APPENDIX 4

Anthropometric assessment of nutritional status

Nutritional anthropometry can be defined as measurements of the physical dimensions and gross composition of the human body as a means of assessing nutritional status. Some 20 years ago it was proposed that anthropometric measurements should be reported in relation to international reference values as a means of grouping and analysing anthropometric data and making comparisons across time and different population groups (Waterlow *et al.*, 1977).

1. CHILD NUTRITIONAL STATUS

Measurement issues

The three most frequently used indicators of the nutritional status of children are based on weight and height measurements: weight for age, height for age and weight for height. The interpretation and transformation of these indicators for determining the prevalence of weight deficiency, stunting, wasting and obesity, and thus for classifying populations according to their degree of risk of under- and overnutrition, are described in detail in WHO (1995). Salient points that may assist the reader in interpretating the empirical evidence presented in Chapter 3 are presented here. In combination, these three indicators provide estimates of both current and past undernutrition or of current states of obesity. These indices alone do not provide insights into the underlying causes – in particular, whether the risk of malnutrition originates from food or non-food factors, or both.

Height for age and weight for height represent two different biological processes. Weight for height is sensitive to acute nutritional disturbances; a low weight for height is described as *wasting*. Wasting particularly tends to occur during the weaning period or in the second year of life, after which its prevalence tends to decline. Height for age is a measure of linear growth; a faltering of linear growth, or *stunting*, may occur as early as within three months after birth. The deficit in linear growth is difficult to reverse unless the child's environment changes for the better. Weight for age represents a convenient synthesis of these two processes. Because of the different distributions over time in children under the age of five, it has been recommended that prevalence data be disaggregated by age whenever possible.

The deviations of actual height and weight measurements from the corresponding age-specific median values in the reference population are converted into standard deviation scores (Z-scores) and a normalized distribution is thus generated for a population. In the case of the weight for height index, the deviations from the height-specific median reference values are normalized. The "normal" range on the normalized distribution for the three indices is taken to be between -2 standard deviation (SD) and +2 SD from the median (=0). The "low" range is then <-2 SD, and the "high" range is >+2 SD. On a population basis, therefore, the proportion of children in the low, normal and high ranges of distribution can be estimated. In populations where a high percentage of children fall into the low range, children are said to face a high risk of being weight-deficient, stunted or wasted.

Data on weight and height indices are often aggregated for "children under five", as is done in Chapter 3. The application of the current NCHS/WHO reference standards for infants (0-12 months) has recently been questioned on the grounds that this is of limited value in assisting health and child care workers in the optimal nutritional management of infants (WHO, 1994). It has been recommended that a new reference be developed; however, insufficient data has been a limiting factor in developing such reference values for infants.

Debates have arisen in the past over whether national reference values for the comparison of nutritional status across populations should be established or whether a single international reference standard should suffice. It is now generally agreed that there should be a single set of reference values. Part of this argument is based on observations that the effect of ethnic differences on the growth of young children is small compared with the environmental effects. National or regional reference values, usually obtained from middle- or high-income groups, tend to differ little from the NCHS/WHO reference values, so the application of the latter in developing countries is likely to lead to few classification errors. Furthermore, national or regional reference values require constant updating, since developing countries are experiencing secular trends of increasing heights and weights. The costs and logistical problems associated with producing statistically valid national reference values are additional concerns. In view of all these considerations, for the time being WHO has decided to endorse the adoption of the NCHS reference values for international use until new international reference values can be developed (WHO, 1995). An international effort towards that end is currently under way (WHO, 1994).

Data source: WHO Global Database on Child Growth

The estimates of the nutritional status of children under five presented in Chapter 3 were provided by the WHO Global Database on Child Growth. The current database includes prevalence figures from surveys in 131 countries, 100 of which have carried out national surveys. In most cases, the original data sets are reanalysed in collaboration with countries to standardize the information in terms of cutoff points, data presentation, reference data, etc. The criteria for the selection of surveys for inclusion in the database are: i) a clearly defined population-based sampling frame; ii) a probabilistic sampling procedure involving at least 400 children under five; iii) the use of appropriate equipment and standard measurement techniques; and iv) the presentation of results as Z-scores in relation to the NCHS/WHO reference population (de Onis *et al.*, 1993).

The surveys included in the current analysis were conducted from 1980 onwards, with two exceptions (Nepal and Liberia). For the purpose of estimating regional figures, these two cases were assumed not to have any relevant data. Almost two-thirds of the country surveys (44) included in the analysis were conducted between 1988 and 1993. The proportions of undernourished children obtained from these surveys were applied to the UN population figures for 1990 to estimate the number of undernourished children; 1990 represents the approximate mid-point of the period 1988-1993 (UN, 1993). This is also the procedure used by WHO itself in its own assessment of child undernutrition. Although the population figures refer to the number of children under five years of age, it should be noted that prevalence figures obtained from the surveys are not in all cases for children within this age group. Furthermore, WHO's classification of countries by region is not identical to FAO's classification.

The 73 countries for which survey data are presented accounted for 90.9 percent of all children under five in 1990 in the 98 developing countries for which estimates of child undernutrition are provided in this study. By FAO regions, these percentages are as follows: Latin America and the Caribbean, 99.9 percent; South Asia, 98 percent; East and Southeast Asia, 95.7 percent; sub-Saharan Africa, 79.5 percent; and the Near East and North Africa, 60.9 percent.

The following aggregation issues had to be addressed in order to arrive at regional and global estimates of underweight, stunted and wasted children: i) the estimation of the number of underweight, stunted and wasted children under five in countries where the survey covered an age group other than that of 0-59 months; ii) the estimation of the number of underweight, stunted and wasted children in countries which were not included in the WHO database; and iii) the choice of a procedure for the classification of countries for calculating regional and global totals.

The first of these issues was addressed by simply applying the proportion of children actually measured and found to be underweight, stunted or wasted to the estimate of the population under five. No adjustment was made to account for possible differences in the prevalence of undernutrition in different age groups within the population under five. In response to the second issue, that of deriving estimates for countries which had no survey data, the WHO methods were followed closely. First, the WHO regional classification was applied to classify the 73 countries. Next a weighted average prevalence of the three anthropometric indicators was calculated for each region and these average rates were then applied to the 1990 population estimates of children under five in the remaining 25 countries. This procedure thus provided an estimate of the number of underweight, stunted and wasted children in those countries. The third issue was then tackled by regrouping the 98 countries according to the FAO regional classification in order to calculate regional and global totals.

2. ADULT NUTRITIONAL STATUS

Body mass index

Weight for height indices have long been used to assess the body composition of adults. Body composition is directly affected by nutritional risks. Different formulations of the height for weight index have been considered, the objective being to find an index that is highly correlated with weight and uncorrelated with height, i.e. interindividual variations should be due to differences in body weight as a proxy for body energy stores and muscle mass and not due to variations in height. The index of weight (kg) divided by height^2 (m) (body mass index [BMI]) has consistently been found to meet this criterion in different population groups. Other formulations have tended to be either correlated with height (e.g. weight/height) or to have a relatively lower correlation with body weight and a negative, albeit low, correlation with height (e.g. weight/height^3 or its inverse).

The BMI is an indicator of body composition. It has been shown to be related to body fat mass and to fat-free mass, the two main components of the body in addition to bone and water. Inter- and intraindividual variations in BMI are then due to differences or changes in body fat mass and fat-free mass. It has therefore been argued that a low BMI value represents a state of chronic energy deficiency (CED). BMI has also consistently been shown to be much less related to fat proportion, thus making it a valid indicator for both women and men. (Women normally have a larger fat proportion than men.)

Questions have arisen about the interpretation of BMI values in different populations. The relationship between BMI values and body energy stores appears to vary among different population groups in developing countries (Immink, Flores and Diaz, 1992; Norgan, 1990). Thus, a comparison across populations may be somewhat compromised but it can reasonably be argued that, in all populations, low BMI values indicate both reduced fat and fat-free mass. It has been found that a reduction in the latter mainly occurs at the expense of muscle (Soares *et al.*, 1991). This, in turn, indicates that CED is likely to impair physical performance. At the upper end of the BMI distribution, the relationship with body fat mass is consistently found to be strong, making the BMI a valid indicator for comparing the risk of various degrees of obesity across population groups. At the same time, weight and height measurements are easily obtained at a low cost and can easily be standardized to minimize measurement errors, while little transformation of data is required to construct the BMI. All these properties make the BMI an attractive index of adult under- and overnutrition.

BMI cutoff points

The cutoff points applied to classify individuals and to obtain estimates of the proportion of the population at risk of being weight-deficient or obese were established by relating BMI values to various degrees of risk of morbidity in healthy reference populations. In a number of developed countries, the majority of adult women and men were found to have a BMI between 20.0 and 25.0, often referred to as the "normal" range of BMI. Optimal levels of BMI in women and men in developed countries are between 20.0 and 22.0, based on the association between life expectancy and the BMI. The lower limit to define CED in adults was obtained by taking the mean -2 SD of BMI distributions obtained from large samples of the United Kingdom's armed services personnel (both women and men), chosen as a provisional reference population because they were known to be fit and healthy. The lower limit, defined as above, turned out to be: 18.5 for men and 17.6 for women, as weighted means in both cases (James, Ferro-Luzzi and Waterlow, 1988). However, the common cutoff point of 18.5 BMI is now recommended for both men and women on the basis of existing evidence on the functional consequences of a low BMI.

There is some empirical evidence to show that a low BMI is associated with negative physiological, biological and socio-economic consequences. The suggestion is that aerobic work capacity is affected at BMI levels above 17.0 but that physical activity is not affected before this level is reached (Durnin, 1994). This is to be expected if low BMI values reflect reduced fat-free mass. Low BMIs in early pregnancy or prior to pregnancy among women in Egypt, Mexico, Kenya and Indonesia were found to be associated with low birth weights (Allen *et al.*, 1994; Kusin, Kardjati and Renqvist, 1994). Adults in Brazil with a BMI of less than 18.5 (or with a BMI greater than 30.0) were found to face a substantially greater risk of being ill than women with a BMI in the normal range (de Vasconcellos, 1994), and the same was found to be true for Rwandese women (Shetty and James in FAO, 1994b). Rural women in Kenya with a BMI of less than 18.5 spent as much time daily in work activities as women with a BMI of more than 18.5, although the latter group on average spent more energy per day (Kennedy and Garcia, 1994). Yet, Rwandese women with a BMI of less than 17.6 had lower average physical activity levels and more rest time each day than women with a BMI above this cutoff point (Shetty and James in FAO, 1994b).

The selection of 18.5 as the cutoff point to define CED in adult men and women may finally represent somewhat of a compromise (James and François, 1994). This cutoff point represents the third percentile among men with a median BMI of 23.0, and among women with a median BMI of 24.0, and a significant percent of overweight individuals may be included in the range of 20.0 to 25.0. With lower median values, for instance 20.0, the third percentile is 16.0 which clearly corresponds to high morbidity risks. Thus, the compromise for women and men in developing countries is to adopt 21.0 to 23.0 as the optimal range, and, as the normal range, 18.5 to 25.0 (James and François, 1994).

Classification of nutritional status

Once weights and heights are measured in a given population, a BMI distribution can be generated for that population. By applying the cutoff points established in the reference population to this BMI distribution, estimates of the proportion of the population that can be said to be at risk of being chronically energy-deficient (<18.5) and the proportion at risk of being obese (≥25.0) can be obtained. The prevalence of adult CED in developed countries amounts to a small percentage. For example, 3 percent of men and 7 percent of women in France were found to have a BMI of less than 18.5 (Rolland-Cachera *et al.*, 1994). The invariable classification errors notwithstanding, the measured proportion of the population in developing countries with a BMI of less than 18.5 and equal to or greater than 25.0 is equated with the prevalence of CED and of overweight adults.

Risks of different degrees of CED are further indicated by dividing the area below 18.5 on the BMI distribution curve and applying the following cutoff points: 18.4 to 17.0, CED grade 1; 16.9 to 16.0, CED grade 2; and less than 16.0, CED grade 3. Equally, at the upper end of the BMI distribution, the degree of risk of obesity is indicated by applying the following cutoff points: 25.0 to 29.9, obesity grade 1; 30.0 to 39.9, obesity grade 2; and equal to or greater than 40.0, obesity grade 3.