30.3-32.7	30.6-33.1	30.9-33.4	31.2-33.7	31.5-34.1	31.9-34.4	32.2-34.8	32.6-35.2	33.0-35.6	33.3-36.0
65-69	32.8-35.2	33.2-35.6	33.5-36.0	33.8-36.3	34.2-36.7	34.5-37.1	34.9-37.5	35.3-37.9	35.7-38.4	36.1-38.8
70-74	35.3-37.7	35.7-38.2	36.1-38.8	36.4-38.9	36.8-39.3	37.2-39.8	37.6-40.2	38.0-40.7	38.5-41.1	38.9-41.6
75-79	37.8-40.3	38.3-40.7	38.9-41.1	39.0-41.5	39.4-41.9	39.9-42.4	40.3-42.9	40.8-43.4	41.2-43.9	41.7-44.3
80-84	40.4-42.8	40.8-43.3	41.2-43.7	41.6-44.1	42.0-44.6	42.5-45.1	43.0-45.6	43.5-46.1	44.0-46.6	44.4-47.1
85-89	42.9-45.3	43.4-45.8	43.8-46.3	44.2-46.7	44.7-47.2	45.2-47.7	45.7-48.3	46.2-48.8	46.7-49.3	47.2-49.9
90-94	45.4-47.8	45.9-48.4	46.4-48.9	46.8-49.3	47.3-49.8	47.8-50.4	48.4-51.4	48.9-51.5	49.4-52.1	50.0-52.7
95-99	47.9-50.3	48.5-50.9	49.0-51.4	49.4-51.9	49.9-52.4	50.5-53.0	51.5-53.6	51.6-54.2	52.2-54.8	52.8-55.4
100-104	**50.4**-52.9	**51.0**-53.5	**51.5**-54.0	**52.0**-54.5	**52.5**-55.1	**53.1**-55.7	**53.7**-56.3	**54.3**-57.0	**54.9**-57.6	**55.5**-58.2
105-109	53.0-55.4	53.6-56.1	54.1-56.6	54.6-57.1	55.2-57.7	55.8-58.4	56.4-59.0	57.1-59.7	57.7-60.3	58.3-61.0
110-114	55.5-57.9	56.2-58.6	56.7-59.2	57.2-59.8	57.8-60.3	58.5-61.0	59.1-61.7	59.8-62.4	60.4-63.1	61.1-63.8

	160 cm	161 cm	162 cm	163 cm	164 cm	165 cm	166 cm	167 cm	168 cm	169 cm
50-54	28.1-30.8	28.5-31.2	28.8-31.6	29.2-32.0	29.5-32.3	29.8-32.7	30.1-33.0	30.4-33.3	30.7-33.7	31.1-34.1
55-59	30.9-33.7	31.3-34.1	31.7-34.5	32.1-34.9	32.4-35.3	32.8-35.6	33.1-36.0	33.4-36.3	33.8-36.8	34.2-37.2
60-64	33.8-36.5	34.2-36.9	34.6-37.4	35.0-37.8	35.4-38.2	35.7-38.6	36.1-39.0	36.4-39.4	36.9-39.8	37.3-40.3
65-69	36.6-39.3	37.0-39.8	37.5-40.3	37.9-40.7	38.3-41.2	38.7-41.6	39.1-42.0	39.5-42.4	39.9-42.9	40.4-43.4
70-74	39.4-42.1	39.9-42.6	40.4-43.1	40.8-43.7	41.3-44.1	41.7-44.6	42.1-45.0	42.5-45.5	43.0-46.0	43.5-46.5
75-79	42.2-44.9	42.7-45.5	43.2-46.0	43.8-46.6	44.2-47.1	44.7-47.5	45.1-48.0	45.6-48.5	46.1-49.1	46.6-49.6
80-84	45.0-47.7	45.6-48.3	46.1-48.9	46.7-49.5	47.2-50.0	47.6-50.5	48.1-51.0	48.6-51.5	49.2-52.1	49.7-52.7
85-89	47.8-50.5	48.4-51.1	49.0-51.8	49.6-52.4	50.1-52.9	50.6-53.5	51.1-54.0	51.6-54.6	52.2-55.2	52.8-55.8
90-94	50.6-53.3	51.2-54.0	51.9-54.7	52.5-55.3	53.0-55.9	53.6-56.5	54.1-57.0	54.7-57.6	55.3-58.3	55.9-58.9
95-99	53.4-56.1	54.1-56.8	54.8-57.5	55.4-58.2	56.0-58.8	56.6-59.4	57.1-60.0	57.7-60.6	58.4-61.3	59.0-62.0
100-104	**56.2**-59.0	**56.9**-59.7	**57.6**-60.4	**58.3**-61.2	**58.9**-61.8	**59.5**-62.4	**60.1**-63.1	**60.7**-63.7	**61.4**-64.4	**62.1**-65.1
105-109	59.1-61.8	59.8-62.5	60.5-63.3	61.3-64.1	61.9-64.7	62.5-65.4	63.2-66.1	63.8-66.7	64.5-67.5	65.2-68.3
110-114	61.9-64.6	62.6-65.4	63.4-66.2	64.2-67.0	64.8-67.7	65.5-68.4	66.2-69.1	66.8-69.8	67.6-70.6	68.4-71.4

* Adapted by permission from Society of Actuaries (1959)—modified for average frame size and nude measurements (ICNND, 1963; Bridgforth—personal communication, 1965).

(17) TRICEPS SKIN-FOLD, ADULTS, SEXES SEPARATE

Sex	Triceps skin-fold (mm)				
	Standard	90 % standard	80 % standard	70 % standard	60 % standard
Male	12.5	11.3	10.0	8.8	7.5
Female	16.5	14.9	13.2	11.6	9.9

(18) ARM CIRCUMFERENCE, ADULTS, SEXES SEPARATE *

Sex	Arm circumference (cm)				
	Standard	90 % standard	80 % standard	70 % standard	60 % standard
Male	29.3	26.3	23.4	20.5	17.6
Female	28.5	25.7	22.8	20.0	17.1

* Adapted from O'Brien & Shelton (1941); Hertzberg et al. (1963).

(19) MUSCLE CIRCUMFERENCE, ADULTS, SEXES SEPARATE *

Sex	Muscle circumference (cm)				
	Standard	90 % standard	80 % standard	70 % standard	60 % standard
Male	25.3	22.8	20.2	17.7	15.2
Female	23.2	20.9	18.6	16.2	13.9

* Calculated from Tables (17) and (18) of this Annex.

Annex 2

FURTHER BIOCHEMICAL TESTS

Selected, more complicated biochemical tests, listed in Table 7 as category 2 tests, are given below. They may be indicated for research purposes.

Protein

J. Edozien (personal communication, 1965) has suggested that the total plasma alpha-amino acids may be assessed and that low levels suggest an inadequate dietary intake of protein.

The possibility of analysis of hair for amino-acid composition, including cystine content, has been suggested, as have various other chemical and physical tests (Ishikawa, Takanohashi & Wako, 1965; Godwin, 1962; Jelliffe & Welbourn, 1963).

Ascorbic acid

Actual tissue levels of ascorbic acid can be more easily measured in white blood cells (WBC), and it has been shown that disappearance of ascorbic acid from these cells closely parallels the development of scurvy (Lowry, 1952). The WBC ascorbic-acid level is, then, a good index of vitamin-C intake and tissue concentrations.

The dietary intake of ascorbic acid can also be assessed by measuring a 24-hour urinary excretion, or, in field circumstances, by estimating the ratio of ascorbic acid to creatinine in a random sample of urine, preferably fasting. Load tests will usually not be practicable in field surveys unless special circumstances permit careful observation of those tested for a period of 24 hours.

Thiamine

Various thiamine load tests have been described, but they are impracticable for field surveys. Similarly, diagnosin of thiamine deficiency by assessment of metabolic alterations that occur (e.g., increased blood levels of lactate and pyruvate) are of limited value in estimating mild degrees of deficiency, and are too elaborate for survey work. Recently, Brin (1962) has introduced a method that tests transketolase activity of a haemolysate of red blood cells. This appears to be a specific test for thiame inadequacy, as it seems to be related to early metabolic change and not merely to

thiamine intake. At present, this method is too complicated for non-specialized laboratories and in any case awaits trial in nutrition survey work.

Riboflavin

Of various possible blood tests, the most consistent and significant appears to be the red blood cell (RBC) riboflavin content. Deficient groups showed values of 10.0-13.1 mcg/100 ml, and those with an adequate riboflavin intake 20.2-27.6 mcg (Bessey, Horwitt & Love, 1956). For usual field purposes, this test is too complicated, and standards for children are not known.

Similarly, load tests have been used for evaluating riboflavin nutrition, and the four-hour urinary excretion following parenteral administration of 1 mg of the vitamin has been advocated. As with other load tests, it cannot, for practical reasons, have wide application in rural surveys.

Niacin

Load tests have been employed to assess the state of niacin nutrition, Thus, 10 mg of niacinamide may be given by mouth followed by urine collection for 12 hours. These tests are aimed at estimating the state of tissue depletion, but are impracticable under field conditions.

Iron and folates

In more elaborate haematological surveys, the serum iron may be estimated, and in iron-deficiency anaemia will be found to be below 50 mcg per 100 ml. According to a recent study, the percentage saturation of plasma transferrin may be a most useful test for iron deficiency—a figure of 16% or less indicating an inadequate supply of iron being delivered to the marrow (Bainton & Finch, 1964). However, in young children, due attention must be paid to the fact that hypoproteinaemia may result in a decrease of the specific iron-binding beta-globulin.

Serum levels of B_{12} and *L. casei* folate levels may be required (see tables below).

SERUM VITAMIN B_{12} CONCENTRATIONS IN MAN

Serum B_{12} level [a] ($\mu\mu$g/ml)	Interpretation
200-960	Range in normal healthy subjects
140-200	Diagnostically indeterminate
80-140	Equivocal; in non-anaemic patients such levels probably indicate early B_{12} deficiency
<80	Levels in anaemic patients with B_{12} deficiency and in patients with neurological complications of B_{12} deficiency

[a] Assayed with *Euglena gracilis*.

INTERPRETATION OF SERUM *L. CASEI* FOLATE LEVELS

Level ($\mu\mu$g/ml)	Interpretation
<3	Folate deficiency
3-6	Probable folate deficiency
6-20	Normal
>25	Elevated

Iodine

In more detailed investigations, the urinary iodine in a urine sample can give an indication of dietary intake. Tests of thyroid function may also be carried out in special research circumstances, especially the PBI (protein-bound iodine). Follis (1964) has recently reported his own extensive results and commented on problems of interpretation.

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INDEX

INDEX

Action, remedial, on results of survey data, 164, 174
Adults, nutritional assessment of, 214
  overnutrition, 217
  standards of reference, 214
  undernutrition, 215
Age assessment in nutritional anthropometry, 58
  average eruption time of deciduous teeth, 62
  average eruption time of permanent teeth, 63
  of young Baganda children, events-calendar for, 60, 61
  standard visual coding of deciduous dentition in, 59
Age considerations in analysis of survey data, 165
  abbreviation, 166
  estimation, 165
  groups, 166
  standards, 165
Age significance in clinical signs produced by nutrient deficiency, 42
Amino acids, test for imbalance of, 86
Anaemia, community surveys for, 93
  in kwashiorkor, 185
  in pregnant and lactating women, 211
  in young children, 207
Analysis of survey data, 164, 165
  age considerations, 165
  expression of results, 166
  grouping of results, 165
Anthropometry, 50-78
  age assessment, 58
  chest circumference, 70
  head circumference, 69
    weight for, in young children, 226
  in protein-calorie malnutrition in early childhood, 194
  linear measurements, 67
    height (or length), 68
    standards of reference, 69, 222-225, 230-235, 238-241
  photography in, 64
  radiological methods, 72
Anthropometry (*continued*)
  results of survey data, mathematical reporting of, 167
    presentation of, 173
    reporting in relation to standards of reference, 167
  soft-tissues, 71-78
    muscle, 75
      standards of reference, 78, 228, 229, 236, 237, 242
    subcutaneous fat, 72
      standards of reference, 75, 227, 236, 242
      subscapular (infrascapular, back) skin-fold, 74
      triceps (upper arm, dorsal arm, arm) skin-fold, 74
  standardization of techniques, 52
  standards of reference, 53-57
    general, 56, 168, 221-242
      actuaries, 57
      Baldwin-Wood, 57
      Harvard, 56
    local, 54
    reporting, 167
  weight, 64
    standards of reference, 67, 221, 224-226, 230-234, 238-241
Arm circumference, in anthropometric measurement, 76
  mid-arm-muscle circumference, 76
  standards of reference, 78
    arm circumference, 228, 236, 242
    mid-arm-muscle circumference, 229
    muscle circumference, 237, 242
Ascorbic acid, biochemical tests for, 90
  research tests, 243
Atheroma, associated with overnutrition, 217
  etiology of, 218
Attrition, dental, 28
Avitaminosis A in young children, 177, 178, 205
  assessment in community, 205
  ecological assessment, 205
  etiology of, 205

Baldwin-Wood standards used in anthropometry, 57
Beam balance scale, 65
Beriberi, clinical signs of, 45
  infantile, 46, 206
    2-5-month mortality rate in, 98
    incidence of, 176
  radiographical signs of, 95
Biochemical tests, 78-94
  applicable to nutrition surveys, 80, 84
    expression of results of, 168
  collection of samples, blood, 79
    number of specimens, 79
    urine, 81
  for specific nutrients, 80, 84
    ascorbic acid, 89, 243
    folic acid, 91, 244
    iodine, 94, 245
    iron, 91, 244
    niacin, 91, 244
    protein, 85, 243
    riboflavin, 90, 243
    thiamine, 90, 243
    vitamin A, 88
    vitamin B_{12}, 91, 244
    vitamin D, 89
  in field surveys, 78
  in protein-calorie malnutrition of early childhood, 197
  interpretation of, 82
    blood data, 84
    presentation of results, 173
    urinary vitamin excretion data, 84
  laboratory considerations, 81
Biophysical methods, 94
  cytological test, 96
  radiographical examination, 94
  tests for physical function, 95
Bitot's spots, 21, 44
  vernacular name for, 104, 205
Blepharitis, angular, 23, 45
Blindness, from avitaminosis A, 205
Blood, collection of samples for biochemical tests, 79
    in field nutrition surveys, 161
    macro-methods, 80
    micro-methods, 81
    storage, 81
  guide to interpretation of data, 84
Blood pressure, 41
Bow-legs, 37, 47

Calendar of events, for assessment of age of young Baganda children, 60
Calipers, skin-fold, 72
Caloric overnutrition, clinical signs of, 44, 217
Cardiomegaly, 41, 45
Cardiovascular system, 41
  blood pressure, 41
  cardiac enlargement, 41, 45
  tachycardia, 41, 45
Caries, dental, 27
    associated with overnutrition, 217, 218
Casal's necklace, 33
Cheilosis, 25, 45
Chest circumference, 70
  in first five years of life, 71
Clinical signs in direct nutritional assessment of human groups, 10-50
  classification of, 12
  descriptive list of, 16-41
  in analysis of results of survey data, 167
    presentation of results, 173
  interpretation of, in relation to nutrient deficiencies, 42
    guide to grouping of, 43-48
  lack of specificity of, 11
  nutritional relevance of commonly recorded signs, 12
  rapid clinical surveys, 49
  standardization of definition of, 14
  technique of examination for, 15
  therapeutic trials as extension of, 48
Conditioning infections related to malnutrition, 112
  associated with kwashiorkor, 185
Conjunctiva, 21
  pale, 21, 47
  pigmentation of, 23
  pingueculae, 23
  xerosis of, 21, 44
Cornea, 21
  colliquative necrosis of, 21
  opacities and scars, 23
  pannus of, 25
  pterygium, 25
  vascularization of, 23, 45
  xerosis of, 21, 44
Craniotabes, 37, 47
Cross-sectional prevalence studies in nutritional surveys, 136
  advantages and disadvantages, 136
  organization, 138
  periodic, 136
  point, 136
  special groups, 138
  types, 137

Cultural influences related to malnutrition, 121
Cytological tests, 96

Dark-adaptation tests, 95
Deficiency, specific, in malnutrition, definition of, 8
Dermatosis, flaky-paint, 33, 43
  pellagrous, 33, 46
  scrotal, 36, 45
  vulval, 36, 45
Diabetes, associated with overnutrition, 217
Diarrhoea, associated with malnutrition, 105
  infective, in artificially fed infants, 177
  " weanling ", 113
Drugs, basic list used in community child-health surveys in East Africa, 153
Dwarfism, nutritional, 192
Dyssebacea, naso-labial, 19, 45
Dysthrepsia, 194
Dystrophia, 194

Ecchymoses, as clinical sign of vitamin-C deficiency, 46
Ecological factors in malnutrition, assessment of, 106-131
  conditioning infections, 112
  cultural influences, 121
    child rearing, 122
    cross-cultural survey problems, 123
    food attitudes, classification of, 121
  food consumption, 114
    household surveys, 115
    special problems of early childhood, 118
  food production, 127
  health and education services, 129
  in nutrition surveys, 141
    expression of results, 169
    presentation of results, 173
  methods of obtaining information, 107
    case analysis, 111
    rapid ecological visits, 108, 115, 131
    special techniques, 111
    survey site, 107
  socio-economic factors, 125
Enamel, erosion, 29, 30
  hypoplasia, 29, 30
  mottled, 27, 29, 48
Equipment for nutrition surveys, 149
  anthropometric, 150
  drugs and inducements, 152
Equipment for nutrition surveys (*continued*)
  general, 153
  laboratory, 150
  transport and accommodation, 149
Eyes, clinical signs in direct nutritional assessment, 19
  angular palpebritis (angular blepharitis), 23, 45
  Bitot's spots (Iskerskii's patches), 21, 44
  conjunctival and scleral pigmentation, 23
  corneal vascularization, 23, 45
  keratomalacia, 21, 44
  pale conjunctiva, 21, 47
  pannus, 25
  pingueculae, 23
  pterygium, 25
  xerosis, conjunctival, 21, 44
    corneal, 21, 44

Face, clinical signs in direct nutritional assessment, 19
  diffuse depigmentation, 19
  moon-face, 19, 43
  naso-labial dyssebacea, 19, 45
Fat, subcutaneous, 72
  as clinical sign in direct nutritional assessment, 36
  diminished, in protein-calorie malnutrition, 43, 186
  increased, in obesity, 44
  methods of assessing amount and distribution of, 72
  retention of, with muscle wasting, in kwashiorkor, 182
Field reconnaissance in planning nutrition surveys, 138
  approach to local people, 138
  involvement of local health workers, 139
  practicability of preliminary plan, 139
Field work in nutrition surveys, 155-164
  daily programme, 164
  general remarks, 163
  household surveys, 155
  public relations, 163
  rapid ecological visits, 163
  stations and line of flow, 156
    anthropometry, 159
    clinical assessment, 159
    dietary inquiry, 162
    identification, 158
    laboratory, 160
  surveys at collecting points, 155

Fluorosis, radiographical signs of, 95
clinical signs of, 48
dental, differential diagnosis between non-fluoride enamel and, 28
Folic acid, biochemical tests for, 91
interpretation of *L. casei* folate levels, 245
research tests, 244
Folic acid deficiency, clinical signs of, 47
Food consumption, 114
assessment of, 116
calculation of nutritive value, 116
comparison with nutritional requirements, 117
cultural patterns, 121
expression of results in dietary assessment, 169
household surveys, 108, 115, 131
special problems of early childhood, 118
Food production, 127
Funnel chest, 37

Gastro-intestinal system, clinical signs in direct nutritional assessment, 40
hepatomegaly, 40, 43
Glands, clinical signs in direct nutritional assessment, 30
gynaecomastia, 33, 43
parotid enlargement, 32, 43
thyroid enlargement, 30, 48
Goitre in pregnancy, 211
Growth retardation, in kwashiorkor, 182
in nutritional marasmus, 186
Gums, clinical signs in direct nutritional assessment, 30
atrophy and recession of, 30
pyorrhoea, 30
spongy, bleeding, 30, 46
Gynaecomastia, 33, 43

Haemoglobin in iron deficiency, estimation methods, 92
levels for particular age-groups, 92, 93
Haemorrhages, musculoskeletal, 40, 46
Hair, clinical signs in direct nutritional assessment, 16
dyspigmentation, 18, 43
easy pluckability, 19, 43
flag sign, 18
in kwashiorkor, 184
in nutritional marasmus, 186
lack of lustre, 16
straightness, 16, 43
thinness and sparseness, 16, 43
Harrison's sulcus, 37, 47
Harvard standards used in anthropometry, 56
Head circumference, 69
chest/head circumference ratio, 70, 196
standards of reference, 70
weight for, in young children, 195, 226
Health and educational services, 129
Height, in anthropometric measurement, 68
standards of reference, 69
weight for height, 234, 235, 238-241
weight for height for age, 230-233
Helminths, intestinal, 113
Hepatomegaly, 40, 43
as occasional manifestation of kwashiorkor, 185
Home visits, guide to list of features identifiable during, 131
importance in assessment of ecological factors in malnutrition, 108, 115
in nutrition surveys, 155
Hydroxyproline, urinary excretion of, 86
Hyperkeratosis, follicular, 33, 44, 46
Hypertension associated with overnutrition, 217

Imbalance in malnutrition, definition of, 8
Inanition (nutritional marasmus), 186
Infections associated with malnutrition, 112
Information useful for assessment of nutritional status, 171
Internal systems, clinical signs in direct nutritional assessment, 40
cardiovascular system, 41
gastro-intestinal system, 40
nervous system, 40
Interpretation of results of survey data, 164, 169
information useful for, 171
presentation, 172
Iodine, biochemical tests for, 94
research tests, 245
Iodine deficiency, clinical signs of, 48
in pregnant and lactating women, 211
Iron, biochemical tests for, 91
research tests, 244
Iron deficiency, clinical signs of, 47
in pregnant and lactating women, 211
in young children, 207
Iskerskii's patches, 21

Keratomalacia, 21, 44
in avitaminosis A, 205

Knock-knees, 37, 47
Koilonychia, 36, 47
Kwashiorkor, 180
  anthropometric measurements in, 182, 183
  diagnostic signs of, 103, 182
    constant signs, 182
    occasional signs, 185
    usual signs, 184
  etiology, 181
  in pre-school children, 179
  nomenclature of, 180
  precipitating factors in, 105, 106
  psychomotor change in, 40
  vernacular names for, 104

Length in anthropometric measurement, 68
  recumbent (crown-heel) in infants and pre-school children, 68
  standards of reference, 69
    length for age, 222, 223
    weight for length, 224, 225
Lines of flow in field nutrition surveys, 158
  anthropometry station, 159
  clinical assessment station, 159
  dietary inquiry station, 162
  identification station, 158
  laboratory station, 160
Lips, clinical signs in direct nutritional assessment, 25
    angular scars, 25, 45
    angular stomatitis, 25, 45
    cheilosis, 25, 45
    chronic depigmentation of lower lip, 25
Longitudinal incidence studies in nutrition surveys, 132
  advantages of, 132
  data collected during, 135
  disadvantages of, 133
  techniques, 134

Malaria, as conditioning infection for malnutrition, 113
Malnutrition, age-specific mortality rates in, 97
  definition of, 8
  ecological factors in, 106-131
  forms of, 8
  importance of age in, 181
  in adults, 215
  in early childhood, 176
    avitaminosis A, 177, 178, 205
Malnutrition (*continued*)
  infantile beriberi, 46, 98, 176, 206
    infants, 176
    iron deficiency, 207
    pre-school children (1-4 years), 178
    protein-calorie, 179-204
    rickets, 206
  in pregnant and lactating women, 211
  in schoolchildren, 208
  infections associated with, 112
  influencing morbidity rates for various diseases, 97
  interpretation of signs in relation to, 42
  morbidity and cause-specific mortality, methods of obtaining data, 102
  protein-calorie, clinical signs of, 43
Marasmus, nutritional, 186
    adult, 216
    clinical signs of, 186
    diagnostic signs of, 103
    in artificially fed infants, 177
    nomenclature of, 186
Mata ajam (night blindness), 206
Maternal depletion syndrome, 211
Measles associated with malnutrition, 105
Mental confusion, 40
Moon-face, 19, 43, 185
Mortality rates, as indicators of incidence of malnutrition, 97-102
  in measles, 105
  need for analysis by one-year age-groups, 102
Muscle, anthropometric measurement of, 75
    standards of reference, 78
      arm circumference, 1-60 months, 228
        6-17 years, 236
        adults, 242
      mid-arm-muscle circumference, 6-60 months, 229
      muscle circumference, 6-15 years, 237
        adults, 242
    technique, 76
Muscular and skeletal systems, clinical signs in direct nutritional assessment, 37
    beading of ribs (rickety rosary), 37, 47
    bow-legs, 37, 47
    calf-muscle tenderness, 45
    craniotabes, 37, 47
    deformities of thorax, 37, 47
    diffuse or local skeletal deformities, 37

Muscular and skeletal systems (*continued*)
epiphyseal enlargement, 37, 46, 47
frontal and parietal bossing, 37, 47
knock-knees, 39, 47
muscular wasting, 37, 43, 47, 182, 186
musculoskeletal haemorrhages, 40

Nails, clinical signs in direct nutritional assessment, 36
koilonychia, 36, 47
mottling, 48
transverse ridging or grooving, 36
Necrosis of cornea, colliquative, 21
Nervous system, clinical signs in direct nutritional assessment, 40, 45
mental confusion, 40
psychomotor change, 40, 43
Niacin, biochemical test for, in direct nutritional assessment, 91
research tests, 244
Niacin deficiency, clinical signs of, 46
Night blindness, 206
Nutrient deficiencies, guide to interpretation of grouping of clinical signs, 43-48
interpretation of signs in relation to, 42
rapid clinical surveys, 49
tests for, 84
therapeutic trials in determination of, 48
Nutrition surveys, 132-175
action on results of, 164, 174
analysis of survey data, 164, 165
field work, 155-164
daily programme, 164
general remarks, 163
household surveys, 155
public relations, 163
rapid ecological visits, 163
stations and lines of flow, 156
surveys at collecting points, 155
interpretation of results of survey data, 164, 169
information useful for, 171
presentation, 172
planning, 138-155
field reconnaissance, 138
preliminary, 138
selection of equipment, 149
selection of methods, 140
statistical guidance, 142
sampling, 142
survey forms, 143-149, 165
technical, 140-155
training of personnel, 153
Nutrition surveys (*continued*)
types of survey, 132
cross-sectional prevalence studies, 136
longitudinal incidence studies, 132
Nutritional anthropometry (*see* Anthropometry)
Nutritional assessment of human groups, adults, 214
direct, 10-96
biochemical tests in, 78-94
biophysical methods in, 94-96
clinical signs in, 10-50
in nutrition surveys, 140
nutritional anthropometry, 50-78
indirect, 97-105
age-specific mortality rates, 97-102
in nutrition surveys, 141
morbidity and cause-specific mortality, 102-105
vital statistics, 97
orientation, 8
pregnant and lactating women, 210
principal aim of, 7
schoolchildren, 208
standardization of methods, 8
young children, 176
Nutritional marasmus (*see* Marasmus)

Obesity, 217
clinical signs of, 44
Obwosi (kwashiorkor), 104, 122
Oedema, in protein-calorie malnutrition, 43, 182
in thiamine deficiency, 45
of subcutaneous tissues, 36
of tongue, 25
Omusana (kwashiorkor), 104
Opacities, corneal, 23
Osteomalacia, clinical signs of, 47
in pregnant and lactating women, 211
radiographical signs of, 95
Overnutrition, clinical signs of, 44
definition of, 8
in adults, 217

Palpebritis, angular, 23, 45
Pannus, 25
Papillae, 27, 45, 46, 47
Parotid gland, enlargement of, 32, 43
Petechiae, 33, 46
Photography, in assessment of nutritional status, 64, 173
Phrynoderma, 33
Pigeon chest, 37, 47

Pigmentation abnormalities, conjunctival and scleral, 23
malar and supraorbital, 46
of hair, 18
of lower lip, 25
of skin, 19, 36, 43
of tongue, 27
Pregnant and lactating women, 210
direct nutritional assessment, 211
biochemical tests, 212
clinical signs, 211
nutritional anthropometry, 212
indirect nutritional assessment, 213
Pressure points, thickening and pigmentation of skin at, 36
Prevalence surveys, organization of, 138
periodic, 136
point, 136
Protein, biochemical tests for, 85
depletion of body stores, 87
dietary adequacy, 85
metabolic changes, 86
research tests, 243
Protein-calorie malnutrition, clinical signs of, 43
geographical comparison of mortality rates in, 101
in adults, 215
in artificially fed infants, 177
in early childhood, 179-204
assessment of ecological factors, 198
direct assessment of prevalence, 193
biochemical tests, 197
chest/head circumference ratio, 196
clinical signs, 43, 193
methods of, 198, 200
muscle depletion, 196
nutritional anthropometry, 43, 194
serial weight measurements, 195
single length measurements, 196
single weight measurements, 194
value and feasibility of field assessment, 198, 199
indirect assessment of prevalence, 197
age-specific mortality rates, 197
cause-of-death records, 197
health-service statistics, 198
intermediate severe syndromes, 188
key findings in prevalence surveys, 201
method of tabulating, 204
kwashiorkor, 180
lines of development in, 189, 190
mild-moderate, 188
Protein-calorie malnutrition (*continued*)
in early childhood (*continued*)
nutritional dwarfism, 192
nutritional marasmus, 186
presentation of data from rapid prevalence surveys, 198
clinical assessment, 198
nutritional anthropometry, 199, 202, 203
statistics from local health services, 201, 203
suggested terminology, 179
methods of obtaining data on, 102
cause-of-death records, 104
health centres, 102
hospitals, 103
surveys, 102
Psychomotor change in kwashiorkor, 183
Psychosis, 40
Pterygium, 25
Pyorrhoea, 30

Radiographic examination, 94
Riboflavin, biochemical test for, 90
guide to interpretation of riboflavin excretion, 84, 91
research tests, 244
Riboflavin deficiency, 45
Ribs, beading of, 37, 47
Rickets, 206
clinical signs of, 47
radiographical signs of, 94

Scars, angular, 25, 45
corneal, 23
Schoolchildren, nutritional assessment of, 208
biochemical tests, 210
biophysical methods, 210
clinical assessment, 209
nutritional anthropometry, 209
Sclera, pigmentation of, 23
Scurvy, infantile, 46
in artificially fed infants, 178
radiographical signs of, 95
Signa de bandera, 18
Sisikan (Bitot's spots), 104, 205
Skin, clinical signs in direct nutritional assessment, 33
diffuse depigmentation, 19, 43
flaky-paint dermatosis, 33, 43, 185
follicular hyperkeratosis, 33, 44
in kwashiorkor, 184, 185

Skin (*continued*)
intertriginous lesions, 36
mosaic dermatosis, 36
pellagrous dermatosis, 33, 46
petechiae, 33
scrotal dermatosis, 36, 45
thickening and pigmentation at pressure points, 36
vulval dermatosis, 36, 45
xerosis, 33, 44
Skin-fold measurement, 72
standards of reference, 75
5-15 years, 236
adults, 242
birth to 60 months, 227
subscapular (infrascapular, back), 74
triceps (upper arm, dorsal arm, arm), 74
Skull, clinical signs in direct nutritional assessment, 37, 47
variations in shape of, 70
Socio-economic factors related to malnutrition, 125
Soft tissues in anthropometric measurement, 71-78
muscle, 75
subcutaneous fat, 72
Special problems in different groups, 176-218
adults, 214
pregnant and lactating women, 210
schoolchildren, 208
young children, 176
Steelyard, used in anthropometric measurement of weight, 66
Stomatitis, angular, 25, 45
Stool samples, in field nutrition surveys, 161
Subcutaneous tissues, clinical signs in direct nutritional assessment, 36
Survey forms, 143-149
analysis of data from, 165
design of, 147
dietary questionnaire, 149
food-consumption, 149
punch-edge cards, 143
rapid ecological visit, 149
rapid screening, 149
single sheet, 143

Tachycardia, 41, 45
Teeth, clinical signs in direct nutritional assessment, 27
attrition, 28
caries, 27
Teeth (*continued*)
deciduous, average eruption time of, 62
enamel erosion, 30
enamel hypoplasia, 30
mottled enamel, 27, 48
permanent, average eruption time of, 63
standard visual coding of, 59
Therapeutic trials, as extension of clinical assessment, 48
Thiamine, biochemical tests for, 90
guide to interpretation of thiamine excretion, 84, 90
research tests, 243
Thiamine deficiency, 2-5-month mortality rate in, 98
clinical signs of, 45
Thorax, deformities of, 37, 47
Thyroid gland, enlargement of, 30, 48
Tongue, clinical signs in direct nutritional assessment, 25
fissures of, 27, 46
geographic, 27
magenta, 27, 45
oedema of, 27
papillae of, 27, 45, 46, 47
pigmented, 27
scarlet and raw, 27, 46
Training of personnel for nutrition surveys, 153
types of staff, 154
Tuberculosis, as conditioning infection for malnutrition, 113

Undernutrition, definition of, 8
in adults, 215
Urine, collection of samples for biochemical tests, 81
in field nutrition surveys, 162
guide to interpretation of urinary vitamin excretion data, 84

Vital statistics as indirect indicators in nutritional assessment, 97
Vitamin A, biochemical test for, 88
Vitamin-A deficiency, clinical signs of, 44
in young children, 177, 178, 205
Vitamin B_{12}, biochemical tests for, 91
serum concentrations in man, 244
Vitamin-B_{12} deficiency, 47
Vitamin-C deficiency, 46
Vitamin D, biochemical test for, 89
Vitamin-D deficiency, 47

Weight, anthropometric measurement of, 64-67
standards of reference, 67
weight for age, birth to 60 months, 221
weight for head circumference, young children, 226
weight for height, adult females, 240, 241
adult males, 238, 239
boys, 234
girls, 235
weight for height for age, boys, 230, 231
girls, 232, 233
weight for length, young children, 224, 225
weight gain during first two years of life, 196

Xerosis, 33
conjunctival, 21, 44
corneal, 21, 44
skin, 33, 44

Young children, nutritional assessment of, 176
definition of, 166
malnutrition in early childhood, 176
avitaminosis A, 205
infantile beriberi, 46, 98, 176, 206
infants, 176
iron deficiency, 207
pre-school children (1-4 years), 178
protein-calorie, 179-204
rickets, 206