

# Measuring hunger and malnutrition

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## Executive Summary

Five types of methods are used for assessing the extent of hunger and malnutrition, each having different applications and comparative advantages in terms of uses for advocacy, policy analysis and decisions, and research. Three of these, the FAO method, household income and expenditure surveys (HIES) and food intake surveys (FIS), estimate dietary intake and try to relate this to energy needs, of which physical activity is the largest single component yet the least measurable. The fourth assesses perceptions of hunger and behavioural response (qualitative methods), and the fifth measures physical effects on growth and thinness (anthropometry). Not only is there no absolute measure (or “gold standard”), but these methods assess different aspects of hunger and dimensions of its effects on health, suffering, behaviour and economics. None the less, triangulating on trends in “hunger” is a reasonable goal and is the underlying intent of the internationally agreed upon obligation to accelerate the reduction in the numbers of people affected.

In principle, the ways ahead are suggested as: shifting towards trend assessment based on patterns of related indicators that capture different dimensions of hunger; estimating global and regional trends every few years with the current FAO methods, with more detailed assessments in selected (“sentinel”) countries through household and individual surveys; developing qualitative methods in the local contexts and starting to use these as modules in other surveys; using small-scale studies for policy and causality research; and balancing resource allocations based on required outputs and decision needs.

The associations between income, dietary energy intake and anthropometry can be understood from national data and point the way to interpreting trends. The prevalence of child underweight differs by income bands. Within countries, the relationship of child underweight prevalence with income appears to be non-linear. This is consistent with child malnutrition being caused by a number of interacting factors, several of which may need to improve before an impact is seen on child growth. Across countries, greater variation is

seen with location than with income. In South Asia, child growth responds much faster to increasing income or food availability – in line with the high incidence of low birth weight and related intergenerational effects. Patterns of within-country indicator trends can be interpreted in relation to food, health and nutritional factors. To this, there is a need to add diet quality, derived from food supply estimates, surveys of food availability and intake, and clinical and biochemical measurements. Combating hunger to promote health and productivity clearly includes adequacy in micronutrients to prevent anaemia and retarded child development, to improve resistance to disease and to bring other benefits.

Based on the detailed descriptions of methods in the other keynote papers, it is clear that the characteristics of the different methods can be complementary, although further research and investments in application will be needed. Not only are indicators expected to go in the same directions, but results from one method can validate others (e.g. underweight and energy inadequacy) with due attention to the concepts and cutoff points involved. In particular, development of the behavioural qualitative methods based on those used to estimate hunger in industrialized countries is suggested, with further use of HIES (calculating dietary energy from survey questions), and application of FIS methods in selected countries to produce time-series data. FAO food balance sheet (FBS) data should be processed also to track diet quality and micronutrient availabilities.

Sustained application of these approaches can lead to valid and understandable assessments of progress in combating hunger, which would be powerful in advocacy terms and important for understanding policy successes and defining new initiatives. Fewer hungry people should result.

## Introduction

At the World Food Conference in Rome in 1974, it was famously asserted by Henry Kissinger that “within a decade, no child should go to bed hungry” (UN, 1975). At this time, FAO’s Fourth World Food Survey (FAO, 1977) was under way, and already much effort had gone into quantifying the extent and distribution of hunger (see review by Naiken in this series). By the estimates used then and continued to the present – indeed, forming the core of these discussions – the total numbers of hungry in world history can now be seen to have peaked in the 1960s (FAO, 2000, p. v; see discussion in Mason, 1996, based on FAO estimates). But if progress is likely from a number of indicators and angles, it is internationally agreed that the rate is too slow.

A series of summits and international conferences promoted and reaffirmed the intent to accelerate the reduction in worldwide hunger and malnutrition. The World Summit for Children (UN, 1990) committed states to halving the extent of child malnutrition by the year 2000, with associated goals for specific nutritional problems. The International Conference on Nutrition in 1992 (FAO/WHO, 1992) reasserted and added depth to such goals. At the World Food Summit (WFS) of 1996 (FAO, 1996a), leaders of 186 countries pledged to reduce by half the numbers of hungry people in the world by 2015 (FAO, 2000, p. iv). The UN’s recent Millennium Development Goals included commitments to a similar intent (UN, 2000).<sup>1</sup>

Accelerated improvement in reducing hunger is thus a widely recognized aim of the international community and of many countries and societies. It has humanitarian, ethical and practical connotations – food as a human right is seldom disputed – and the consequent power to catalyse policy decisions and resource allocations. A part of

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1 The WFS target is halving the number of hungry, more difficult than the MDG of halving the proportion, but none the less relevant here (de Haen, personal communication, 2001).

this movement is to know the extent of the problem, what progress is being made and what more can be done about it.

Curiously, all this is feasible without exact definitions and reliable numbers, such is the emotive strength of the concern for hunger. But undoubtedly, an important feature of sustaining this concern and translating it into effective action is to clarify the concepts, refine the description of the problem, estimate the extent of progress in different parts of the world and for different groups of people, evaluate the impact of current actions and suggest appropriate new policies. Hunger and malnutrition are difficult to define in precisely measurable terms and furthermore are difficult to estimate, especially for large groups of people. The preparation and holding of the International Symposium on Measurement and Assessment of Food Deprivation and Undernutrition in June 2002 has the potential for a far-reaching contribution towards ensuring that more people have enough to eat, through improved understanding of the problem and its solution. The conventional need for good quantification supporting right-minded decisions is sometimes viewed as a luxury when faced with suffering that demands urgent attention; but time and again, it has been seen that a systematic and cost-effective approach requires sound information and analysis. This paper tries to bring together the consensus on methods for assessing these numbers and their trends, and to indicate ways ahead where differences in opinion (far fewer than the points of agreement) need to be resolved.

A first small step may be tolerance on terminology. For now, the term "hunger" can be used (as here, in the text and title) in its everyday meaning, perhaps as shorthand, but it is close enough to "food deprivation"

and "undernourishment" that using more than one term is often redundant. The term "malnutrition" – commonly used to mean the physical effects of restricted diet on the body – is used here to mean the biological and functional consequences of hunger.<sup>2</sup> While this fosters communication, the underlying concepts and definitions do need to be tight, and the way in which they are to be measured should be agreed upon – more so if measuring trends is a major aim.

The five methods presently used to measure different aspects of hunger and malnutrition are described in the following papers published in the current series:

- (1) "FAO methodology for estimating the prevalence of undernourishment", by L. Naiken;
- (2) "The use of household expenditure surveys for the assessment of food insecurity", by L. Smith;
- (3) "Individual food intake survey methods", by A. Ferro-Luzzi;
- (4) "Measures of nutritional status from anthropometric survey data", by P. Shetty;
- (5) "Qualitative measures of food insecurity and hunger", by E. Kennedy.

The present paper aims to give a synthesis on methods for estimating the numbers of people suffering from food deprivation and undernutrition. In addition, issues of diet quality and micronutrient malnutrition and the relation of diet and nutrition to biological and functional outcomes, notably growth as measured by anthropometry, are explored. Issues applying to all methods and indicators are first addressed in the next section, followed by considerations referring to different aspects of hunger and malnutrition. Different methods are then compared. Priorities for new data acquisition through surveys and other means in developing countries are suggested.

<sup>2</sup> An extensive discussion of terminology is in the paper by Shetty in this series. In the present paper, malnutrition is used for physical effects of inadequate nutrition (e.g. growth failure, specific nutrient deficiencies like iron deficiency anaemia), which Shetty refers to as malnutrition and undernutrition, for specific deficiencies and general non-specific results.

## General considerations: issues applying to all methods

### ■ The aim is to measure progress in the numbers of hungry

The WFS goal shifts the focus from estimating levels to estimating trends in the numbers and percentages of hungry people. The stress in the past was more on levels: “840 million people in developing countries subsist on diets that are deficient in calories...” (FAO, 2000, p. 1); “... in 1997–99, there were 815 million undernourished people in the world” (FAO, 2001, p. 2). A change to stressing trends – that is progress (or lack of) – would have several advantages. It would imply that action is being taken or is needed to bring about change. Methodologically, assessing trends can move attention correctly towards triangulating on estimates of change in several indicators rather than on the minutiae of one estimate of a level of malnourishment versus another. The next announcements might be along the lines: “the numbers of hungry people have fallen by (say) a quarter in the ten years since the World Food Summit ...”, or even better, going on something like: “... approaching the goals set, but stressing the need for intensification of the policies that can now be seen to have contributed to this important progress ...”.

### ■ What uses can be made of estimates of trends in hunger?

Before discussing the various methods, we should consider possible uses of their results. One use – sometimes maligned by scientists – is to make statements for political advocacy about the numbers of “hungry” or about how this number is changing. The reason for scepticism is that the estimate is so ill defined and approximate, yet not presented as such, that it is sometimes seen as having only a public relations meaning. But in fact, it is a powerful statement, and many people relate to it – probably more than to similar

pronouncements on poverty – because it has a deep, instinctive and emotionally charged meaning. We have some responsibility for making it meaningful (even if not “right”, which we may never know). For this, we do need global and regional estimates built from data that are comparable across countries and available for many (or all) countries and for most years. This is the role that the FAO results fulfil, and as discussed below, the dietary energy supply (DES) data are one of the very few sources that can lead to this.

We probably do not know precisely what decisions are made on this basis, but it is much more powerful to say that things are bad and getting “worse” than to say just “bad”; and “bad but getting better” sends a quite different signal. Moreover, it is not that assistance turns off at “bad but getting better”: it can lead one to ask “What’s going right?” and to say “Let’s help it along.”

A second use of data on hunger is for analysing policies, to evaluate what works or does not and to indicate what new or adjusted policies are needed. The data and analyses needed for this purpose may be different from those needed for advocacy purposes. Here, changes of hunger indicators must be defined by different population groups and related to actual and potential policies and programmes. A finer level of detail may be obtained with in-depth studies of specific causes of hunger, ranging, for example, from access to resources, land and employment, etc. to food habits as investigated in FIS (see paper by Ferro-Luzzi in this series). These types of surveys are especially well suited to investigating causes. Although samples are small and may represent only limited populations, thus having restricted external validity, the nearer the causes are to basic biology, the more likely they are to be generalizable, as people are biologically much the same everywhere.

The uses of the results of the various methods, from policy analysis to research into causes, is clearly intended for making decisions on better policies and programmes

METHODS FOR THE MEASUREMENT  
OF FOOD DEPRIVATION AND UNDERNUTRITION

**TABLE 1. UTILITY OF ESTIMATES BY VARIOUS METHODS OF ASSESSING FOOD SECURITY FOR ADVOCACY AND ANALYSIS**

Method	Use		
	Political advocacy	Policy analysis	Research into causes
(1) FAO: DES/CV (coefficient of variation)	Main use: global and regional level	More useful at the global level than the national level	Not very useful except for broad intercountry trends
(2) Household income and expenditure survey	Useful: national and subnational level	Main use	Useful
(3) Food consumption/ individual intake	Rarely available at the national level, thus less useful	Useful, usually for subnational groups	Main use
(4) Anthropometry	Useful at all levels, but for physical malnutrition and not food security	Useful for physical malnutrition not food security	Useful for physical malnutrition not food security
(5) Qualitative method	Useful: national and subnational level	Useful	Useful

**TABLE 2. SUITABILITY OF DIFFERENT MEASURES FOR TREND ESTIMATION**

Method	Suitability for trend analysis	Dimensions of hunger measured
(1) FAO: DES/CV	Only reflects DES change as CV held constant; but only method available for all countries/years.	Energy intake, with averaged adequacy at population level
(2) Household income and expenditure survey	Potentially suitable when there are repeated comparable large-scale surveys	Energy intake, with some household adequacy; economic aspects (e.g. employment, wages, food prices) also possible
(3) Food consumption/individual intake	Repeated comparable large-scale surveys very rare and expensive.	Energy, better chance of relating to requirement, hence adequacy
(4) Anthropometry	Suitable and widely used for trends, but does not measure only (or even) food security	Some aspects of health, changes often related to food access changes (but see Thailand, for example)
(5) Qualitative methods	Probably very suitable within country, but cross-country comparisons need more work	Suffering, behaviour and economic activity may be assessed

by convincing arguments about what actually should be done. A drawback of the statements about “800 million hungry” has been that the exhortations have been to do something, but that something has not always been explicit or evidence-based. These methods can provide the data and the appropriate analysis and interpretation to make more convincing arguments for explicit action.

Finally, to propose a further balance between the different methods, we need conclusions ranging from ascribing causality (with a probability) to seeing if trends are headed in the right direction. This range of results from multiple methods is valuable (see Habicht, Victora and Vaughan, 1999) and has some parallels to the range of data from DES through HIES and FIS. The utility of the five different methods discussed in this paper to address advocacy and analysis is outlined in Table 1.

For the assessment of trends, we can also consider triangulation of the different methods – much easier for trends than for absolute numbers. Thus, we would be reassured to see that the trends were going in the same direction and better still at roughly the same rates for different indicators of dimensions of hunger. This argues for applying more than one method at a time, keeping in mind the comparative advantages of each method for trend analysis as outlined in Table 2.

### ■ Do we really need global and regional estimates every few years?

Let us assume that we are looking at deriving a set of indicators from the different methods that may complement each other while not measuring quite the same underlying realities. How far is the strategy determined by universality (needing estimates for all countries) and periodicity (every few years)? In other words, do we really need point estimates every three years or so for all countries, perhaps aggregated regionally

and globally, like the DES method delivers at present? Other approaches could be developed to provide accurate trend data in a limited number of sentinel countries.

In related areas, for example micronutrient deficiencies, (see Mason *et al.*, 2001a, pp. 18–20) conclusions on trends including those at the regional level can be based on three lines of evidence:

- (1) Trends from comparable national surveys repeated at different times (uncommon, but most valuable).
- (2) Fitting a trend line to a scatter of surveys from different countries and times (less satisfactory, but informative when there is a strong trend, like for clinical vitamin A deficiency).
- (3) Aggregating and interpolating data to consistent country-years using statistical models, then comparing regional aggregated estimates at different times – somewhat similar in concept to the FAO DES/CV (coefficient of variation) method.

The piecing together of evidence from these three methods aims to look for a consistent and credible pattern. For hunger, we would want to see if the different methods produced comparable trends, as discussed later with reference to Figure 10.

The World Food Summit and interests of FAO Member governments seem clearly to demand global and regional estimates every few years. Even if the results are very much approximations, if the trend is reasonably certain and confirmed by other data, the perceived need could be met by a combination of available methods starting with the FAO DES method. In fact, it may not be worth going to great lengths to improve the DES estimates themselves, but perhaps it would be better to invest resources in obtaining complementary data, moreover data with further uses. For the present time, this implies remaining with the FAO DES estimates as currently calculated and presented in the State of Food Insecurity (SOFI) Report (FAO, 2000, 2001), and not

making the effort to improve this well-tested method any further (and in practice, perhaps not trying to re-estimate the coefficients of variation).

Choosing certain countries for more directly estimating trends through an application of national HIESs repeated in a comparable way would be very important for assessing trends with some confidence and could provide additional data. If we saw consistent and understandable patterns of change in energy intakes related to estimates of requirement in as few as ten countries over the next few years, we would have much more confidence and understanding of the trends. Many of the surveys listed in table 3 of the Smith paper in this series (and others since 1998/99) presumably could provide a baseline.

Finally, perhaps linked to HIESs, expanding the application of the qualitative methods described in the paper by Kennedy would give a different, but highly complementary, set of indicators: trends that may be similar but would tell a broader story by assessing perceptions of, and responses (behavioural and economic) to, hunger. However, there is no baseline for this at present, and developing this would be an urgent first step.

## ■ Defining what is being assessed – hunger

The first question is to decide on and to define in quantifiable terms what is to be assessed – “hungry people”. This leads to the issue of whether it can be measured at all; a number of authors have commented that there is no “gold standard” against which to assess practical measures. Hunger is closely related to food security referring to “access by all people at all times to enough nutritionally adequate and safe food for an active and healthy life” (FAO, 2000, p. 1), and some of the key measurements of this concept are very similar. The definition of hunger used for the Sixth World Food Survey took into account, for the first time, the critical issue of

the reference period. The resulting definition was: “the number of people who do not get enough food energy, averaged over one year, to both maintain productive activity and maintain body weight” (FAO, 1990, 1996b). This definition of what is measured should be kept but may need to be explicitly reaffirmed.

The present Symposium has a particular importance if trends are now to be the focus, as it will be difficult to change definitions retrospectively in the future. The features of “hunger” that drive the concern for combating it include:

- ▶ **EFFECTS ON HEALTH:** From physical malnutrition, as indicated by wasting (low weight-for-height), underweight (low weight-for-age) or stunting (low height-for-age), to micronutrient deficiencies leading to lowered immunocompetence, anaemia, developmental and cognitive defects, etc. (See Figure 9 and related discussion);
- ▶ **SUFFERING:** The pain and distress of hunger, the “uneasy or painful sensation caused by lack of food”, people’s concerns for their children;
- ▶ **BEHAVIOUR:** Among the destitute, food-seeking dominates decisions and behaviour in a way that favours short-term survival to the exclusion of much else;
- ▶ **ECONOMIC:** Reduced productivity, both from lowered energy availability for work and from lowered physical fitness resulting from malnutrition, as well as changes in risk-taking and coping strategies.

The measurements considered here are aimed at capturing some of these dimensions. If direct measurement were possible, it would be extremely useful to know the adequacy of dietary food energy intake for individuals, that is, “intake in relation to their requirements” for a defined level of function and reference period. Such a measure would probably predict well the four aspects of hunger indicated above (health, suffering, behaviour and economic). A central question

concerns whether adequacy of dietary food energy intake and changes in this can, in fact, be measured. Three of the background papers have this as their central concern: the FAO method, household income and expenditure surveys and individual food intake surveys.

### ■ The correlation between energy intake and need

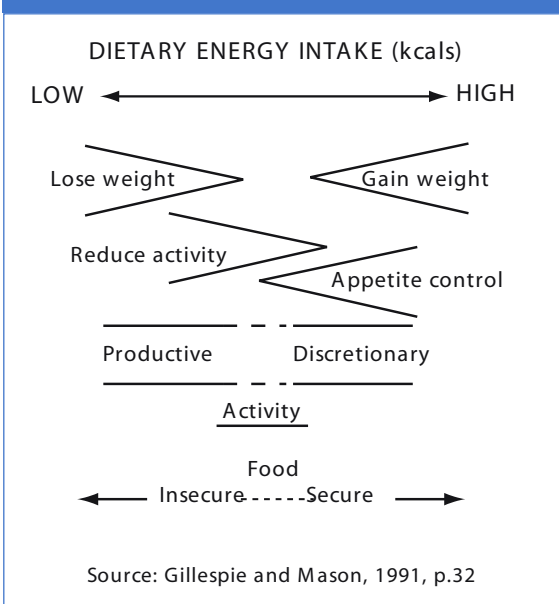
The FAO methodology development as described by Naiken in this series has been largely concerned with this correlation but has adopted a “cutoff” approach – using a single cutoff rather than the “bivariate formula” (see appendix A of the Naiken paper in this series). The issue is that until food availability is restricted, intake will tend to meet requirement, and taking account of this needs to be done at the individual level, for which, however, there are virtually no data. This is a central issue, moreover one that will introduce bias into assessing progress, thereby tending to underestimate improvement. This is not a statistical argument primarily but a biological one, as follows.

When people do not have enough to eat, they respond by reducing energy expenditure, first the more discretionary activities then more productive activities. They do this partly in response to the physiological signal of hunger. As their intake increases, they start to control their intake through appetite (i.e. presence or absence of hunger) while undertaking all the activity they want to. At this stage, their intake and requirement are equal (averaged over a few days, perhaps), and the correlation at the population level is nearly 1.0. Thus, the point at which hunger is no longer a problem is, almost by definition, the point at which the correlation is nearly perfect. Above this, after a plateau, intake again may be less correlated with need and may exceed it, leading to obesity; however, we are not trying to investigate this side of the distribution.

Figure 1 shows a range of energy intake from “low” to “high” for an individual.

At the low end, weight is lost and activity reduced, productive later than discretionary. As the intake rises, appetite control begins to function, and as much activity as wanted is supported. The task is to assess the number of individuals in the band where activity is unconstrained, and the intake is controlled by appetite before reaching the “weight gain” area at the high end of the scale – these are the non-hungry. This requires assessing the situation of each individual: estimates from population means will not do it, because we have to classify each individual by both intake and requirement, depending on their own situation. Thus, the number is actually unknowable from any conceivable data system, but the trade-offs can be examined. If we knew the position of individuals in terms of intake with respect to requirement – meaning they are partitioned by a cutoff corresponding to the point at which they have enough to eat, where appetite controls the intake and the correlation is nearly perfect – and if we could measure this, we could make the plot that would look roughly like that in Figure 2 (hypothetical results). This leaves aside for now the period over which we match intake with need, but this seems likely

FIGURE 1. IMPLICATIONS OF DIETARY ENERGY INTAKE. SOURCE: GILLESPIE AND MASON (1991, P. 32)



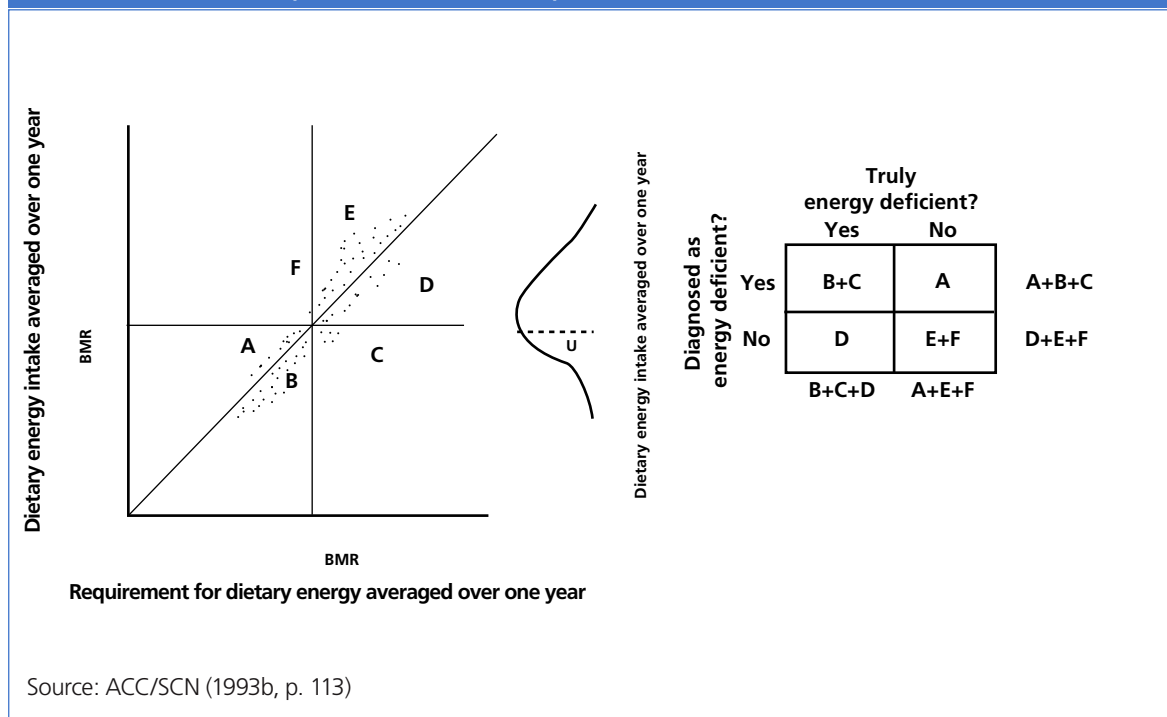
to be only over a few days: after 2–3 days of not enough to eat, hunger corresponding to the concern specified earlier will probably exist. Figure 2 suggests a year as a reference period, in part aligned with the food balance sheet (DES) estimates. Averaging DES out over a year does not allow “transient or seasonal hunger” to be picked up. From this point of view, the DES approach will always be an underestimate of those experiencing transient hunger.

Figure 2 has been composed, as noted, from hypothetical data as it is unlikely that real data like these exist, which is part of the problem. The figure aims to illustrate the association between intake and need, with each data point representing an individual’s average intake and requirement for productive activity, as in the current FAO definition, over a year. The 45 degree line is where intake ( $y$ -axis) equals requirement ( $x$ -axis). Those who should be counted as having inadequate food energy are below this 45 degree line. Those above the 45 degree line are getting more than enough – so it is likely that the points cluster around the diagonal with less scatter above

it, more so as intake increases. Because the individual requirement values are not known, we cannot count in this way. What is done is to count those below the horizontal line, that is below a cutoff applied to the population as a whole. This is the method used by the FAO DES approach and also for the analysis of household survey data. Thus, we count those in the areas A + B + C as having inadequate intake, when we would like to know those in B + C + D, hoping that A and D are roughly equal and cancel out.

The next issue concerns what would happen if the food availability increased and the average intake went up without, as is likely, a corresponding change in requirement. The whole cloud of points in Figure 2 would rise upwards: those in A would increase, and those in D would decrease. They would cancel out less, and we would tend more to overestimate the numbers with inadequate food and therefore tend to underestimate the extent of improvement. In other words, with improvement, more people will reach a high correlation of intake with need, but if these are still estimated to be below the

FIGURE 2. HYPOTHETICAL ILLUSTRATION OF THE RELATIONSHIP BETWEEN DIETARY ENERGY INTAKE AND REQUIREMENT (AS FACTOR TIMES BMR).



population mean intake cutoff, they will be incorrectly classified as underfed – more so as the intake increases.

Thus, the distribution shown in Figure 2, on the one hand, represents much of what we would like to know, and on the other hand, it shows that this is in practice unknowable. If we could make this assessment, the implications of inadequate food (health, suffering, behaviour, economic) would flow from it. Therefore, it is perhaps a useful theoretical standard (possibly the theoretical real “gold” standard). In fact, if we could measure, at least in small samples, the intake and make some estimates of the requirement (see paper by Ferro-Luzzi in this series), we could calculate the sensitivity and specificity of alternative indicators with respect to this standard, derived from a 2 by 2 table like that shown in Figure 2. This would be very valuable and would guide the interpretation of larger sets of data and in addition might be a valuable area for research.

### ■ Time reference periods

A common sequence among those at risk of hunger is to go through periods of satisfying dietary energy needs – for example after harvests or when casual labour wages are obtained – followed by periods of deprivation when activity is decreased and body weight may be lost, to be regained in the next cycle. Those constantly below requirement lose weight and eventually starve. It was regarded previously that this requirement level would be somewhat above the BMR (at which only the bedridden would not starve), and a level of  $1.27 \times$  BMR was taken as that below which life would not be sustained (FAO, 1996b). Moreover, the extent of actual starvation, which is mainly confined to acute emergencies and famines, can be assessed from data on such emergencies (e.g. ACC/SCN, 1993a; ACC/SCN, 1994, pp. 57–82), and is relatively small compared with the around 800 million considered “undernourished”.

The reference period of one year is in line with that for food supply estimates and

probably should be retained. One question is: What length of time during which hunger is experienced should be counted into the estimate? Presumably, insufficient food for one day is too short (and accounts in part for very high prevalences of low intake estimated from 24-hour recall surveys) – individuals may be sick, travelling or fasting. Moreover, some of the other dimensions of hunger (e.g. health and economic) probably do not respond from low intake for one day if this rebounds the next day. Perhaps causes of the short-term hunger are relevant, and these can be captured particularly in the qualitative surveys. The criterion for when to include short-term hunger may in fact be when it is serious enough to affect health, cause suffering, change behaviour and/or reduce economic activity. At a guess, this means only a few days’ hunger; it also relates to prospects in the near future of obtaining enough food (which is another implication of the term security). On balance, a one-year reference period should be retained as the basis, with transient hunger assessed by other methods – notably the qualitative measures.

### ■ Conclusions so far

From these general considerations preliminary conclusions are suggested below:

- ▶ Shift emphasis to measuring trends.
- ▶ Finalize definitions of what is being measured, including reference periods with decisions on, for example, what period is counted as “hunger”.
- ▶ Develop a set of indicators showing a pattern of change, capturing different dimensions of hunger such as energy adequacy, health, suffering, behaviour and economic.
- ▶ Estimate global and regional trends every few years as an approximate but vital context along the lines of the present FAO estimates in SOFI; these should continue with an emphasis on DES, but perhaps the coefficients of variation for energy intake should not be updated.

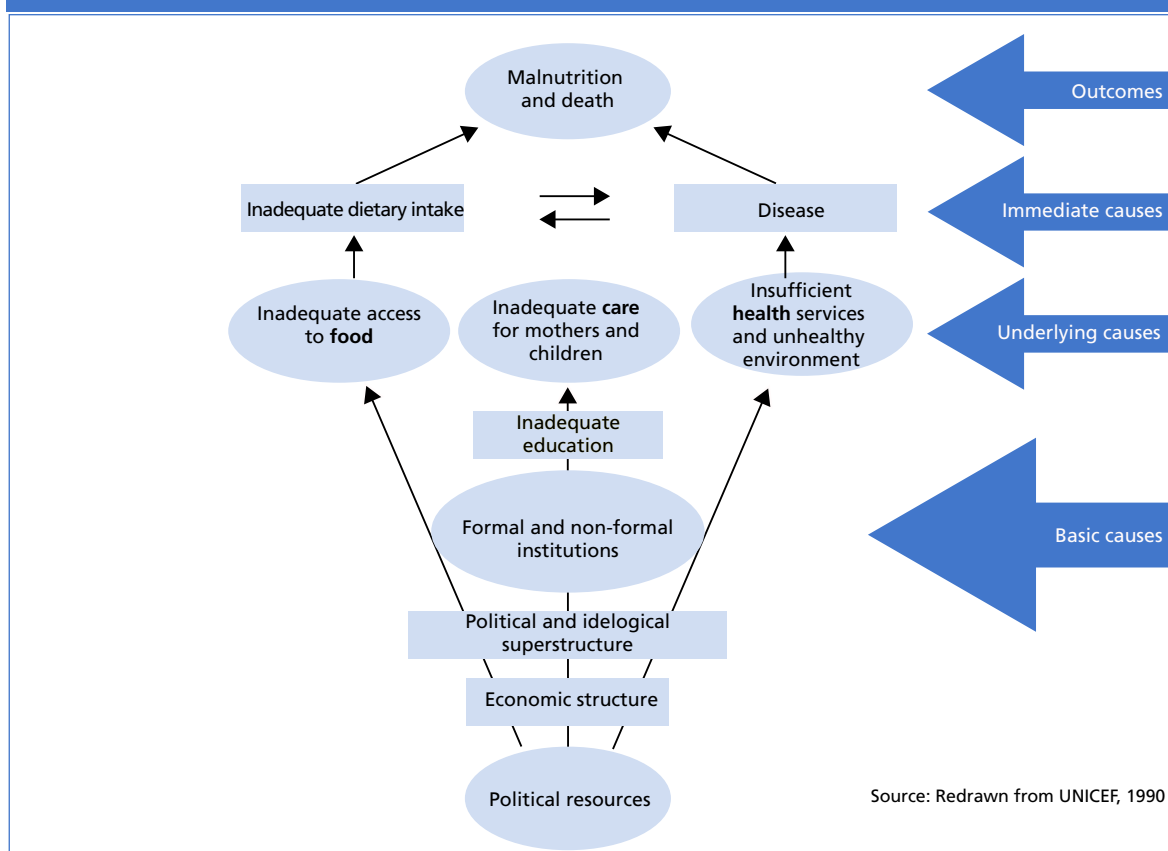
- ▶ Obtain directly estimated trends in energy intake, possibly in relation to requirement, from a limited number of countries with data from repeated national HIES-type surveys.
- ▶ Phase into qualitative methods, perhaps linked sometimes as modules to HIES, to assess perceptions of and responses to hunger; these tend to be culture-specific and need local development and baseline data.
- ▶ Use detailed studies such as food intake surveys for policy analysis and for investigating causes of hunger.
- ▶ Strike a balance between these methods for resource allocations. This will necessitate studies of costs and feasibility and foreseeing what the results might look like and where they would lead.

## Income, diet quantity and quality, and biological and functional outcomes

### Income, energy supply and anthropometry

Income is a determinant of food intake, which in turn is a major factor in determining height in growing children and body weight. The latter pathway is illustrated in the “UNICEF framework” (UNICEF, 1990; reproduced in Figure 3) and is widely accepted as a common language for discussion – in shorthand, “food, health and care” being the proximal determinants of dietary intake and hence of nutritional status. Thus, it is clear that child anthropometry, weight-for-age or underweight and height-for-age or stunting, is a different measure of energy intake. The extent to which it can substitute for measures

FIGURE 3. CONCEPTUAL FRAMEWORK FOR THE CAUSES OF MALNUTRITION IN SOCIETY.

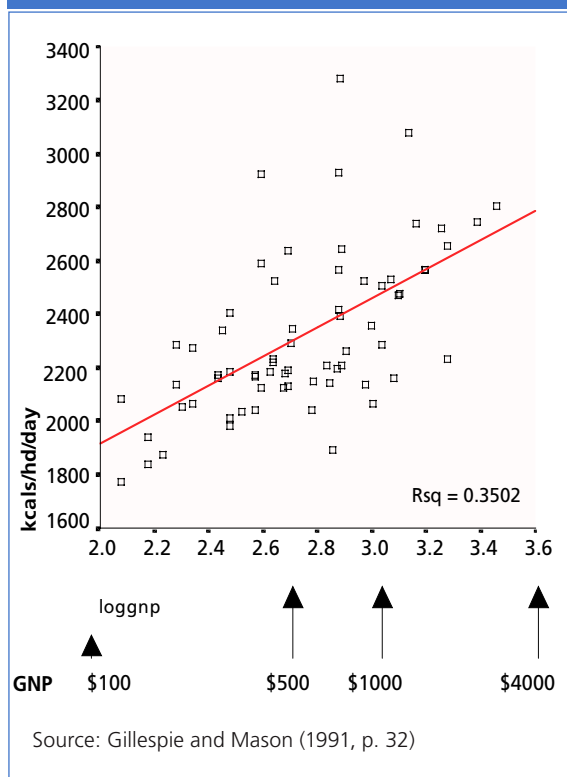


of energy intake depends on both theory and observation. The theory is clear – these are two related but different measures. Because energy intake is so difficult to measure at the individual level, data to examine the actual relation are very scarce. Overall, there is no doubt that the relation between energy and anthropometry exists – at the national level at one point in time, for example; but whether, at this level, changes in energy supply are sensitively reflected in changes in anthropometric indicators is less clear. Some results from aggregated data are briefly introduced to illustrate these points. In part because income data are more common than dietary energy data – and these two have a well established relation – the three variables considered are income, dietary energy and child underweight. Data are from the 1980s to 1990s and were obtained from several standard sources – DES from FAO, national income (as measured by gross national product (GNP)) from World Bank and underweight from ACC/SCN (1994, 1996).

Estimates of DES are highly correlated with estimates of GNP. An example is shown in Figure 4 for national estimates in which the relationship is generally linear. For individual or household data, the relation is known to be non-linear, the slope starting steep and then levelling off (the Engel curve), but this is not apparent in the national average data. The overall relation is well established and has been the basis for alternative estimates of the extent of inadequate food intake (Reutlinger and Selowsky, 1976).

National income (GNP) itself is correlated with prevalences of child underweight, as shown in Figure 5 (see also box in ACC/SCN, 1992, p. 9). In Figure 5A, the relation is given for all countries for which data were available, expressed here as logit prevalence ( $\ln(P/1 - P)$ ) for a better fit. An important distinction is seen by regional groups of countries, in Figure 5B, with a significantly greater slope in South Asia than elsewhere. This is another manifestation of the interaction first shown by Haaga *et al.*

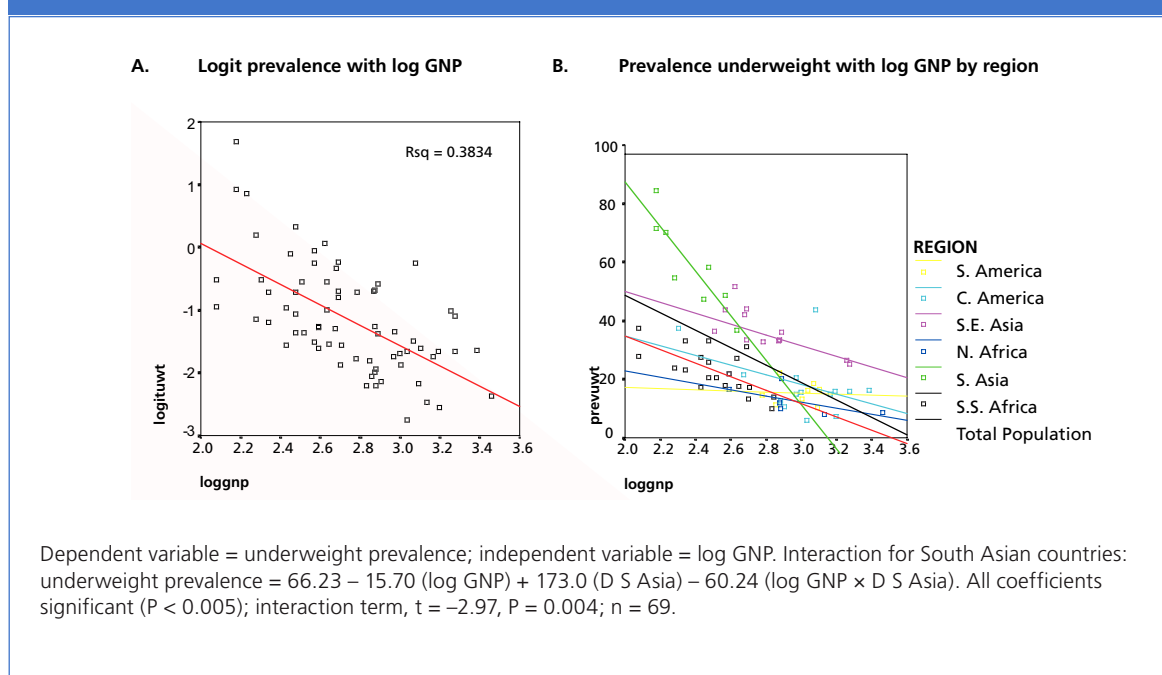
FIGURE 4. RELATION OF DES (KCAL/PERSON/DAY) WITH LOG GNP.



(1985). The coefficients are shown in Table 3 and are significant for Asia and sub-Saharan Africa and overall.

DES (measured as kcal/person/day, estimated as an annual average at the national level) is correlated with underweight prevalences. This relation is shown in Figure 6 and Table 4, with the relation overall shown in Figure 6A and by region in Figure 6B. Here, too, the strikingly different slope for South Asian countries is apparent, meaning that underweight prevalence falls more steeply with increasing energy in South Asian countries (more details are in ACC/SCN, 1993b, p. 97). The relationship is not seen in sub-Saharan Africa, although this may result from limited variation. However, the association between DES and prevalence of underweight remains significant, even omitting the South Asian countries. Thus, increasing income at the national level is associated with increasing DES, and increasing both income and food energy supply are associated with reduced underweight prevalence. The

FIGURE 5. RELATION OF CHILD UNDERWEIGHT PREVALENCE WITH NATIONAL INCOME (GNP).\*



shape of the relationships is important. For DES and underweight prevalences with no transformations to improve linear fit, as shown in Figure 6B, the slope is only steep for South Asian countries, and the coefficient is –0.026 on average. This means that for every 100 kcal increase in DES, the underweight prevalence is expected to decrease by 2.6 percentage points. This result, showing a slow response in underweight to dietary energy increases, is probably not due to uncertainties in the DES estimates, as a very similar picture is seen using GNP. Here, the slope with log GNP is –29.8, meaning that, for example, for US\$100

of GNP increase (e.g. from US\$500 to US\$600), underweight on average changes by 2.3 percentage points.

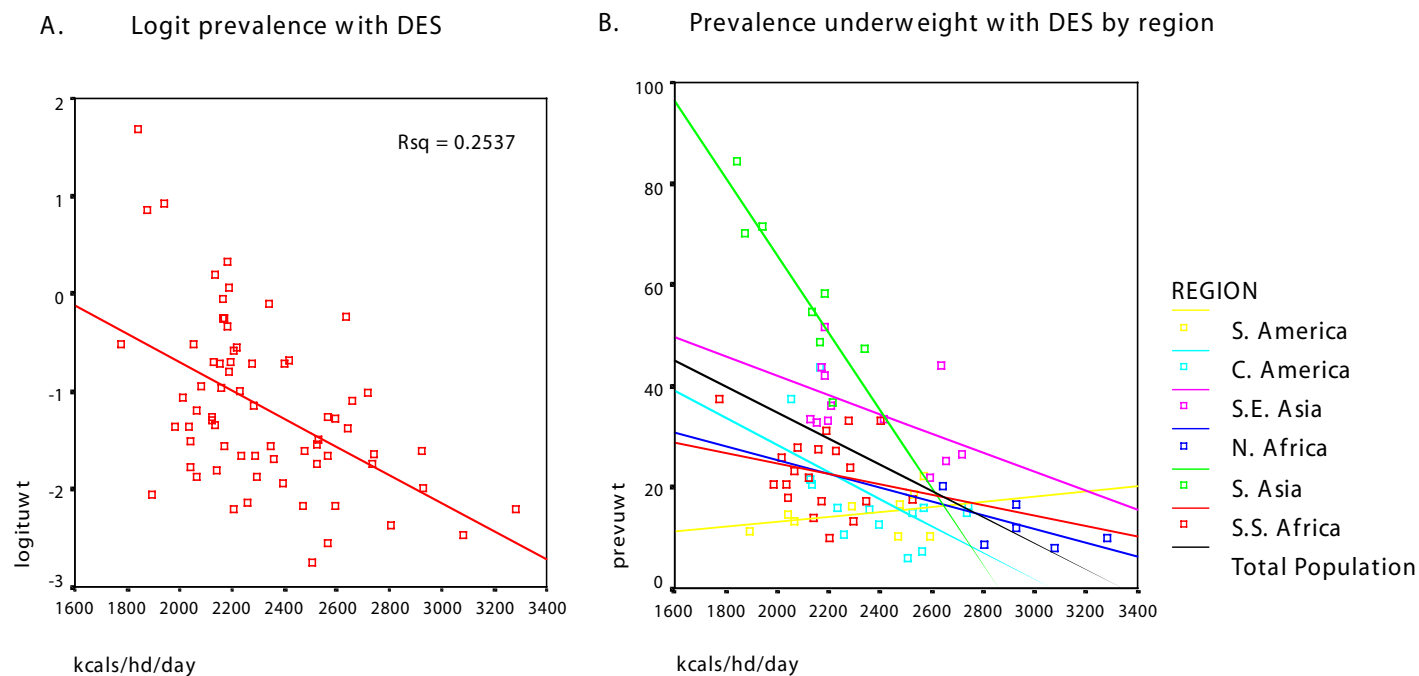
Such national comparisons are a very rough way to examine these relationships. While there are not enough data on large population groups to study the shape of the relationship of underweight with energy, recent compilations of results from the Demographic and Health Survey (DHS) and World Bank surveys by Gwatkin and co-workers (Gwatkin *et al.*, 2000) do now give the possibility of studying income/underweight relations cross-sectionally in a considerable number of

countries, and these are very useful. Figure 7 shows the results of these comparisons through plots of the prevalences of underweight children against estimates of income: the middle quintile is taken as the mean GNP, and the first and last two quintiles were calculated from the published income distributions (E. Seiber, personal communication). From viewing the graphs,

TABLE 3. REGRESSION RESULTS BY REGION IN REFERENCE TO FIGURE 5

Region	n (number of countries)	B (coefficient)	P-value of coefficient
South Africa	20	–22.9	0.001
South Asia	8	–75.9	0.003
North Africa	6	–10.6	0.173
Southeast Asia	12	–18.3	0.063
Central America	14	–16.6	0.125
South America	9	–1.92	0.885
Total	69	–29.8	0.000
Other than South Asia	61	–15.7	0.000

FIGURE 6. RELATION OF CHILD UNDERWEIGHT PREVALENCE WITH DES (KCAL/PERSON/DAY).\*

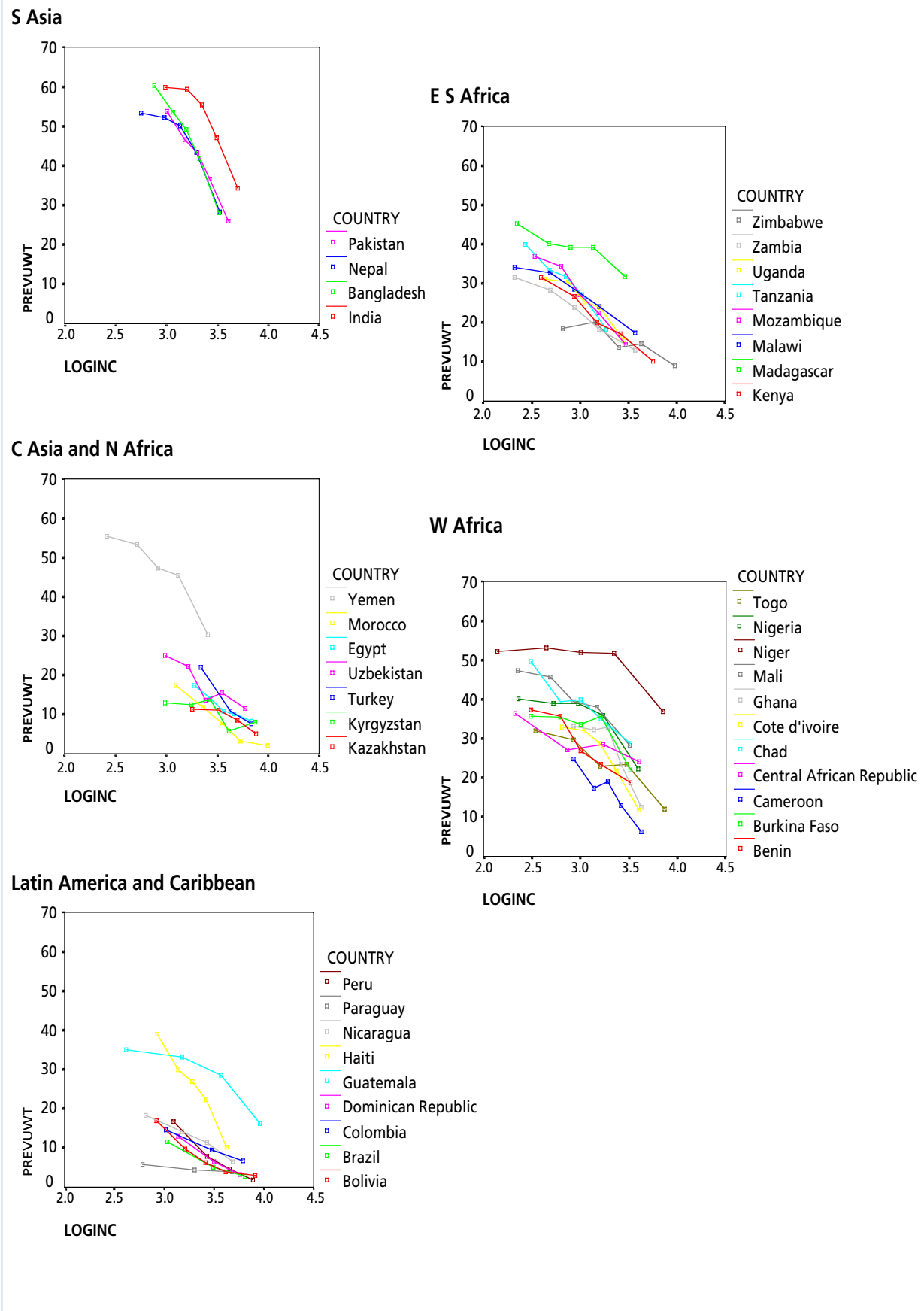


\* Dependent variable = underweight prevalence; independent variable = kcal (DES). Interaction with South Asia: underweight prevalence = 53.70 – 0.01345 (kcal) + 165.2 (D S Asia) – 0.06316 (kcal × D S Asia). All coefficients significant ( $P < 0.005$ ); interaction term,  $t = -3.00$ ,  $P = 0.004$ ;  $n = 69$ .

TABLE 4. REGRESSION RESULTS BY REGION IN REFERENCE TO FIGURE 6

Region	n (number of countries)	B (coefficient)	P-value of coefficient
South Africa	20	-0.010	0.313
South Asia	8	-0.077	0.003
North Africa	6	-0.014	0.195
Southeast Asia	12	-0.019	0.092
Central America	14	-0.027	0.026
South America	9	-0.005	0.833
Total	69	-0.026	0.000
Other than South Asia	61	-0.014	0.003

FIGURE 7. PREVALENCES OF UNDERWEIGHT CHILDREN BY INCOME QUINTILE.



a number of points relevant to the current discussion present themselves.

First, the relation between child malnutrition and (log) income is not linear, with a tendency for underweight not to start to reduce with increasing income until a threshold level is reached. This is seen more in the poorer and Asian countries. This shape contrasts with that expected for food intake, which tends to rise more steeply in the lower-income groups. The weak slopes are even less than those from the national data in Figure 6, such that a doubling of income (e.g. from US\$500 to US\$1 000) in the Asian or African countries would lead to a decrease in prevalence of less than 5 percentage points. Thus, income growth alone is not seen to provide a reasonable solution to malnutrition for the poorest people. Second, much of the variation between countries is not accounted for by income. For instance, at US\$1 000, prevalences are 50–60 percent in Asia, 20–35 percent in Latin America and the Caribbean, and 15–50 percent in sub-Saharan Africa. Third, income–underweight relations may therefore be important predictors of change within countries but not between countries, especially in different regions. Fourth, the weak and non-linear relation with income among the poor may well result from the interaction of a number of determinants of child malnutrition. It is commonly observed that such interactions are in the direction that anthropometric indicators improve more when risk factors are improved among the already better-off groups – for example in the better educated. Examples for environmental sanitation are seen in Mason *et al.* (2001b, pp. 48–49), and other similar examples are readily seen in cross-sectional DHS or UNICEF Multiple Indicator Cluster Surveys (MICS) data. Therefore, a number of factors need to be in place before there is significant improvement – in line with a slow start, for example as education improves, but before additional factors related to income bring about actual improvement.

Such findings stress that physical malnutrition, as measured by anthropometry, has a complex but understandable relation to income and to dietary energy. It is not a substitute (or proxy) for these, but observing patterns of change in a set of indicators of physical malnutrition, food access and poverty can give a valuable picture for assessing trends. Examples are given later.

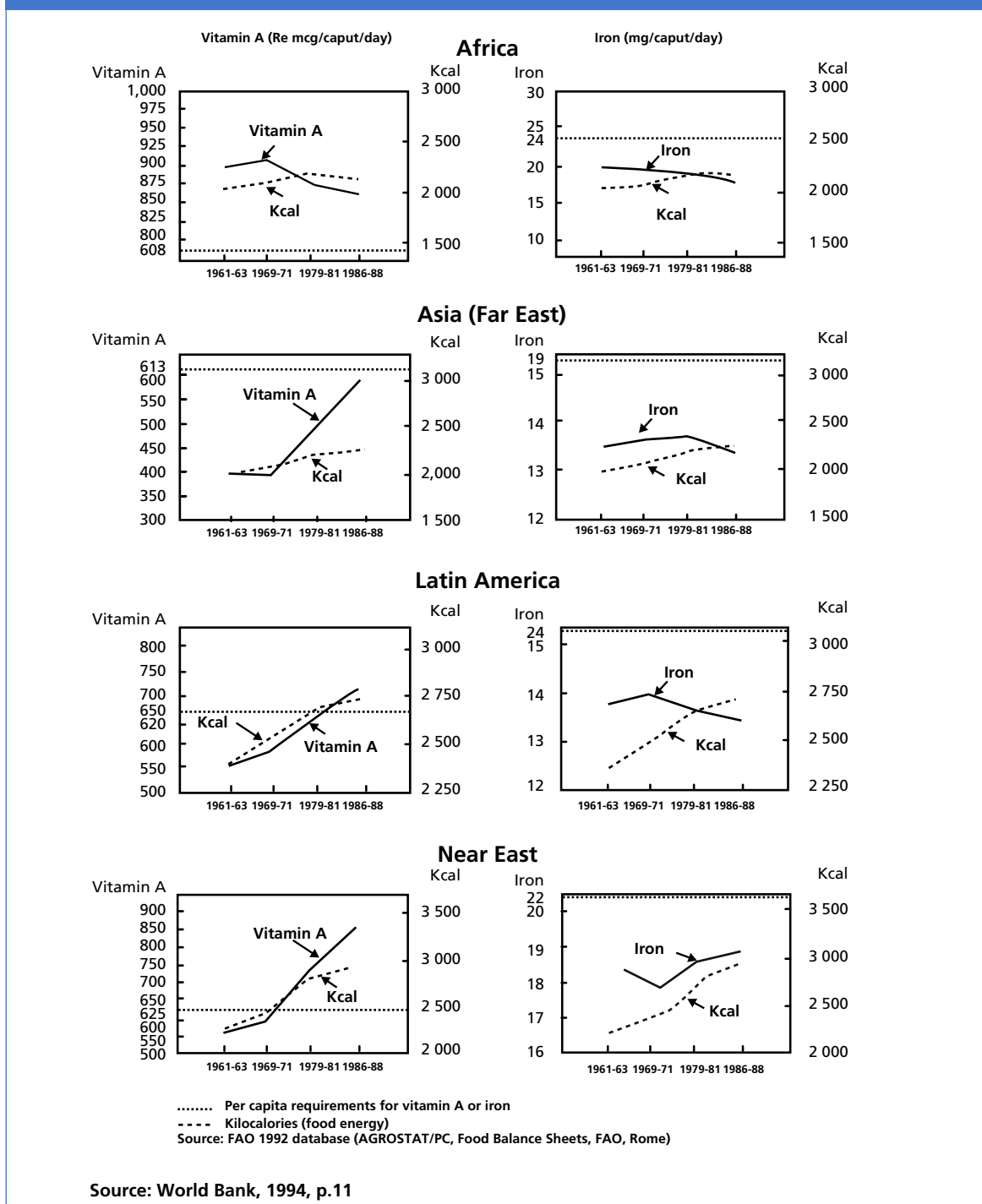
### ■ Micronutrient deficiencies

Food intake is important for more than dietary energy; inadequate diets have serious consequences beyond hunger, growth failure and thinness. The sensation of hunger probably results from a lack of food energy, which is why the concern for hunger has largely meant total food. Micronutrient deficiencies have been referred to as “hidden hunger” (WHO/UNICEF/World Bank/Canadian International Development Agency/US Agency for International Development/FAO/UNDP, 1991), although the term never really caught on. Lack of nutrients, aside from lack of energy, has profound effects economically as well as impacts on health and behaviour. Moreover, in theory, the extent of inadequate diet quality is likely to be greater than for quantity, as the cheapest foods have the poorest quality and (because of hunger) poor people will aim first to fill their stomachs to meet their energy needs (Allen, 1994). In practice, micronutrient deficiencies are observed to be extremely widespread, probably more so than malnutrition as assessed by inadequacy of energy intake or by anthropometry (Mason *et al.*, 2001a, p. 38), although the comparisons depend on rather arbitrary cutoffs.

It could have been said at the World Food Conference in 1974 with as much justice that “no child should go to bed anaemic, blind, mentally retarded, educationally subnormal or sick from impaired disease defences ...”.<sup>3</sup> An issue now is whether there is reason

<sup>3</sup> In fact, the full text noted that the participants had resolved that “... within a decade no child will go to bed hungry, that no family will fear for its next day’s bread, and no human being’s future and capacities will be stunted by malnutrition” (UN, 1975).

FIGURE 8. CHANGES IN AVAILABILITY OF VITAMIN A, IRON AND FOOD ENERGY BY FAO REGION FROM 1960/65 TO 1986/88. SOURCE: WORLD BANK (1994, P. 11).



to include explicit concern for inadequate diet quality in the policies and monitoring systems for hunger alleviation. Both for policy and programme actions and for assessment of trends, the approaches are similar and complementary, as briefly introduced here.

The national availability of micronutrients can be tracked from the same input data as for dietary energy in the FAO Food Balance Sheets. This requires extensive application of food composition values to the range of food commodities consumed, itself necessitating updating, which is now in progress by FAO.

Results were available in the FAO database up to 1990, as compiled in ACC/SCN (1992, pp. 39–50) and World Bank (1994, p. 11). An example is shown in Figure 8 for the period from 1960 to 1990. These graphs show vitamin A availability increasing faster than food energy in Asia and the Near East, and declining in Africa but still greater on average than requirement. Dietary iron supply, in contrast, was falling except in the Near East and was less than requirement on average. It is important to take into consideration whether the source of iron is animal or plant, as these have very different bioavailabilities (see ACC/SCN, 1992, pp. 42–45). Such results were useful overall for tracking probable changes in micronutrient intakes, and they predicted changes in biological outcomes, such as vitamin A status and anaemia, that were subsequently estimated. In fact, a comparison of regional trends in dietary iron supply and anaemia suggested that iron deficiency was worsening in Asia, owing in part to displacement of crops such as pulses with a higher iron content by cereals, as a result of the application of Green Revolution technology (ACC/SCN, 1992, pp. 46–47). Available estimates of vitamin A supply were seen to be associated with prevalences of clinical vitamin A deficiency (Mason *et al.*, 1998, pp. 24).

Household surveys that provide data on food energy availability also provide estimates of micronutrient intakes; this is commonly done in food intake surveys but less so in HIESs. The food frequency approach advocated by Ferro-Luzzi in this series is in fact designed to assess dietary quality more than energy intake levels. Thus, estimates of micronutrient intake from food frequency surveys and HIESs can be used to validate estimates obtained from other means. One drawback that needs attention is that certain non-staple foods, especially snacks

that are consumed in smaller quantities and may provide higher concentrations of micronutrients, tend to be missed in surveys, leading to a likely underestimate of levels of micronutrient intake. However, trends may be assessed, at least in terms of direction, with care as to the comparability of methods over time.

The more extensive data in current use on micronutrients come from clinical and biochemical assessments. A recent assembly under the auspices of the Micronutrient Initiative (Mason *et al.*, 2001a) showed that clinical vitamin A deficiency was receding quite rapidly, while there was no evidence that the prevalence of iron deficiency anaemia was declining in any region. Iodine deficiency (assessed as goitre) is seen to fall rapidly where there is effective iodine fortification of salt, occurring in an increasing number of countries. Subclinical deficiencies of vitamin A and iodine remain very extensive and carry significant risk, but their trends are hardly known, and deficiencies of other micronutrients, zinc for instance, have been scarcely described. The methods for clinical and biochemical assessment are reasonably well known – certainly enough for immediate wider application – and an option in the context of monitoring hunger is to provide support and coordination with these types of assessments.

Further analysis of currently collected data (notably of micronutrient supply from food balance sheets) and assembly from different sources<sup>4</sup> could lead to better measurement of progress and identification of intervention needs.

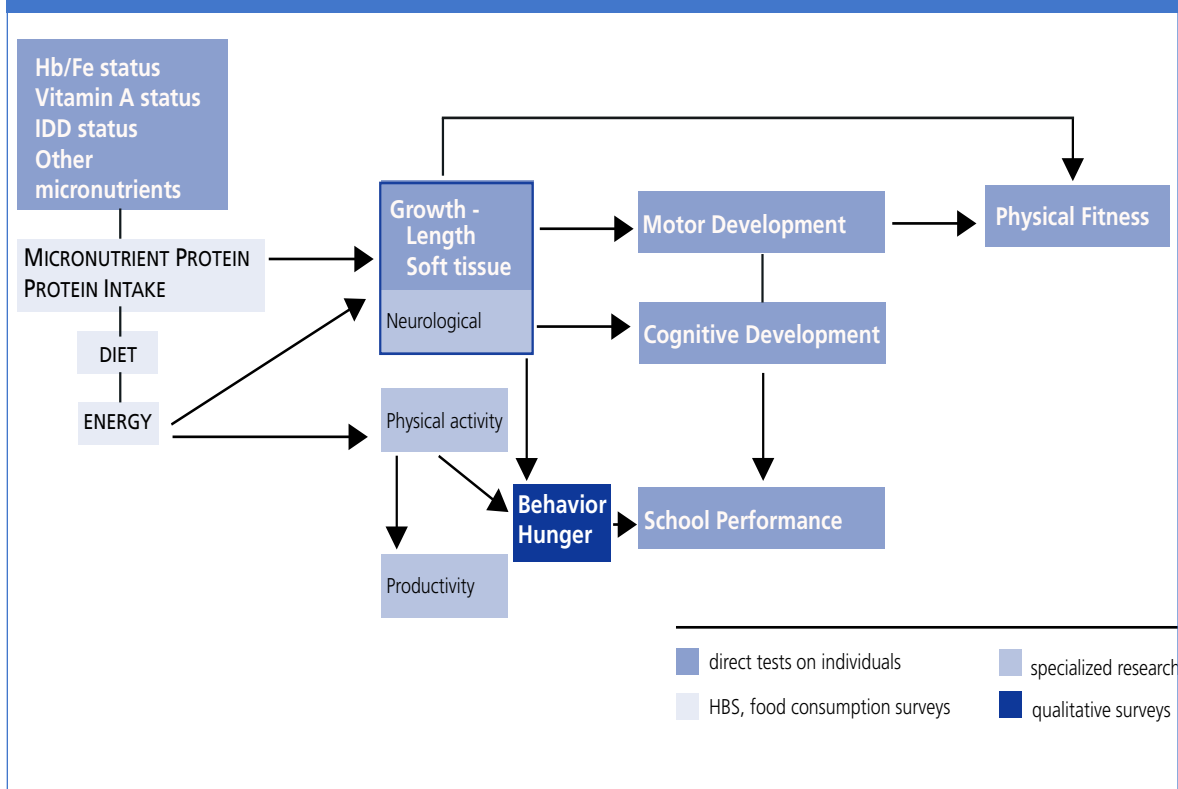
### ■ Biological and functional outcomes

The concerns about hunger are primarily for the results of inadequate nutrition, not really the actual nutrient intakes themselves.

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4 A global survey supported by Micronutrient Initiative and UNICEF is under way to ascertain recent trends in deficiencies and programmes and to update the year 2001 “Micronutrient Report”, coordinated by the present author. These results could be usefully combined with dietary intake estimates.

FIGURE 9. NUTRITION AND BIOLOGICAL AND FUNCTIONAL OUTCOMES.



Inadequate intakes are taken to predict or cause undesirable outcomes in health and biological development, behaviour and productivity. Therefore, it makes sense to consider measuring these outcomes as part of monitoring progress in reducing hunger. A scheme illustrating the relation of diet to biological and functional outcomes is shown in Figure 9. This scheme suggests that we may need to move beyond growth and clinical and biochemical status, and include in our concerns motor and cognitive development, behaviour, school performance and educability, physical fitness and productivity. In particular, work in recent years has re-emphasized the long-term effects of early nutrition on cognitive development and school performance (Brown and Pollitt, 1996), with implications for subsequent functioning and economic activity.

Most nutritional deficiencies interfere with the complex metabolic processes that run human beings. In part, this is straightforward; for example, a significant number of key enzymes are metallo-enzymes, requiring

metals from the environment to function. Other required nutrients are essential for hormones (iodine, for instance). But more generally, the complexity of biological systems means that they can be readily disturbed. The immune system, a marvel of evolution, is probably compromised by most nutrient deficiencies, and it seems likely that cognitive function may be similarly vulnerable. The role of iron in cognitive functions has recently been identified, distinct from its function in haemoglobin. It makes little sense to monitor and intervene for individual nutrients except perhaps when there is a particular opportunity, like infrequent massive vitamin A dosing, an intervention applicable to almost no other nutrient. People need enough food of adequate quality, so monitoring the level of total intake as energy plus selected key nutrients should be the way to go.

However, as the eventual objective concerns the functioning of individuals, opportunities could be taken to periodically check on progress in this area as well. Perhaps, biology and function provide useful headings.

Function has an importance in moving away from the often somewhat arbitrary cutoff points used to derive prevalences of undernutrition (e.g. a Z-score below two standard deviations of the reference population mean (-2 Z-score)). From Figure 9, some potential indicators can be selected.

Growth and haemoglobin would seem suitable for regular assessment – and indeed, this is becoming standard with DHS and UNICEF–MICS surveys. Other micronutrient status measures (notably vitamin A and iodine, but others too) may need some further research, but should be used more

**TABLE 5. COMPARISON OF FIVE METHODS FOR ASSESSING HUNGER AND MALNUTRITION**

Method (author of background paper in this series)	Main indicator(s)	Level at which indicator applies	Period to which indicator applies	Relation to hunger	Relation to diet quality and micronutrients	Applicability to evaluation
FAO: DES/CV (Naiken)	Percentage with low energy (interpreted as inadequate)	National only	One-year average	Aims to estimate percent with food inadequacy	Could be assessed like energy	Limited; possibly for national long term policies
Household Income and Expenditure Surveys (Smith)	Household energy intake	Population subgroups, national if national sample	Usually a few days; sometimes repeated to give estimates of fluctuation (e.g. seasonal) or trends	Energy intakes; if related to household requirements (not usually) gives percent with food inadequacy	Can be estimated; less common than energy	Suitable; measures of program participation, etc. need to be included, and surveys repeated
Food intake Surveys; Food Frequency (Ferro-Luzzi)	Individual intake, related to requirement, hence adequacy	Individuals, population subgroups, not usually national.	24-hour recall to a few days; may be repeated	Most direct estimate from measuring intake	Usually estimated and related to requirement	Suitable for small sample research into causality including impact evaluation
Anthropometry (Shetty)	Percentage underweight or stunted (children); thin (low BMI) adults	National, population subgroups; measures effects of inadequate food, not hunger itself	Point estimate of stunting reflects some months or years, underweight and thinness less time	Not specific to food inadequacy, but trends and levels may give some bounds to hunger estimates	Related, directly and through birth weight, although this needs more research	Suitable for evaluation, using measure of physical effects on growth and health
Qualitative Measures of Food Security (Kennedy)	Percentage reporting experience of food insecurity and hunger	Individual, subgroups, national	Usually monthly, then repeated to give annual estimate	Direct estimate of reported experience and related behaviour	Not readily assessed in quantitative terms	Suitable for large-scale evaluation, with qualitative outcome measure

widely for assessment. It might be feasible to assess trends in school performance over the long term – this would have considerable meaning and influence – but for this indicator and for functional measures in general, new methods need to be developed.

## Comparison of methods

The estimates of hunger and malnutrition can be used to make comparisons across several dimensions: within countries or regions through time in order to assess trends and hence progress; across countries to compare levels at one time with ranking, for instance, to develop priorities; or a combined approach comparing both trends and levels. The estimates themselves are subject to error and their interpretation may present difficulties, even if they are accurate. In general, comparisons of countries through time are more reliable, as systematic errors may remain similar and not affect trend estimates greatly. The interpretation of indicators is simpler when done within the same population and society, rather than across countries. These are practical reasons why trend estimates may be preferable even beyond their usual greater utility for policy and programme decisions. Interpretation of illustrations of results from available methods will now be considered – first trends and then cross-country comparisons. Some comparative features of the five methods are summarized in Table 5, referred to in more detail later.

### ■ When applied to the same population, how do trends match up?

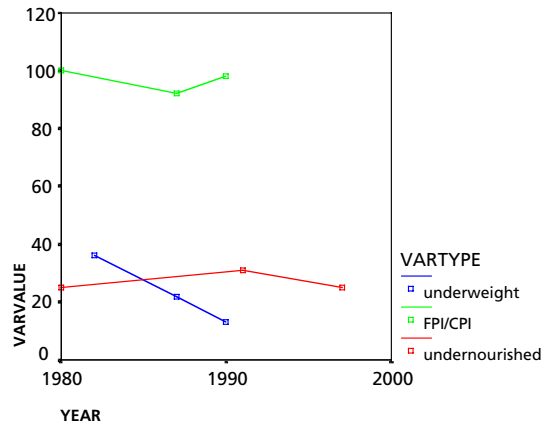
While different indicators are rarely available for the same years and countries, trends can be compared in selected cases, as shown in Figure 10 for Thailand, Philippines, Kenya, Zambia and Bangladesh. At present, the most widely available trend estimates are from the FAO DES/CV method (FAO, 2000) and from repeated anthropometric surveys and monitoring systems. Estimates of change

from comparable national HIESs are not readily available for these countries, but point estimates for three of the countries are given by Smith in this series and are included in the figure. Another indicator that has proved useful in assessing changes in food security is the ratio of the food price index to the consumer price index (FPI/CPI), where changes in this ratio can predict changes in underweight (ACC/SCN, 1989). This indicator is included in the figure. These variables measure different aspects of hunger and malnutrition; thus, analysing the trend pattern generally gives a comprehensible picture. Generating and interpreting such patterns in real time, rather than retrospectively as was done here, could provide a valid basis for monitoring trends in hunger. As illustrations, each story is briefly told next.

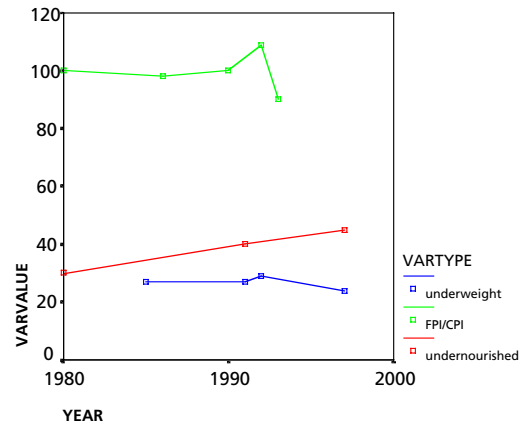
In Thailand, the prevalence of child underweight decreased rapidly in the 1980s, partly as a result of extensive village health and nutrition programmes and partly from economic development. The timing of the trends suggests that the improvement in nutrition gathered pace in the early 1980s before the economic takeoff, which accelerated in the later 1980s and early 1990s (ACC/SCN, 1993b, p. 39). In fact, the DES estimates from food supply indicated a calculated small increase in the numbers of undernourished because the FBS estimates reflected a decrease in energy supply. While this calculated increase in the undernourished is unlikely to be correct, it is interesting that the remarkable improvement in child nutrition probably did take place without a general increase in food energy availability. The relative price of food fell somewhat, indicating better access, especially for the poor and, together with income growth, probably contributed to the child nutrition (underweight) improvement. Other indicators not shown here, for instance improved sanitation and access to health care, increased education expenditure and rapidly falling fertility (ACC/SCN, 1993b, pp. 38–41), are probable explanations of decreased

FIGURE 10. TRENDS IN FOOD AND NUTRITION INDICATORS FOR SELECTED COUNTRIES.

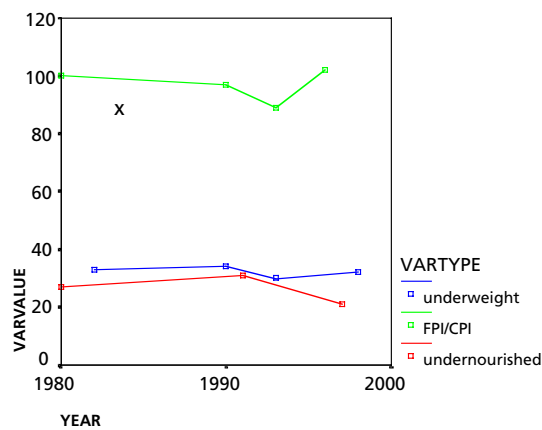
### Thailand



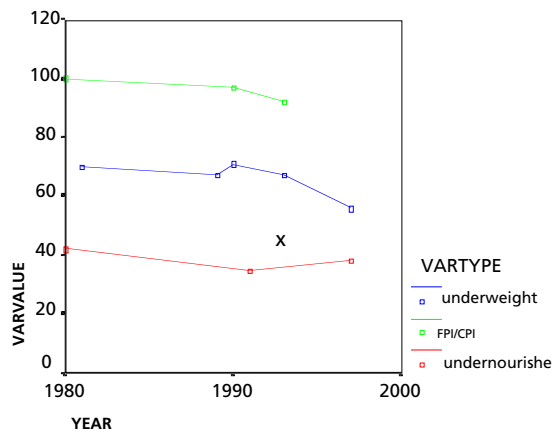
### Zambia



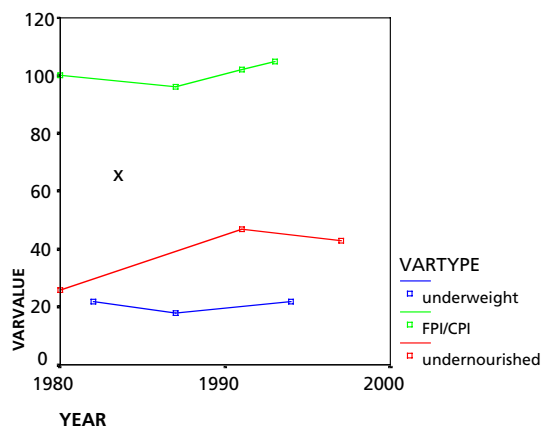
### Philippines



### Bangladesh



### Kenya



X refers to HIES estimates of inadequate kcals, Smith, fig. 2

'Underweight' is the prevalence of children (0 through 5 years) less than  $-2SDs$  of the WHO/NCHS standards.

'FPI/CPI' is the ratio of the food price index to the consumer price index, 1980 = 100

'Undernourished' refers to inadequate kcals, DES, from the FAO DES/CV method.

malnutrition, together with the effective expansion of community-based programmes throughout the country (Tontisirin and Winichagoon, 1999).

In the Philippines, nutritional indicators, including anaemia and even vitamin A deficiency, have shown no improvement and perhaps some deterioration recently (Food and Nutrition Research Institute and UNICEF, 2001); nor in fact has the nutrition situation improved in the last 20 years (unlike the rest of Southeast Asia) (Heaver and Mason, 2000). The estimated prevalence of low energy consumption (undernourished) increases somewhat in the 1980s, then falls in the 1990s – this is in line with the underweight trends, except for the latter period when survey results show this rising again. The underweight trend matches that in the FPI/CPI and is in line more with other indicators, such as GNP and social sector expenditures, than with DES-derived estimates (see ACC/SCN, 1994, p. 49). The percent of low consumption from the HIES quoted by Smith in this series, marked as X in Figure 10, is very inconsistent with the other indicators, and indeed a prevalence of inadequate energy consumption of more than 80 percent cannot be correct. The stagnant trend in malnutrition is comprehensible overall in the context of slow economic growth, little sign of change in food consumption and no widespread community-level programmes addressing nutrition (in contrast to most other Southeast Asian countries; Mason *et al.*, 2001b).

In Kenya, the broad pattern is consistent across the indicators, showing a trend for deterioration in nutrition over the period from 1980 to 1997. This is in line with poor economic performance, declining expenditures in the social sector, periodic droughts and related factors (ACC/SCN, 1993b, pp. 51–55; ACC/SCN, 1994, pp. 35–37). To analyse the situation in the short term with more detail on trends year to year, the DES-derived indicator is the least useful as it is only calculated for every 5–10 years, while the anthropometric underweight indicator would be more useful

for trend analysis. Thus, the prevalences of undernourishment and underweight go in different directions in the 1980s. Both could be correct – underweight improving (for a while) with health interventions, while the food economy deteriorated sharply – as also shown by the FPI/CPI for the 1990s data. Again, the HIES estimate of inadequate energy intake of more than 60 percent seems unlikely to be correct, or in any case appropriate to represent a nationally applicable figure.

In Zambia, the mid-1980s to mid-1990s were times of economic crisis with hyperinflation (despite a relatively stable FPI/CPI) and an observed increase in the infant mortality rate (IMR) (ACC/SCN, 1994, pp. 53–56). This problematic situation was picked up by the DES indicator, which showed increasing prevalences of inadequate energy availability. The child underweight surveys were difficult to compare but may have underestimated the deterioration in the first part of the period.

In Bangladesh, the indicators show an improvement in the 1980s and 1990s after having the worst food and nutrition situation in the world. In this case, a revision to the FAO 2000 data (used in Figure 10) alters the trend for 1991–1998 to show an improvement; still, the earlier DES indicator did go in the wrong direction in this case. The apparent increase in underweight around 1990 may be due to the comparison of different data sources. The HIES estimate of access to dietary energy is in concordance with other data and is more credible in this case. The generally improving trend in the nutrition situation supported by related indicators such as IMR is due to a number of factors including economic growth, increased food production (in part with high yielding varieties), better access to health care and falling fertility rates (Institute of Nutrition and Food Science, 1998). Presently, nutrition programmes are expanding greatly, which should lead to accelerated improvement in child nutrition (Mason *et al.*, 2001b, p. 25), although during the period shown in Figure 10, these were less extensive and probably did not account for much of the improvement.

Again, the DES-derived indicators appear to track long-term trends adequately, especially with the 2001 revision. Triangulation on other indicators such as anthropometry, the FPI/CPI and associated socio-economic and health indicators should be useful for identifying shorter-term changes (e.g. year to year) and for interpreting whether true progress has been made (see ACC/SCN, 1993b, pp. 16–20; ACC/SCN, 1994, pp. 9–12).

This is a greatly abbreviated description of these interesting results. The main point is that they are probably understandable even if the various indicators sometimes go in different directions. The differences in indicators may well be real rather than reflecting error, and we should not expect them always to match, as they measure different factors. We would greatly benefit from additional indicators, for example of energy intakes measured by more direct methods and from qualitative assessments of perceptions of hunger and responses to it. The bottom line is that we need several indicators and need to interpret them carefully. None the less, together, they may be able to support statements on progress in reducing the extent of hunger, useful to measure progress on the World Food Summit resolutions.

#### ■ How valid is ranking countries by levels of hunger and malnutrition?

All the methods are likely to be subject to different systematic errors related to the characteristics of the countries. The food balance sheet estimates from which the DES is derived depend on assessments of production and use. The production of cereals, for example, is estimated differently for roots and tubers, which are often kept in the ground as storage crops and whose production is notoriously hard to estimate. Thus, countries with roots and tubers as a significant proportion of production (e.g. in West Africa) cannot be compared easily with mainly cereal producers. However, some cultures depend more on street foods (e.g. in much of Asia) than others, and these are

also very hard to assess by the FBS method, or indeed by household surveys. Similarly, waste in the household varies with wealth or poverty, among other factors, such that the energy intake in industrialized countries tends to be overestimated from FBS calculations (i.e. household waste is underestimated) and underestimated in conditions of poverty.

Dietary energy supplies need to be compared with requirements, as discussed earlier, before they can be interpreted, and these also vary both on average and for households. The four factors that determine energy requirements for populations are the demographic composition, body size, environmental temperature and activity. Of these, activity accounts for at least 35 percent of the requirement; the other three factors can be estimated reasonably well, but the contribution of activity is scarcely known. For this reason, the denominator for estimating energy “adequacy” is uncertain and known with varying certainty across populations. Thus, the DES itself cannot be compared directly across populations; however, within the same population group, the denominator probably does not change as much through time, and therefore trend estimates, again, are likely to be more meaningful than cross-sectional comparisons. Similar considerations apply to estimating dietary energy intakes by HIES or FIS.

The constraint of finding a basis for comparison between countries at one point in time is common and requires great effort to resolve. For national income, GNP estimates have been refined (with a considerable investment) over the years, now with allowance for different denominators to correct for cost of living in the purchasing power parity estimates. Body size, directly measured, is less subject to systematic or random error, although there is a denominator problem in age reporting, errors that are amplified substantially in estimating weight- or height-for-age indices. The larger problem for cross-country comparisons is in interpretation. It is known that well-nourished children of normal birth weight and with well-

nourished mothers grow almost identically up to at least five years (WHO, 1983), so from this viewpoint, using a common standard to interpret weight- or height-for-age can indeed allow valid cross-country comparisons. There are, however, some assumptions that have not been adequately studied and need to be made more explicit if the cross-country comparison of child anthropometry (as opposed to the within-country trends) is to be truly feasible. A first assumption is that even though children everywhere grow the same up to five years of age when healthy, this does not mean that they will “fail to grow” to the same extent when faced with the same degree of deprivation. For example, in some cultures, they may be less active in order to conserve energy. This effect may be modified by diet composition and quality – it has been observed that children in vegetarian cultures (e.g. Hindu) tend to be smaller. Studies on this within societies with mixed backgrounds (e.g. Mauritius, Fiji, Guyana, South Africa) could examine whether the observed differences are accounted for by factors such as income, education and health environment. On a cross-country basis, as shown in Figure 7, it is striking that there are such large differences across countries on average or within income bands at the same income, as across income within these countries (i.e. reading Figure 7 vertically or horizontally). Therefore, similar levels of underweight do not at all imply the same degree of poverty, at least across countries.

A second assumption implicit in using cross-country comparisons of prevalences of underweight from anthropometry is that similar prevalences are associated with similar risks of mortality, morbidity, or developmental failure. However, this is clearly not so – the IMRs in Asia are generally lower than in sub-Saharan Africa, but the underweight prevalences are higher. The eight prospective studies of mortality in association with anthropometric measurement, assembled by Pelletier (1994), showed quite different mortality risks across countries at the same anthropometric levels; the slopes were similar, but they were well separated. This differential, particularly for Asia, has been known for some time but not fully explained. Much of it results from low birth weight that is closely related to subsequent underweight, when comparing by region (ACC/SCN, 1992, pp. 56–57) and in Asia by country (Mason *et al.*, 2001b), and hence is related to an intergenerational effect in Asia. But why this persists in Asia is a question for which there are plenty of plausible hypotheses (see, for example, Ramalingaswami, Jonsson and Rohde, 1996) but no agreed upon answer as yet. This is one important reason why cross-country comparisons of child growth are still lacking in some conviction as a basis for ranking nutritional deprivation.

### ■ Anthropometry can bound hunger estimates

The relation between anthropometric and dietary energy inadequacy is not symmetric, as ill health can cause growth failure in the presence of adequate food access. Food intake often will be reduced owing to poor appetite in sickness, even in the presence of an adequate food supply. However, in a stable situation, people will not be of adequate body size with inadequate food energy, even if health is good. The implications are illustrated in Table 6. Treating this association by placing individuals in categories depends crucially on the cutoffs and implies that the cutoff of –2 Z-score for weight-for-age

TABLE 6. ILLUSTRATION OF ASSOCIATION BETWEEN DIETARY ADEQUACY AND ANTHROPOMETRY (HYPOTHETICAL DATA)

Weight-for-age	Adequacy of dietary energy		
	% inadequate	% adequate	Total
% < -2 Z-score	20	10	30
% > -2 Z-score	0	70	70
Total	20	80	100

used in the illustration is related to energy intake below requirement, i.e. to hunger. In this case, the cutoff may be approximately correct. Crucially, therefore, in a steady-state situation, there should be no one in the “inadequate energy – adequate weight” category (note that the bottom left cell in the Table 6 is equal to 0). It is not possible to maintain an adequate body weight with inadequate energy. This may help relate the indicators to each other to some extent, referring again to the example in Table 6.

First, if the cutoffs for energy and weight are roughly comparable and in a stable situation, the prevalence of inadequate energy should not exceed the prevalence of underweight, which helps to bound the estimates. This is seen in the Philippines and Bangladesh in Figure 10 but not in Thailand, where it seems likely that the food inadequacy level was overestimated. In the African countries, estimates of the prevalence of a low energy intake (undernourished) do exceed underweight prevalences. However, child underweight prevalences in Africa are also relatively low in relation to other parameters such as GNP. Again, this may reflect the differences between regions, in turn related in part to the far smaller incidence of low birth weight in Africa. It implies that falling below  $-2$  Z-score for weight-for-age has a different connotation in Africa than in Asia. Second, however, in an unstable situation where food availability is rapidly deteriorating, trends in underweight should also be rising. At the start, this can only be due to increased wasting. There will be a lag, so that temporarily, a low consumption may exceed underweight, as it is temporarily possible to be of adequate weight with inadequate consumption. Consequently, the zero cell in Table 6 will be non-zero but not for a long period. This might not be picked up by the DES estimates, only available in the following year or later. We definitely expect that trends in DES-derived indicators should go in the same direction as anthropometric indicators. We can argue that energy inadequacy should

be less than low body weight, but not more; and some reconsideration of the comparative cutoff points might be useful to take this further.

Summary comments on the individual methods in the light of their likely relation to each other are given next.

### ■ FAO method

This method uses the DES from FBS calculations, coupled with estimates of the CV of energy consumption, to estimate the numbers below a cutoff aimed to define hunger. In practice, the CV is set from only a limited number of estimates and is not considered to have changed over the period of calculation: changes in CV would have large effects on the prevalence estimates. Thus, changes in the percent undernourished are driven by the changes in DES, or in other words, the percent undernourished is a way of expressing the DES figure. The method is described in detail in the paper in this series by Naiken. Some features are compared with other methods in Table 5.

A crucial feature of the DES estimate is that it is done for all countries and years, although only 3-year country averages are published. Only national income (GNP/GDP) and demographic data (e.g. IMR) share this distinction. If data on diet are to be generated for each country and year, this is practically the only way it can be done. The results are closely related on a cross-sectional (at-one-time) basis to underweight prevalences (figure 6; ACC/SCN, 1992) but less so to trends.

If there are to be comprehensive estimates of undernourishment based on data for all countries and all years, DES-based estimates are the only option for the foreseeable future. While they can and should be supported by specific household surveys, even in the richest countries these are not done each year and are unlikely to replace DES estimates. It should be noted that interpolation of sparse results does not solve this (see the paper by Smith in this series) as the input data for interpolation,

however good the model, must still vary by year. DES, measured in kilocalories, must continue therefore as a basic measure in this field and should continue to be interpreted, with due caution, in terms of percent undernourished. However, given the intrinsic difficulties, it may not be worth great efforts to refine the method further; rather, it should continue to be used in its current state as a basic indicator of the likely direction of trends.

The extent to which DES-derived estimates pick up real trends and give valid rankings has been discussed above. Following a set of indicators and interpreting these can add credibility and depth. It should be borne in mind that this process attempts to measure something that is practically unknowable – how much individuals in populations eat in relation to their needs – without the available resources for necessary research efforts to develop more powerful methods and to build a more extensive database.

An excellent potential development would be to estimate supplies of important micronutrients through the FBS procedure. This was done in the past and is perfectly feasible to reinstate, if requiring some effort. A wise and feasible early step could be to reinstate FAO's estimates of micronutrient availability. Certainly, this would project FAO instantly into the forefront of this subject area, as the data would be widely used and quoted. It might also provide success stories to report in the context of the World Food Summit follow-up.

In summary, the pluses for the DES/CV method are that it delivers estimates of hunger for all countries and years and is the only method that can do that. It is, however, quite inaccurate from the point of view of both the mean energy values and the estimates of distribution. Like the other energy methods, but even more so, it cannot satisfactorily relate intakes to requirement, thus limiting its ability to convert intakes to adequacy and subsequently to measure hunger accurately. However, it does provide values averaged over a year rather than for

shorter recall periods that may be unstable, but this also means that transient hunger is not included.

### ■ Household Income and Expenditure Surveys

Direct measures of energy intake have long been feasible from HIES, as described in the paper by Smith in this series. It means that either food quantities or prices must be recorded on the questionnaire of household economic activity for conversion of expenditures to kilocalories. This is still not a routine procedure within HIESs, although it has been advocated literally for decades. A new effort to achieve this could be highly cost-effective. Like other energy estimates, the results are not readily interpreted in terms of adequacy, as requirements are not known. Care should be taken not to make judgements on whether estimated intakes are adequate or not. Thus, energy intake estimates should be reported as such and not in relation to needs unless these have been specifically assessed (which is unusual). This constraint needs to be explicitly recognized.

The pluses of energy consumption estimates from HIESs are that they directly provide household-level energy intakes and their distribution. Undoubtedly, the intake estimates are thus more accurate than DES-derived indicators, as the latter stem from national average estimates, not household surveys. However, the intake estimate reference period from HIESs is short, much less than a year, and as mentioned above, their coverage is sparse.

One promising way ahead might be for HIES-derived estimates of energy intake to be focused in selected ("sentinel") countries. While relating the results to requirement would remain difficult, estimating the trend in average intake would be invaluable towards providing a direct assessment of change. These HIES-derived data with suitable analysis, especially of causal factors, could contribute also to policy studies of better ways to achieve progress in reducing

food insecurity. This type of analysis may of necessity be cross-sectional, at least initially in the absence of time series data, but even cross-sectional investigations can be useful if they are specifically oriented to the local situation, rather than aimed at establishing general relationships.

### ■ Individual food surveys

Food intake surveys generally refer to the direct assessment of quantities of food consumed by individual household members, as illustrated by Ferro-Luzzi (see figure 1 of the Ferro-Luzzi paper in this series). This contrasts with the household expenditure method that estimates average food quantities at the household level from data on food expenditures and prices, although some of these surveys do also ask about weights of foods. Food intake surveys also pay more attention to food composition and therefore are able to provide information on intakes of nutrients as well as dietary energy. Such methods aim to give more precise measurements of intake and sometimes attempt to measure requirements, including energy expenditure, although these are quite difficult and expensive to estimate. Thus, although the intake figures may be more accurate, their interpretation in terms of adequacy, i.e. identifying hunger, remains problematic.

This approach is not an alternative to HIES because of its more limited application owing largely to resource demands, but rather it may provide a better understanding of data that are more widely available. The determinants of dietary patterns and habits can be studied from food intake surveys. Energy and nutrient intakes can be related to outcomes of interest, such as health, behaviour and activity, and interactions with disease can be investigated. This is important for better understanding observed changes, for analysing policies and for proposing changes to accelerate improvement. Indeed, this ability of food intake surveys could be considered their primary role rather than

expecting that they provide a major source of monitoring data at national levels.

One particular method developed in food intake surveys, the food frequency questionnaire, is however recommended by Ferro-Luzzi for wider application in the present context. This method aims to estimate food intakes by interview through standardized descriptions of portion sizes as well as amounts cooked and served. Considerable investment would be needed to adapt this method to local cultures and dietary habits, to develop relevant food composition tables and to validate and interpret results for comparisons across countries. The research pedigree of food intake methodology has taken account of individual requirements, including activity levels, in a way that other methods have tended to omit. Thus, this crucial issue in interpreting intake estimates in adequacy terms – essential for defining hunger from intake data – is implicit in this approach. In practice, wide application of the food frequency approach would require a significant commitment of effort and long-term follow-through. The needs are quite similar to those for qualitative measures of food security, discussed below, and there might be an advantage in pursuing the development of these two methods together.

### ■ Qualitative measures of food insecurity and hunger

The methods described in the paper by Kennedy in this series are still new and have largely been developed for application in North America, initially relating to safety net programmes like food stamps. They are quite different in concept from the others, and they concern such questions as: whether meals have been skipped owing to inadequate funds or supplies; worries about not being able to feed the children; and hunger and weight loss themselves (see questionnaire samples in the Kennedy paper). This approach would seem highly relevant – indeed overdue – especially if it is recognized that the issue of hunger goes beyond only energy intake

itself, as discussed in the first section of her paper. Assessing perceptions of hunger and related behaviour is much more than a proxy or indirect measure; it tries to get to the heart of the problem of hunger. Unlike methods that estimate energy intake, the qualitative method does incorporate the concept of adequacy in relation to needs. Moreover, there is evidence supporting the contention that subjective reporting on the sensation of hunger can be reliable in relation to other estimates of food insecurity, as discussed by Kennedy in this series. While validation is needed in different cultural settings, this seems no more difficult than for other social and behavioural research.

Several other attempts to estimate experiences qualitatively and retrospectively, such as the question used in Indian surveys concerning whether the respondent had had “a square meal each day”, apparently produced estimates too low to be believed – but such is our uncertainty about the real extent of hunger that maybe this deserves a second look. The concern for cross-country comparability, brought up by Kennedy, is mitigated if one objective is to compare trends rather than absolute levels. Seeing that the indicators of qualitative hunger perception and response were changing in the same direction as other estimates for defined population groups as well as nationally could provide enough information for a credible and adequate hunger monitoring system. Further, all the indicators have problems of cross-country comparability in some way, which is why studying within-country or within-region trends should be promoted. The DES mean estimates are biased by the production system (e.g. roots and tubers), and the distribution around the means no doubt depends on cultural factors not captured in the CVs used. Dietary energy estimates from HIES and food intake surveys are certainly more comparable within population groups than across, especially where dietary habits vary culturally, an example being the consumption of foods outside

the home. As seen earlier, a cross-country comparison of underweight prevalences is not straightforward either. This was most striking in the case of the South Asian effect, but even more generally because the relative extent to which different populations fail to grow in the face of deprivation is not known. Comparing prevalences by income band, as shown in Figure 7, shows a greater effect of location than income in many cases.

In any event, the suggestion is that qualitative methods be developed in country- and culture-specific ways (requiring a significant investment of research as a start-up) in order that a short questionnaire could be included in broader surveys, such as the HIESs. This will lead to better descriptions of within-country differentials and presumably of trends in the future. Some work of this type has already begun in Bangladesh (Webb, Coates, and Houser, 2001) and in several other countries. A key factor for wider application will be the feasibility of incorporating the questionnaire in other surveys (HIES, and/or those with health or anthropometric measures, like DHS and UNICEF–MICS). The equivalent of the shorter six-question format from the US module would be preferred to the longer 18-question core module, but clearly, the trade-offs will need to be assessed by in-country research.

Overall, the approach might be to:

- ▶ develop the country-specific questionnaire with the required significant investment in a selected number of countries;
- ▶ test the incorporation of the questionnaire in broader purpose surveys and compare results;
- ▶ use this as one method to triangulate on trends, perhaps in sentinel countries to begin with.

## ■ Anthropometry

Child anthropometry is now well established as a general measure of child growth and development determined by dietary intake and health for the individual child (Beaton

*et al.*, 1990). These factors in turn are determined by the household's food security, health factors, and in-household behavioural factors that have become known as "care" – as displayed in the UNICEF framework (UNICEF, 1990; figure 3). This term provides a useful point of reference and a common language. Thus, holding other factors constant, changes in food availability may be reflected in changing child anthropometric indicators, most commonly underweight prevalence. None the less, children do not require much of a households' food, and the relation between the change in child underweight and the change in food availability is quite small. Child anthropometric indicators (e.g. underweight) empirically do show a broad relation to energy availability. In models at national levels for estimating underweight (e.g. ACC/SCN, 1992), DES is very significantly associated and so is GDP, which is highly collinear. The anthropometry–dietary energy supply relation is probably not linear, similar to GDP relations that are non-linear as discussed earlier, and there are important interactions, notably for South Asia, for which the slope is significantly greater than elsewhere (Haaga *et al.*, 1985).

Change in child anthropometric indicators is non-specific to cause, and moreover it is asymmetrical. As illustrated in Table 6, when child growth is adequate, household food security is likely to be adequate as well. But the opposite may not apply – poor growth can be due to other factors. Anthropometry provides a method for assessing nutritional and health problems across the population. As described by Shetty in this series, anthropometric assessment can be applied more widely, although it requires some further development for groups other than young children. Malnutrition also affects adults, and measures such as BMI are reasonably well established, but data on certain subgroups are still lacking. The elderly are increasing in proportion worldwide and constitute an emerging vulnerable group that could be assessed readily by anthropometry

to measure wasting, among other outcomes.

However, anthropometry does not measure food security, nor is it a "proxy", but it is related in a reasonably understandable way. This means that, again, trends in anthropometric indicators are useful for confirming or clarifying trends from other indicators. As illustrated earlier, they may not always go in the same direction but usually can be understood and therefore help to assess whether hunger is indeed being reduced.

### ■ Combining methods

To monitor progress towards the WFS goal of halving the numbers hungry by 2015, it seems that we do have suitable methods if we combine them. The combinations that may be considered include:

- ▶ obtaining trends for all countries and years (hence regions) from DES in percentages below an energy cutoff, along current SOFI lines;
- ▶ using the FBS procedure to estimate trends in micronutrient supplies, starting with iron and vitamin A;
- ▶ providing support in selected ("sentinel") countries to obtain comparable estimates of energy intakes over time, every five years or so, through an expanded HIES programme;
- ▶ supporting individual dietary intake surveys in a few countries (probably those sentinel countries with energy data from HIESs) for analysis of the causes and meanings of observed changes, and for assessment of current and future policies and programmes;
- ▶ supporting a gradual expansion, based on research, of qualitative methods for assessing hunger perceptions, focusing more on trends than cross-country comparability (although this would be a long-term aim);
- ▶ including qualitative methods in HIESs and other household surveys, such as the DHS and UNICEF–MICS surveys;

- ▶ checking that observed trends from these methods are in line with anthropometric trends, and that we understand the relation;
- ▶ checking that micronutrient trends are in line with trends from deficiency and control programmes;
- ▶ using multiple indicators to triangulate on likely trends.

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