Some Indicators for a Broad Assessment of the Magnitude of Protein-Calorie Malnutrition in Young Children in Population Groups

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IN RECENT YEARS more attention has been paid to health problems of populations of technically underdeveloped countries. Among those populations, children are more severely affected, and protein-calorie malnutrition[1] is one of the more severe problems. Action programs directed toward the control of those conditions need to establish the magnitude and nature of the problem as the basic and preliminary step. Consequently, it is necessary to measure protein-calorie malnutrition in children, especially in rural tropical communities.

The WHO Study Group on "Measurement of Levels of Health" met in Geneva in 1955[2] and in considering several indicators of health recommended further studies on the use of indicators to measure the nutritional condition of populations. The Fifth Session of the Joint FAO/WHO Expert Committee on Nutrition met in 1957 and in its report[3] suggested that there is a need for *simple, objective "Nutritional Indicators" which can be used by general public health workers with a limited knowledge of nutrition.* The committee emphasized the importance of seeking such indicators, although the difficulties involved were fully recognized.

The aim of this paper is not to define the methods for the diagnosis of deficiency diseases but to discuss, in a preliminary fashion, several possible indicators which might be used—although realizing their limitations—to determine roughly the extent or magnitude of the nutritional problem posed by protein-calorie malnutrition in early childhood in a given area or country.

For this purpose potential indicators may be drawn from several sources, namely: (1) vital statistics, (2) anthropometric measurements, (3) clinical signs, (4) food consumption, and (5) laboratory tests.

INDICATORS FROM VITAL STATISTICS

Sebrell and Hundley[4] suggest that indirect or presumptive evidence of nutritional status can be gained from such information as crude death rate, infant mortality rate and the tuberculosis death rate.

Mortality Rate in Children One to Four Years of Age

Since the child below one year is usually protected by the mother's milk, and since the school-age child can compete at home for more and better food, the impact of protein-calorie malnutrition is specially noticed in children between one and four years of age.

It is true that in official certification of deaths, diarrhea is the first and most important cause of mortality in children under five years of age but, as has been shown by Scrimshaw et

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Indicators	Countries, Areas, Villages or Specific Groups of Population		
	A	B	C
Percentage of deaths in children under 5 years of age	5	20	50
Percentage of births with a weight less than 2.5 kg.	3	10	20
Preschool children (one to four years)			
Mortality rate in the one to four age group per 1,000	1	15	40
Anthropometric measurement (Gómez's classification)			
1st degree of malnutrition	5	20	40
2nd degree of malnutrition	3	15	30
3rd degree of malnutrition	0.5	5	10
Percentage with edema	..	3	6
Percentage with easily plucked hair	1	10	20
Percentage with a total protein level less than 6 gm.	..	3	6

al.,[5] a great proportion of deaths attributed to either diarrheal diseases or parasitism are really due to severe malnutrition. And, even more important, most of the deaths would probably not have occurred if the children had been fed properly.

From the point of view of vital statistics, it appears that the mortality rate in children one to four years of age may be a good indicator of the protein-calorie malnutrition problem in a given area or country.

Bengoa[6] in 1955 was of the opinion that when the mortality rate in the one to four-year-age-group is more than 10 per 1,000, it could probably be related to a serious protein nutrition problem, although other factors would be contributing to this high mortality. There are still countries in which the mortality rate in children one to four years of age is above 30 per 1,000, whereas in the United States of America, England and North European countries it is about 1 or 2 per 1,000.

The best way to express this mortality is undoubtedly by means of the specific one to four mortality rate (number of deaths among children aged one to four years divided by the population one to four). However, official statistics in technically underdeveloped countries are usually inaccurate, and, even if that was not the case, the population one to four has to be estimated, and consequently is not accurate. This mortality has also been expressed as the per cent of deaths among children aged one to four from the total number of deaths.

Wills and Waterlow[7] have suggested that the ratio of death rates for children aged one to four years to that of infants aged one to twelve months might serve as an index. The death rates are expressed by Wills and Waterlow as a percentage of all deaths registered.

INDICATORS FROM ANTHROPOMETRIC MEASUREMENTS

The Birth Weight

The many references on this subject are well known and will not be included here. Generally speaking, it is agreed that the nutritional status of the mother has some influence on the weight of the fetus, along with other factors such as racial genetic influences, the age of the mother, sex, plurality of birth and certain diseases.

Platt[8] has suggested that a record of birth weights of infants may provide a useful indicator of the state of nutrition of mothers and possibly of the community generally.

The question arises as to the best way of using the birth weight as an indicator. The average of the total figures in a given population does not show the variations which exist in countries with different levels of nutrition. It appears to be more satisfactory to obtain the percentage of newborns with a weight below a conventional arbitrary figure, for instance, 2.5 kg. (this figure corresponds incidentally with the prematurity index).

Alternatively possibly more useful information might be obtained by using an index based on a comparison of the birth weight of the poorly nourished lower socioeconomic groups of a country or region with that of the apparently well nourished upper socioeconomic group of the same genetic composition. Jelliffe[9] has suggested that this index might be termed the

"socioeconomic birth weight quotient," defined as:

$$\frac{\text{average birth weight in lower socioeconomic group}}{\text{average birth weight in upper socioeconomic group}} \times 100$$

The difficulty with this index may be largely in defining and discovering the upper socioeconomic group considered to be "well nourished."

Assessment by Weight of Preschool Children

For some years the Mexican School of Pediatrics, under the direction of Dr. F. Gómez, has advocated the classifying of malnutrition in early childhood into three categories or degrees, depending upon the percentage deviation of the weight below the average for the group.[10]

1st degree of malnutrition = from 75 to 90% of the "average" weight
2nd degree of malnutrition = from 60 to 75% of the "average" weight
3rd degree of malnutrition = below 60% of the "average" weight

As an experimental approach to the use of this classification in field surveys the following results were obtained in three studies carried out in Central America and the Caribbean area:

Degree of Malnutrition	Country A[11]	Country B[12]	Country C[13]
1st degree	41%	54%	37%
2nd degree	36%	20%	21%
3rd degree	7%	2%	3%
Normal	16%	24%	40%

The names of the countries are not given because the types of population surveyed were not the same in the three studies and the results are not comparable from a statistical point of view. However, the results clearly suggest that this classification may be used as objective indicator of the prevalence of protein-calorie deficiency in the child population.

The strongest objection to using this classification is that the children's ages are often not known precisely. In some instances, it may be possible to check with birth certificates, but usually these do not exist, so that approximations may have to be made, based on the age as stated by the mother checked against locally important "time-marking" events, both natural and political.

Another controversial subject concerns the definition of the "average" weight, which, of course, it is necessary to obtain in a previous study in order to apply Gómez's classification correctly, although frequently standards obtained from elsewhere (i.e., United States of America or Europe) may be used. This may make for confusion and the standards used must be clearly defined. Perhaps ideally this type of result might be given *both* in relation to local standards *and* to widely accepted arbitrary standards universally recognized as a yardstick, as, for example, is the case with the 2.5 kg. level for birth weight.

Obviously this classification has certain limitations. For example, it does not differentiate between the different *forms* of malnutrition. However, it is undoubtedly one of the most important devices for measuring the public health significance of protein-calorie deficiency diseases in the preschool age group as in each syndrome, especially in kwashiorkor and nutritional marasmus, a low body weight is a constant finding. In addition, differentiation into the three degrees permits a grading of the nutritional status of a preschool child population which cannot be achieved in any other way.

Arm Muscle and Fat Measurement

It seems possible that a rough gauge of depletion of calories and proteins may be obtained by directly measuring the body's principal stores, that is, subcutaneous fat as an index of calorie inadequacy, and voluntary muscle for evidence of protein depletion. Based on this principle, one of us (D. B. J.) has tentatively suggested the low arm circumference index.[14]

This would be based on the fact that, in all forms of protein-calorie malnutrition in preschool children, muscle wasting appears to be a marked and constant feature. The mid-upper arm circumference, at the level of the belly of the biceps, can be simply measured and may give a rough gauge of muscle depletion. Aver-

age values of apparently normal children require to be known for the particular population. The low arm circumference index might then be defined as the percentage of children whose measurements fell below a pre-agreed level, possibly 80 per cent of the average values in "normal" children. Plainly this approach requires considerable further thought, as well as field trial.

Height and Weight of First-grade Children

Hundley et al.[15] have shown that the height and weight of first-grade children (six to seven years old) may yield an index of nutritional status of sufficient sensitivity to detect favorable or unfavorable trends of less than "mass starvation" magnitude.

INDICATORS FROM CLINICAL FINDINGS

Two main practical difficulties have been found in the use of clinical surveys to evaluate the prevalence and incidence of a given deficiency disease. First, there are several signs which are not specific to a given deficiency and, second, the estimation of many of the clinical signs is very subjective.

Jolliffe[16] used several key clinical signs as indices in order to evaluate the incidence of deficiency diseases in Newfoundland, e.g., angular stomatitis in riboflavin deficiency; follicular keratosis of arms in vitamin A deficiency; and red hyperemic gums in ascorbic acid deficiency.

The same approach has proved to great value in public health activities in Venezuela where key signs have been used for some time as a measure of the incidence of certain deficiency diseases.[17]

Edema

In a recent review[18] of the clinical aspects of kwashiorkor, the basic features were found to be: growth retardation and edema.

Growth retardation has already been suggested in this paper as an anthropometric indicator. It may also be possible to consider edema in preschool children as a key sign or indicator of protein-calorie malnutrition. Apparently there are few other conditions, from the public health point of view, that commonly produce significant cases of edema in tropical preschool children. The fact that it may also occur in some children with renal disease, severe anemia and beriberi does not prevent its use as an indicator of malnutrition in infants. The edema must be tested in the pretibial region, with a "moderate" pressure with one finger for approximately three seconds. A prolonged pressure, especially in the hot weather found in tropical areas, may produce minimal pitting even in well nourished normal subjects.[13] If there is any doubt as to the validity of the pitting test, the edema must not be recorded.

In spite of the lack of complete objectivity in the appreciation of edema, it does appear that this sign, carefully tested for, can provide considerable public health information, provided other causes of edema are excluded in doubtful cases. It must, however, be realized that, as only one form of advanced protein-calorie malnutrition shows edema, this index will give an indication of only one facet of the problem.

Easily Plucked Hair

Changes in hair are almost constantly present in protein malnutrition. Alterations in the color, texture, straightness, denseness and "pluckability" have been described. In children who live in the environment of tropical areas, where sunshine, dust and lack of hygiene are prevalent, it is difficult to establish when the color and the texture are abnormal. These factors, however, will not alter "pluckability," and easily plucked and detachable hair has been suggested by Guatemalan workers as an additional indicator of protein malnutrition. The sign is investigated as follows: A group of 20 to 30 hairs from the anterior half of the head is taken between the thumb and index finger and pulled firmly and steadily. In an undernourished child ten or more hairs will be plucked easily and without pain. In a study carried out in Guatemala by one of us (C. P.) it was shown that 27 per cent of preschool children in a poor rural area had this sign, and a significant statistical correlation was found between this sign and the weight of the children. A main difficulty with this test lies in

standardization of positiveness, that is, how many hairs plucked out and how hard it must be pulled.

Alternative hair signs have either been suggested or might be worth investigating. A "hypochromotrichia" index has been considered, based upon lightening in the color of children's hair.[19] Difficulties are numerous, and include the problem of defining hypochromotrichia in relation to color change, area of scalp and length of hair involved, as well as a lack of complete correlation between this change and protein-calorie malnutrition.[13]

INDICATORS FROM FOOD CONSUMPTION AND COST OF FOODS

The United Nations Report on International Definition and Measurement of Standards and Levels of Living[20] suggested the following indicators from food consumption data: "(a) National average food supplies in terms of calories at the 'retail level' compared with estimated calorie requirements. (b) National average food supplies in terms of total proteins at the 'retail level,' and (c) National average food supplies in terms of animal protein at the 'retail level.' "

As the same report says, the average availability of food is, of course, not a direct measure of nutritional intake; neither does it give an indication of the distribution of food within the population. However, it may be of value.

The fact is that much better information is obtained through actual patterns of consumption on a family basis, or even better, on an individual basis, especially in preschool children. However, the technic for carrying out such surveys is not so easily undertaken by non-specialized personnel. This kind of study could be considered as supplying fundamental complementary information to that obtained from the indicators under discussion.

A simple indicator in relation to foods and infant malnutrition might be to compare the cost of a liter of milk (or its equivalent in dry milk) with the average salary of non-qualified workers in agriculture and industry, in the area or country. Although in certain countries milk is not a usual food in infant feeding, in most countries this indicator could provide a reasonable background to infant malnutrition problems. In areas or countries where the cost of a liter of milk is $0.20, and the salary $1.00 the reason for the frequency and comparative prevalence in certain areas and countries is quite understandable. Although it is not in itself an indicator of infant malnutrition, it might be considered as an indirect appraisal of the situation.

INDICATORS FROM LABORATORY TESTS

In spite of the enormous advances in the field of nutritional biochemistry, there is no new test available which can be used in field surveys as an indicator of protein malnutrition.

Hitherto, serum protein levels have been used to measure the level of protein nutrition, and all workers report very low figures of serum protein in kwashiorkor, about 4 to 4.5 gm.

During a recent survey made by INCAP[21] in a poor sector of Guatemala City, clinical indications of pre-kwashiorkor were found in 6 of 100 children. The total serum protein of these six children was: 4.50; 5.48; 6.24; 5.74; and 5.67. The rest of the children had an average of 6.73 ± 0.34. Frequently in field surveys the figures on serum protein are given as average, sometimes with the standard deviation. It would be more practical for our purpose to give the frequency distribution at different levels, and particularly the percentage below an arbitrary figure, for instance, 6 gm. This value could offer more than presumptive evidence of the morbidity of protein malnutrition. However, to take this indicator independently of others suggested in this paper would be of little value. This indicator, as the others, must be considered and analyzed in conjunction with other factors.

There is no doubt that albumen levels would be a better indicator, but the problem is that whereas the total protein level is easy to obtain, even in rural areas with a densimetric method, the determination of albumen levels needs special equipment.

In addition, as will be appreciated, even standard serum samples may be difficult both to collect and transport in unsophisticated, relatively remote tropical communities, especially as blood will usually have to be taken from either the external jugular or femoral

veins in children of this age; while interpretation of results, especially from one part of the world to another, may not be straightforward, owing to interrelated effects on the levels of plasma proteins of the immune processes occurring in hyperendemic malaria, or of intestinal helminth infection, or of liver damage. However, despite these objections, this does seem to be the most potentially useful approximate laboratory public-health indicator of protein-calorie malnutrition.

Platt and Heard[22] have suggested that the determination of urea nitrogen and ammonia nitrogen as a proportion of the total urinary nitrogen may offer a simple method of assessing nutritional status with respect to protein. This test has the great merit of simplicity, as a single morning specimen of urine provides all the required information. This indicator could be of value, but requires much further testing.

The possibility of using hair samples does not appear to have been considered; although some workers have found the cystine to be low in the hair of children with kwashiorkor,[23,24] while others have not.[19,25] There is plainly need for much further work into chemical and physical differences (if such exist consistently) between the hair of normal children of a particular ethnic group and those with protein-calorie malnutrition. The advantages of hair samples in relation to ease of collection, transport and storage are self-evident.

CONCLUSIONS

We realize that the indicators presented herein by no means represent a completely satisfactory solution to the problem. However, we do believe that these would at least serve as first steps toward the attainment of the highly desirable objective indicated in the introduction, namely the definition of simple indicators to be used by general public health workers with limited knowledge of nutrition.

It is obvious that it will be difficult to find a simple indicator which by itself can show the extent of infant malnutrition and serve to evaluate the problem. These indicators also need careful interpretation in association with background information on the health situation of the area, dietary habits, etc.

An important aspect of the problem is that the accuracy of the evaluation of malnutrition in infants must be consonant with the required uses of the data. For example, it may not be necessary to know with great precision whether the preschool mortality rate in a given country is 40 or 50. In either case, the same policy and administrative action would undoubtedly be indicated. It is important, however, to know, at least approximately, how precise measurements are, that is, to know their relative margins of error. This and other related problems involved in the use of indicators have been clearly pointed out by the Report on International Definition and Measurement of Standards and Levels of Living.[20] It is also equally important to know whether or not a sample in which the indicators proposed have been used is representative of the whole population or of a selected group. In the latter case, this group should be clearly defined and its numerical importance in relation to the total population should be indicated.

It is our opinion that indicators to be used in determining the severity of infant malnutrition by public health workers must be based on some essential principles: (1) The indicators must be *simple* to collect and to interpret. (2) They must be as *objective* as possible. (3) They must be *numerically measurable*, so that they can also be used in evaluation programs. (4) They must be as *specific* as possible, but not necessarily completely so. Very few signs in medicine or in public health are absolutely specific.

It is unnecessary to add that these indicators do not replace the traditional anthropometric measurements, clinical surveys and laboratory tests in a given population.

The following table is a theoretic example of some of the indicators discussed in order to demonstrate their possible use in evaluating the public health significance of protein-calorie malnutrition.

SUMMARY

Protein-calorie malnutrition in preschool children is probably the most common and important nutritional problem in the world today. To assess the effect of both planned

would-be ameliorative public health measures and also such unplanned socioeconomic and cultural changes as are occurring everywhere, it is necessary to measure the dimensions of this problem on a broad public health basis.

The present paper outlines certain steps in this direction and suggests possible simple potentially useful indicators derived from the following sources: (1) vital statistics, (2) anthropometric measurements, (3) clinical signs, (4) food consumption and (5) laboratory tests. Advantages and limitations are discussed. Probably a combination based on data from all these sources would be most valuable. The need for further investigation is stressed.

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