Human nutrient requirement estimates

Estimation des besoins nutritionnels de l'homme
Estimación de las necesidades humanas de nutrientes

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Derivation, interpretation and application in evolutionary perspective

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Published estimates of human nutrient requirements date from the last half of the nineteenth century (Leitch, 1942; Young, 1964; IUNS, 1983) although the specific nutritional properties of certain foods had been recognized long before (Leitch, 1942). A major impetus for the development of reports on human nutrient needs was the pressure of food shortages associated with wars or other disruptions. Thus, in the First World War, the Inter Allied Food Commission had the benefit of a standard for energy requirements prepared by Lusk. The primary purpose of this standard was in the planning of food shipments from North America to Europe. During the Depression years of the 1930s dietary standards appeared in the United Kingdom, the United States and Canada. In each case, a primary motivation appeared to be the need to plan food supplies and welfare allowances (based on the cost of a required package of foods).

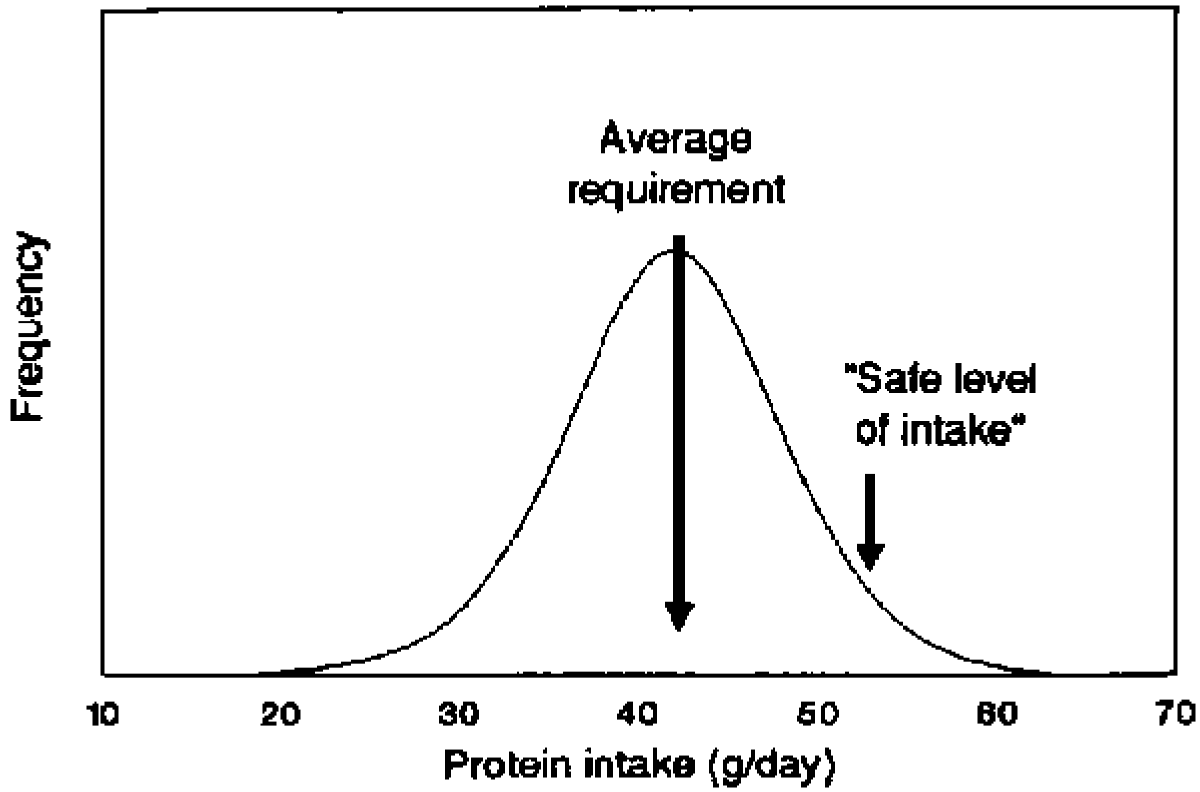
A 1935 report of Burnet and Aykroyd to the Assembly of the League of Nations appears to have motivated that body into initiating a long chain of international reports on human nutrient needs, a chain that continues to the present. The first report (League of Nations, 1936) attempted to describe average values representing the requirements for energy and protein of individuals grouped by age, sex and activity. A subsequent report addressing fat, minerals and vitamins was issued (League of Nations, 1938). Clearly, the impetus for this set of reports was the planning of food supplies and ration scales. During the Second World War an energy standard was used as the basis for planning food supplies needed for the "prevention of disease and unrest" in the civilian populations as they were liberated (Ebbs, 1991). In that particular application both physiological and psycho-social needs were incorporated in the estimated requirement for food even when it was explicitly recognized that it would be extremely difficult to meet the projected needs.

In the postwar period, with expansion of the scientific basis of nutritional knowledge, there was already a precedent for attempts to apply this knowledge in the monitoring of food supplies and intakes. Many individual countries, as well as the new United Nations agencies which replaced the League of Nations, embarked upon a programme of regular updating of their nutrient requirement reports. The number of countries issuing national reports also increased. By 1983 at least 50 national, regional and international reports addressing human nutritional needs were in use (IUNS, 1983). Many of these were local derivations of FAO/WHO, United States or United Kingdom recommendations; nevertheless, among the reports there were substantial differences in some of the numeric estimates presented (IUNS, 1983). Advocated intakes of vitamin C are a notable example, ranging, for adult males, from as high as 60 mg per day to as low as 20 mg per day.

The earliest "dietary standards" had been little more than estimates of average intakes among seemingly healthy people (usually men) and addressed only those food factors then presumed to be essential to life - energy, carbon and nitrogen, and later "ash". As biological knowledge increased and more and more essential dietary components were identified, so the number of nutrients included in requirement reports also increased. The most recent American report addresses needs for energy and 24 nutrients (National Research Council, 1989a). The newer reports also gave separate estimates for an increased number of different age/sex groupings. In 1983 the number of such groupings ranged from a low of 15 in the Federal Republic of Germany to a high of 58 in Japan (IUNS, 1983).

As time went on, particularly after the 1920s, the evidence for requirement estimates progressively changed from the observation of intakes of seemingly healthy groups to experimental studies in which the intake of a nutrient was varied and the intake needed to prevent a defined sign of deficiency was estimated. With this evolution of evidence came a recognition of individual variation in requirements - variation separate from that which could be explained by characteristics such as age, sex, body size, physical activity and even nature of the diet. Characteristics recognized as influencing nutrient requirements were progressively built into the published requirement estimates either by tabulating estimates for different classes of individuals or by providing guidelines for adjustment of requirement estimates to meet different conditions. Examples of the latter are adjustments for protein quality (amino acid composition and digestibility) or adjustments for expected bioavailability of iron and zinc as a function of the nature of the diet consumed. There remained a variation in requirements among individuals with seemingly similar characteristics consuming the same type of diet. This is the individual variation that was progressively recognized in requirement reports (see Fig. 1). Unfortunately, different committees did not always apply the same approaches in attempting to build in these considerations. Published estimates of requirements, often based upon the same evidence, began to diverge, reflecting judgements and approaches adopted by individual committees.

Distribution of protein requirements among young adult men (70kg) - Distribution des besoins en protéines chez déjeunes hommes adultes (70 kg) - Distribución de las necesidades individuales de proteínas en varones adultos (70 kg)



Source: FAO/WHO/UNU, 1985

By the mid twentieth century, nutrition research had been directed toward the identification of biochemical markers that could be used to detect depletion of body tissue levels of nutrients or signs of metabolic disturbances occurring before the appearance of any clinically visible signs of functional disturbance. It is understandable that subsequent nutrient requirement estimates were designed to prevent these "subclinical deficiencies" as well as to preserve externally apparent good health. This led to further differences in published estimates depending again on judgements made by individual committees. The previously cited example of diverse recommendations for vitamin C is clearly a reflection of such differences in judgement about "subclinical deficiency", as there was little disagreement about amounts needed to prevent the clinical signs of scurvy.

In the 1985 FAO/WHO/UNU report on energy and protein requirements, explicit attention was focused upon the consideration of "requirement for what?" - for what body size and composition and for what levels of occupational and non-occupational activities. In that report, normative judgements about desirable levels of physical activity as well as desirable body weight for height (body mass index or BMI) were introduced. Thus, the report offered approaches to estimating energy needs for the status quo situation and also energy needs for what was deemed to be a desirable state of health and well-being. The inclusion of non-occupational activities gave recognition to the fact that social functions, as well as "work", are an aspect of human performance that must be considered.

Subsequent committees addressing requirements for vitamin A, iron, vitamin B_{12} and folate (FAO/WHO, 1988) and for trace elements (FAO/WHO/IAEA, 1992) described "basal requirements" sufficient to maintain all demonstrable functions of the nutrient and "normative requirements" sufficient to maintain tissue stores or adaptive capacities that were judged to be desirable (see Fig. 2 for iron example). These were extremely important steps forward and, in the future, may bring considerable harmony into the description of nutrient requirements.

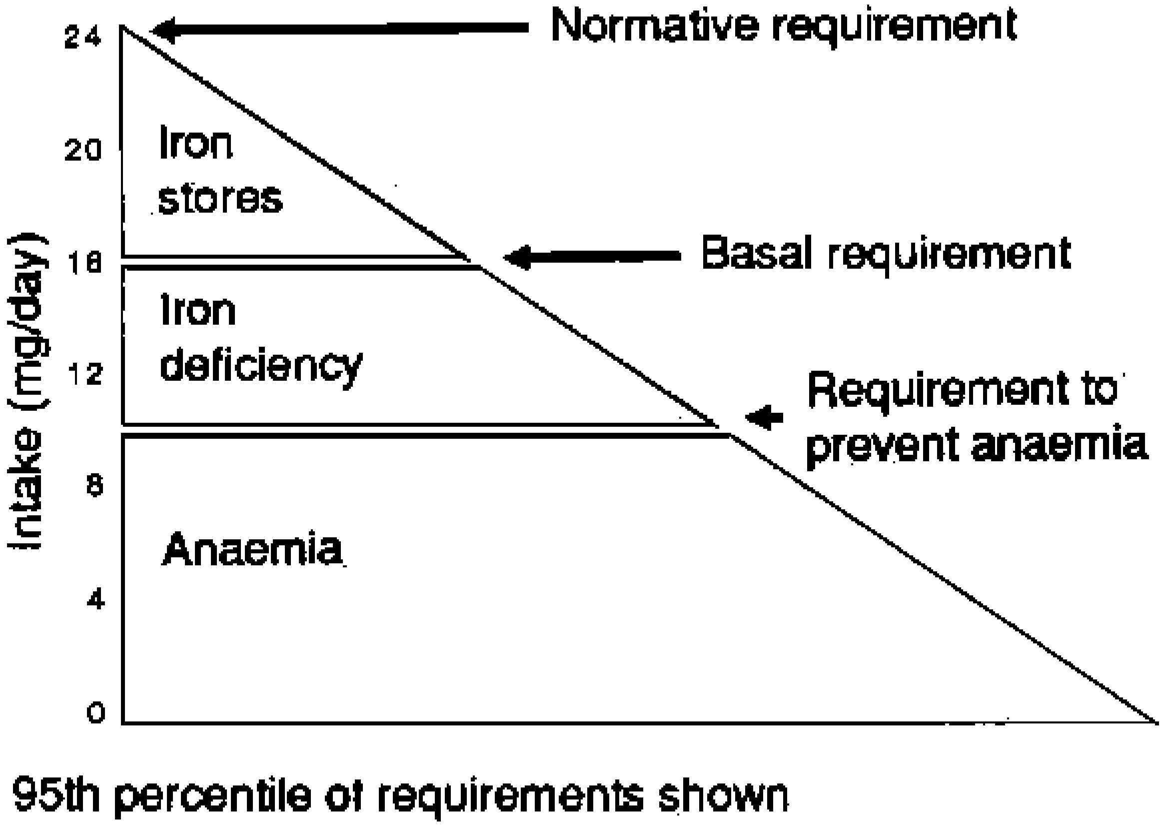
In the last 25 to 30 years, and particularly the last ten years, the series of interagency reports on human nutrient needs have made real attempts to develop and apply consistent conceptual frameworks for estimating and describing human nutrient requirements. Historically, these UN reports have exerted a major influence on national reports. It is a reasonable expectation that, in the future, there will be a gradual adoption of consistent approaches to descriptions of human nutritional needs. It is now necessary that approaches to application take into account these conceptual clarifications of the meanings of the requirement estimates.

EVOLUTION OF THE USES OF REQUIREMENT ESTIMATES

As mentioned above, the earliest motivation for development of nutrient requirement estimates and dietary standards appears to have been related to planning or assessing food supplies of large groups or total populations. By and large the numbers generated in the early reports were to be compared with per caput estimates of supplies (group means).

A committee preparing a revision of the 1969 United Kingdom requirements report (Department of Health and Social Security, 1979) noted that "more difficulties have been encountered about the use of figures than about their validity". The committee suggested that, "although the figures (in the 1969 report) were intended to apply to groups of people, they have been used mistakenly as. recommendations for individuals,.,". It is a moot point whether figures in the 1969 report had been designed and developed as applicable to groups (to group mean intakes) rather than individuals (the distribution of intakes among individuals), even though the report claimed that intended application.

Fig. 2 - Iron requirements for menstruating women consuming a diet with high iron availability - Besoins en fer des femmes en âge de procréer et ayant un régime alimentaire riche en fer - Necesidades de hierro en mujeres menstruantes que consumen alimentos con un alto contenido de hierro

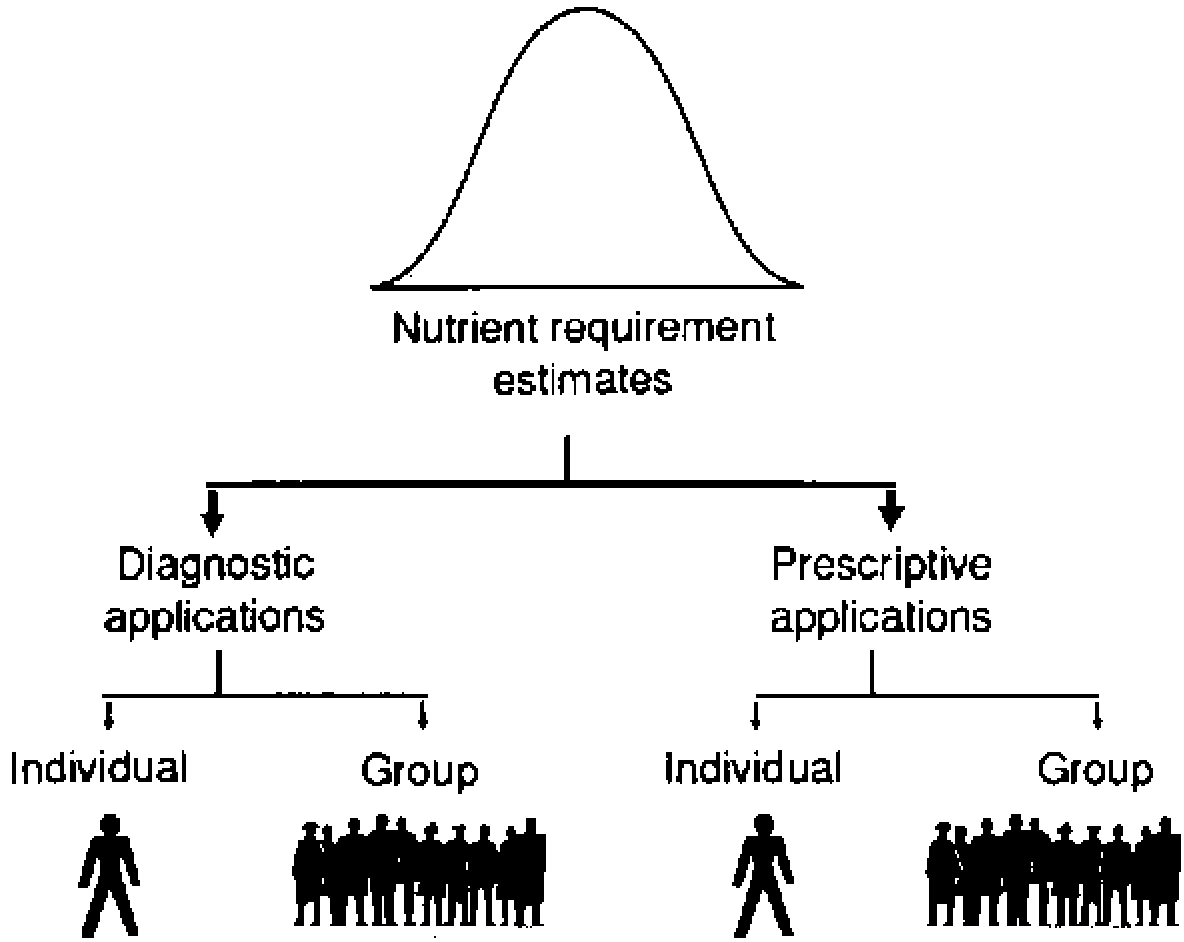


Source: FAO/WHO, 1988

Major discrepancies between the constructs used in deriving and describing nutrient requirement estimates and the constructs proposed for application were becoming apparent to many of those involved. Some saw this as a problem of derivation of requirement estimates, while others attacked the approaches to application. The only real consensus was that serious problems existed and that the credibility and utility of the reports was at risk.

By the 1940s, major interest was swinging toward the distribution of food and nutrient intake within large groups and populations. At first this disaggregation was to the level of population subgroups, then to the household unit and finally to the level of the individual within the household. The conflict and contradiction can be seen in Second World War food rationing. Of necessity, rationing provided entitlements at the level of each individual, but it was based (for energy) on per caput population or large group mean requirement estimates. The emerging issue was clear. How could a single numeric estimate of needs be applicable to a population mean, to a household mean and to an individual? It could not. Somehow, expected variabilities of intake and of requirements had to be taken into account. Early evidence of an awareness of the emerging problems and of the need to introduce statistical concepts into the derivation and interpretation of nutrient requirement estimates appeared in a paper by Pett, Morrell and Hanley (1945) and was re-emphasized by Pett (1955) ten years later. These papers documented the importance of recognizing variability of requirements among similar individuals and variation of intakes among individuals in both assessment and planning. This awareness was an obvious and direct consequence of the evolution of knowledge about requirements and the evolution in application of requirement estimates. It was driven also by the appearance of dietary surveys that attempted to estimate individual intakes. The earlier paper (Pett, Morrell and Hanley, 1945) set out the issue even though statistical concepts, and more particularly nutritional thinking, were not then advanced enough to deal with the issues. These issues and concepts were presented at early meetings of FAO, WHO and the United States Food and Nutrition Board but were said to have "fallen on stony ground" (Pett, personal communication, 1988).

Fig 3 - Classification of applications of human nutrient requirement estimates - Classification des applications des estimations des besoins en nutriments de l'homme - Clasificación de las aplicaciones de las estimaciones relativas a las necesidades humanas de nutrientes



Much later, Lorstad (1971), in an FAO periodical, published a seminal paper which described application of statistical theory to this duality in requirement and intake distributions. The Eighth Report of the Joint FAO/WHO Expert Committee on Nutrition (FAO/WHO, 1971) discussed the Lorstad arguments and issued a statement on some guiding principles. However, it is only quite recently that the principles identified by Pett, Morrell and Hanley, elucidated by Lorstad and discussed by the FAO/ WHO committee found support in a detailed examination of the application of nutrient requirement estimates in the assessment of intakes as estimated in large surveys (National Research Council, 1986).

Gradually the concepts are being built into the series of UN agency reports on human nutritional needs (FAO/WHO, 1973; FAO/WHO/UNU, 1985; FAO/WHO, 1988; WHO, 1990; FAO/WHO/IAEA, 1992).

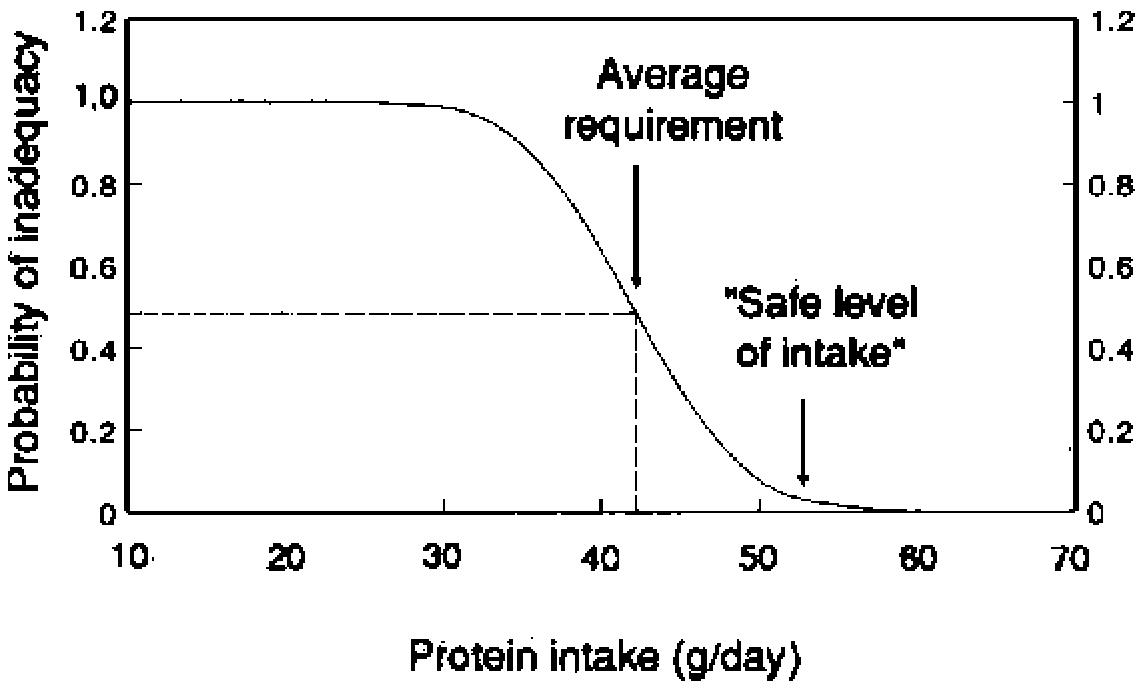
CURRENT APPROACHES TO INTERPRETATION AND APPLICATION

At this stage one may recognize a categorization of major uses of human nutrient requirement estimates. Following an approach put forward by Valverde at the time of the FAO/WHO/UNU meeting on energy and protein requirements (FAO/WHO/UNU, 1985), the applications can be divided into those that are diagnostic and those that are prescriptive. The former group is characterized by the examination and interpretation of nutrition surveys, the assessment of probable adequacy of estimated intakes and assessment of per caput food disappearance data. Prescriptive applications might be characterized by activities related to the planning of food supplies for population groups, for institutional feeding or in counselling an individual.

The second dimension of usage that becomes important is the division of these applications into those concerned with population groups and those directed toward particular individuals (see Fig, 3).

The correct approaches to interpretation and application of nutrient requirement estimates differ among these classes of application. Suitable constructs merging statistical and biological concepts have gradually evolved. These can serve to address most types of applications, although one must expect further refinements and improvements. However, there is still another class of application that remains undeveloped: application of requirement estimates in the evaluation of individual commodities (or in food labelling). This is mentioned in the final section on challenges for the future.

Fig. 4 - Probability or risk of inadequacy of protein intake for an adult male weighing 70 kg (cumulative distribution of requirements portrayed in Fig. 1) - Probabilité ou risque d'apport protéinique insuffisant chez un homme adulte de 70 kg (distribution cumulative des besoins présentée à la figure 1) - Probabilidad o riesgo de insuficiencia del aporte proteínico observado en varones adultos (70 kg). (Distribución acumulativa de las necesidades representada en la Fig. 1)



Source: Based on FAO/WHO/UNU, 1985

Diagnostic assessment of observed intakes

The United States National Research Council (1986) issued a report describing a probability approach to assessing intake. In this approach, the distribution of individual requirements is transformed into a cumulative distribution portraying the likelihood that any given level of intake will be inadequate for a randomly selected individual (Fig. 4). The probability of inadequacy is simply the proportion of similar individuals expected to have higher requirements (the area under the requirement distribution to the right of the stated level of intake). This concept was also described in the FAO/WHO/UNU (1985) report on energy and protein requirements and has been repeated in subsequent requirement reports.

When probability assessment is applied to a group (Fig. 5), the prevalence of inadequate intakes (or population risk of inadequacy) is estimated by first multiplying the probability of inadequacy by the frequency of occurrence for each interval of intake; this computation is then summed across all intervals to give the expected number of affected individuals in the group. Note that this approach provides an estimate of prevalence of inadequate intakes but does not identify which individuals have inadequate intakes. To implement the approach, one needs on estimate of the mean requirement and the likely distribution of requirements, as well as estimates of the distribution of usual intakes. If the requirement distribution is likely to be symmetrical, the assessment is not very sensitive to the standard deviation of requirements or even whether or not it is normal (National Research Council, 1986). Thus, the most important descriptor of the requirement distribution for this application is the average requirement for the specified class of individuals (e.g. young adult men or young adult women). This is not the number usually published in requirement reports, although in the future one may expect committees to provide this estimate as well as the conventional "recommended intake" or "safe level of intake".

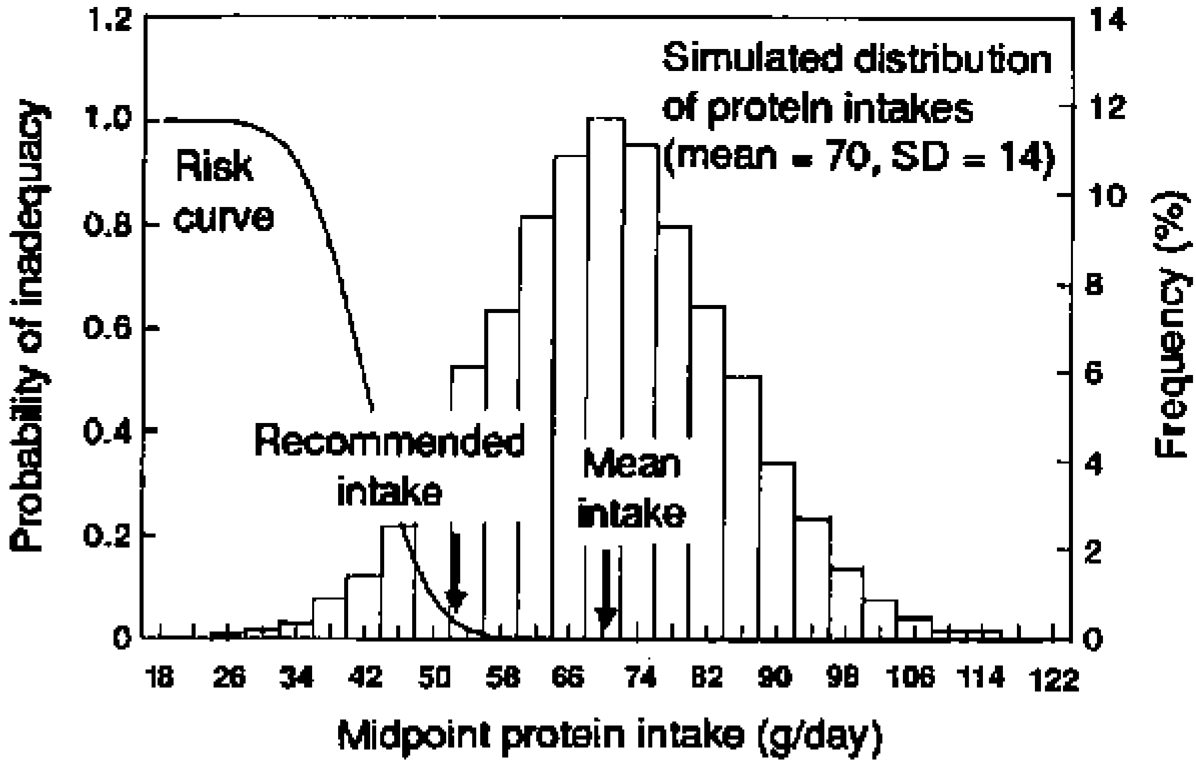
For reasons set out in detail elsewhere (FAO/WHO/UNU, 1985; National Research Council, 1986), the probability approach is not applicable to energy.[1] Published energy requirement figures are usually estimates of group mean requirements and as such are intended to be compared with group mean intakes. Recently, on behalf of FAO, James and Schofield (1990) outlined an approach to estimation of per caput energy needs for comparison with per caput energy supplies estimated, for example, from food balance calculations. This was undertaken to provide an improvement on approaches that FAO has used in its World Food Surveys. The reader must recognize that the James and Schofield approach is not applicable to nutrients.

[1] A critical assumption of the simple probability assessment is that intakes and requirements are not correlated when examined within strata of the population (e.g. young adult men) and when factors potentially affecting both are controlled (e.g. when thiamine is examined as mg per 1 000 kcal rather than mg per day). In the case of energy, there is strong reason to believe that, over moderate time periods, energy intake and energy expenditure ("requirement") are strongly correlated as part of a "regulated" energy balance. This violates the core assumption of the probability approach. It also explains why it is appropriate to compare group mean intake and group mean requirement estimates for energy but not for nutrients.

For both energy and nutrients, assessment can now be conducted for different levels of requirements. For nutrients, one can assess the adequacy of existing intakes to meet basal requirements or to meet normative requirements. Parallel assessments of per caput energy intake can be obtained. The distinction between energy and nutrients is that there is at present no satisfactory way of estimating the prevalence of inadequate energy intakes. Calculating the proportion of individuals with inferred intakes below a cut-off point, as FAO (1985) did in the Fifth World Food Survey, may be useful for comparisons among countries or across time. However, it does not provide a valid estimate of the proportion of the population that is undernourished with regard to energy (although this is often, and quite erroneously, inferred), (Beaton, 1983).

Fig. 5 - Probability assessment applied to a hypothetical distribution of protein intake in adult men (expected inadequate intake, about 2 percent) - Evaluation de probabilité

appliquée aune distribution hypothétique d'apport protéinique chez les hommes adultes (la prévalence probable d'apport insuffisant est de 2 pour cent) - Aplicación de la evaluación de la probabilidad a una distribución hipotética de aportes proteínicos en varones adultos (la proporción prevista de aportes insuficientes es de un 2 por ciento)



Source: Based on FAO/WHO/UNU, 1985

If only per caput nutrient intake can be estimated (i.e. if distribution of intakes among population strata, and among individuals within strata, is not known), there is no fully validated approach to assessment. Approaches that do exist or that are evolving depend upon assumptions about the distribution of intakes. (See below for discussion of assumptions used in the prescriptive approach for population planning.)

The probability estimation procedure can be applied, in theory, to the assessment of nutrient intake of a particular individual. It would yield the likelihood that the observed intake was adequate or inadequate to meet that individual's actual needs. Here, a precise estimate of the distribution of requirements would be needed. The much greater limitation to this application is the difficulty, if not virtual impossibility, of obtaining a precise estimate of the particular individual's "usual" intake (intake averaged over a period of weeks or months). A major factor here is the variability of reported intakes from day to day[2] (Fig, 6). Also of concern, for some nutrients, is the imprecision of estimation of bioavailability when applied to the individual diet. For energy, as noted already, there is no satisfactory approach to application of the probability approach to the individual subject.

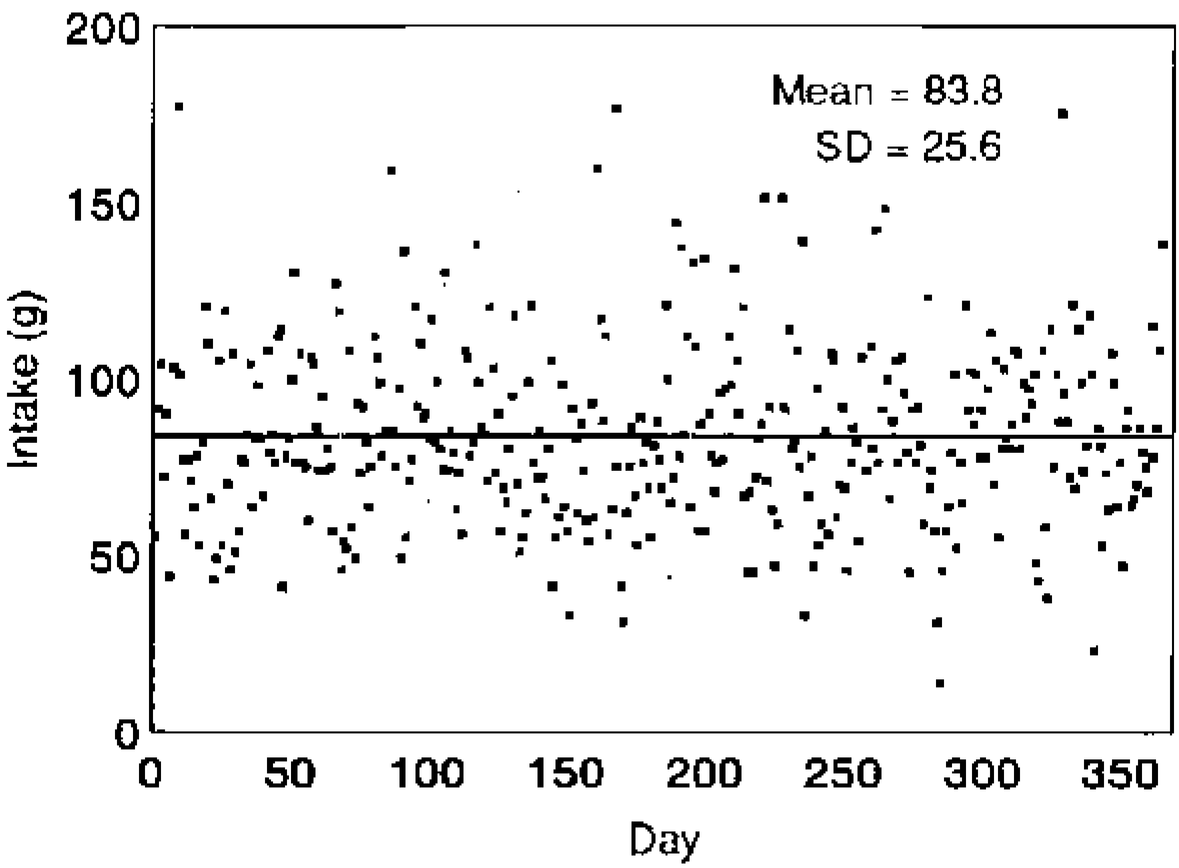
[2] To exemplify the problem, consider the assessment of a young man's estimated protein intake. The day-to-day variation of protein intake is likely to have a coefficient of variation of about 20 percent or more. If his intake were estimated to be 0.6 g/kg with a single day's observation, then the 95 percent confidence interval for the estimate of his usual intake would be about 0.36 to 0.84. This would span the whole range of the requirement

distribution; thus the assessment would be that the likelihood of inadequacy lies somewhere between 0 and 100 percent - not a very useful assessment. As the number of days of intake estimates is increased, the effect of day-to-day variation is reduced and the confidence intervals narrow. Nevertheless, to obtain a reliable estimate of risk might require a logistically impossible number of days of data. Fortunately, in application of the probability approach to population groups, as in survey data, the impact of day-to-day variation can be estimated and corrections applied to obtain improved estimates of the prevalence of inadequate intakes (National Research Council, 1986).

Prescriptive applications

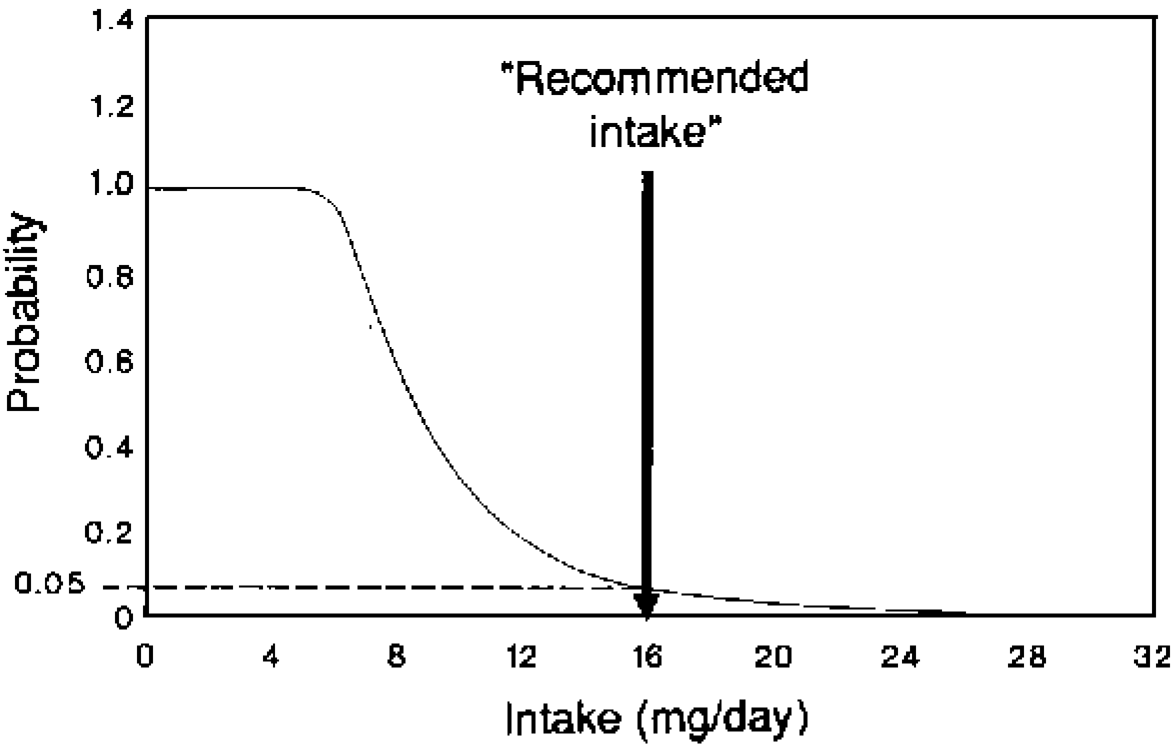
In the preceding discussion of the evolution of estimation and application of requirement estimates, it was emphasized that the first applications referred to feeding of populations or population groups. The main consideration was total energy supply, while secondary consideration was given to the nutrient composition of the foods provided. Estimation of per caput energy needs, adjusted for anticipated losses of food, was and is the appropriate planning figure.

Fig. 6 - Observed day-to-day variation in individual protein intake over 365 consecutive days (some subjects exhibit long-term trends within this variation) - Variation quotidienne observée de l'apport protéinique individuel pendant 365 jours consécutif s (certains sujets présentent des tendances à long terme à l'intérieur de ces variations) - Variación diaria de los aportes proteínicos notificados en un sujeto a lo largo de 365 días consecutivos (algunos sujetos muestran tendencias a largo plazo dentro de esta variación)



Source: Based on Mertz & Kelsay, 1984

Fig. 7 - Probability of inadequacy of iron intake for a menstruating woman consuming a high availability diet - Insuffisance probable de l'apport de fer chez une femme en âge de procréer et ayant un régime alimentaire riche en fer - Probabilidad de insuficiencia del aporte de hierro en una mujer menstruante que consume alimentos con un alto contenido de hierro



Source: Requirements based on FAO/WHO, 1988

Obviously, planners must be concerned with issues of inequitable distribution of per caput food supplies, but this concern need not affect the per caput prescription. What has evolved in recent years is recognition of the absolute importance of defining and estimating the costs of expected activity levels of people in the population. Since these may differ considerably among strata of the population, planners might wish to subdivide the total population into groups that can be considered, and monitored, as distinct entities.

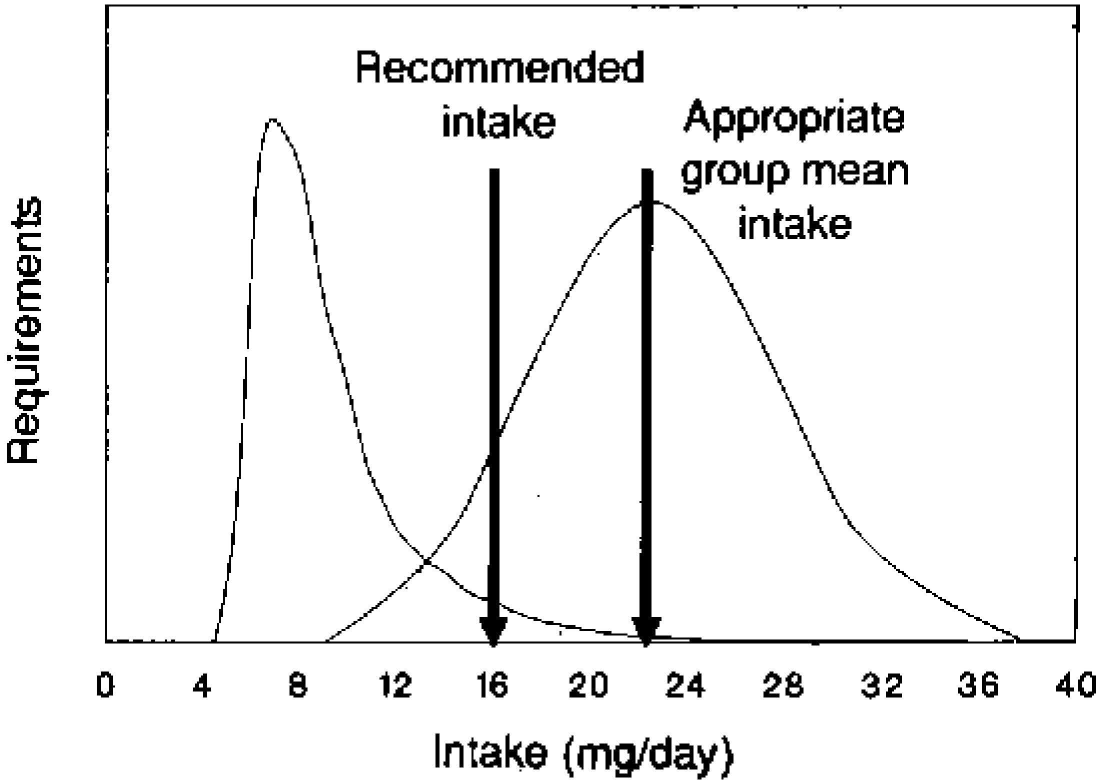
A new and potentially important conceptual approach lies in estimation of food needs to be met if the profile of existing activities is to be changed. This is not to imply that existing intake limits existing activity; that we may not know. Rather it is simply a recognition that if an intervention being undertaken is expected to increase physical activity, as might be the case, for example, in the introduction of incentives for increased production by small farmers in a developing country, there will be an associated increase in energy requirements which, if not met, could limit achievement of programme goals. We have the knowledge to predict the general energy costs of incremental activities; thus, if the planner can describe the expected change in activity profile, an energy prescription as a programme corequisite can be provided.

There are then acceptable and tested prescriptive approaches for application of energy requirements to populations and groups. The same cannot be said for application to a particular individual. At best we can describe the mean requirement of a group of similar individuals. The true desirable intake for a particular individual might fall in a range of 75 to

125 percent of that. Conversely, the energy cost of a change in activity of the individual can be estimated.

The situation is reversed for nutrients. Here there are published numbers that, in effect, anticipate prescriptive applications to the individual. That is, the "recommended intake" or "safe level of intake" found in most requirement reports is the level of intake that meets or exceeds the actual requirement of most individuals in the specified class. As such it is a level of intake that conveys very low risk of inadequacy for the particular individual and hence can be safely "prescribed" for the normal healthy individual (Fig, 4 presented an example based on protein requirements; Fig. 7 provides an example based on iron requirements of menstruating women, a highly skewed requirement distribution). This assumes that there are no detrimental effects of excess in this range. (This is not the assumption for energy, where detrimental effects are attributed to levels falling below or above actual need.) For most nutrients, detrimental effects are seen, in healthy individuals, only at appreciably higher levels. The FAO/WHO/UNU (1985) group put forward the notion of a "safe range of intakes" - a range in which the individual's intake was neither so low as to engender risk of inadequacy nor so high as to encounter risk of "toxicity". The report noted that while much attention had been directed toward defining the requirement distribution and hence the risk curve for inadequate intakes, relatively little attention had been directed toward the curve defining risks of excess.

Fig. 8 - Low-risk iron intake distribution lor menstruating women consuming a high availability diet. - Distribution de l'apport de fer à faible risque chez les femmes en âge de procréer et ayant un régime alimentaire riche en fer - Distribución de bajo riesgo del aporte de hierro en mujeres menstruantes que consumen alimentos con un alto contenido de hierro



Source: Requirements based on FAO/WHO, 1988

The FAO/WHO committees considering nutrient requirements initially offered misleading advice on application of nutrient requirement estimates to populations. In essence, the early FAO/WHO reports (e.g. FAO/WHO, 1962, 1965a, 1965b) followed approaches adopted for energy and described the development of a per caput requirement estimate for nutrients, a weighted average of the recommended intakes for individuals. This ignored issues of distribution of intake. That approach was challenged in the first report on iron requirements (FAO/WHO, 1970) and was explored further by the Joint FAO/WHO Expert Committee (FAO/WHO, 1971). In the words of a United Kingdom report (Department of Health and Social Security, 1979) what was wanted for population prescriptive planning application was "the average amount of the nutrient which should be provided per head in a group of people if the needs of practically all members of the group are to be met". This involves a joint consideration of the distributions of intakes and of needs among individuals.

It was not until a committee met to consider human trace element requirements (FAO/WHO/IAEA, 1992) that this joint consideration was actually attempted for nutrients. The committee had to estimate an expected distribution of intakes. With that estimate in hand, it then asked how far above the mean requirement the mean intake of a group of individuals, e.g. young adult men, would have to be before the prevalence of inadequate intakes, or the "population risk", could be considered acceptably low. Conceptual foundations had been put in place in the earlier paper by Lorstad (1971), working in FAO, and by the United States National Research Council report (1986). In essence, for nutrients for which the requirement distribution is believed to be reasonably. symmetrical, the rule of thumb is that group mean intake should be about two standard deviations *of intake* above the average requirement. This may be contrasted with the previously reported "recommended intake" or "safe level of intake" which in recent years has been set as two standard deviations *of requirement* above the average of individual requirements. Figure 4 portrayed the resulting positioning of the appropriate distribution of protein intakes of adult men, (Prevalence of inadequate intakes, or population risk, would be about 2 percent in that portrayal,) Since the variability of intake is generally much higher than the variability of requirement, the new group mean estimates are higher than the former recommended intakes.[3]

[3] This may be illustrated for protein requirements of adult men. The average requirement has been estimated as 0.6 g egg or milk protein per kg body weight per day, and the coefficient of variation (CV) of the requirement as 12.5 percent. This leads to a "recommended" or "safe" level of intake of about 0.75 g per kg per day (FAO/WHO/UNU, 1985). In North American studies, the variability of usual intake among adult men appears to have a CV of about 20 to 25 percent. Using the higher estimate, the group mean intake that would be consistent with a prevalence of individuals with intakes below their own (unknown) requirements would be (2 x 0.25 x mean intake) above the average requirement of 0.6. This can be rearranged algebraically to yield an estimate that the lowest acceptable group mean intake would be (average requirement x1/ 0.5) = (2 x average requirement) or about 1.2 g per kg per day. If the lower estimate of the variability of intake in the group (CV = 20 percent) were accepted, the necessary group mean intake would also be lower (1.67 x average requirement or about 1 g per kg per day).

With a highly skewed requirement distribution, such as that for iron in menstruating women, the task of identifying a low-risk population intake distribution is more difficult but not impossible. Fig. 8 portrays the requirement distribution and the low-risk population intake distribution, (Predicted prevalence of intakes inadequate to meet basal requirements is 2 to 3 percent.) The approach embodied in the FAO/WHO/IAEA (1992) report is still applicable only to population strata (adult men, adult women, etc.). To address total populations, one must still deal with distributional issues across these strata, which is the problem that had been raised in the Eighth Report of the Joint FAO/WHO Expert Committee (FAO/WHO, 1971).

The developments of the last 20 years have at long last provided a consistent set of conceptual frameworks for both the development and application of human requirement estimates. It may take another decade or more before they are widely understood and accepted, and still longer before they are widely adopted in practice. The UN agencies can influence this course by themselves adopting the new constructs and encouraging their wider use.

In the meantime, one can see that many existing applications of human requirement estimates fit into one or another of the classes of application described above. Thus, for example, nutritional standards for institutional feeding or for design of complete meal packages are both prescriptive applications; the first relates to population groups and the latter relates to individuals.

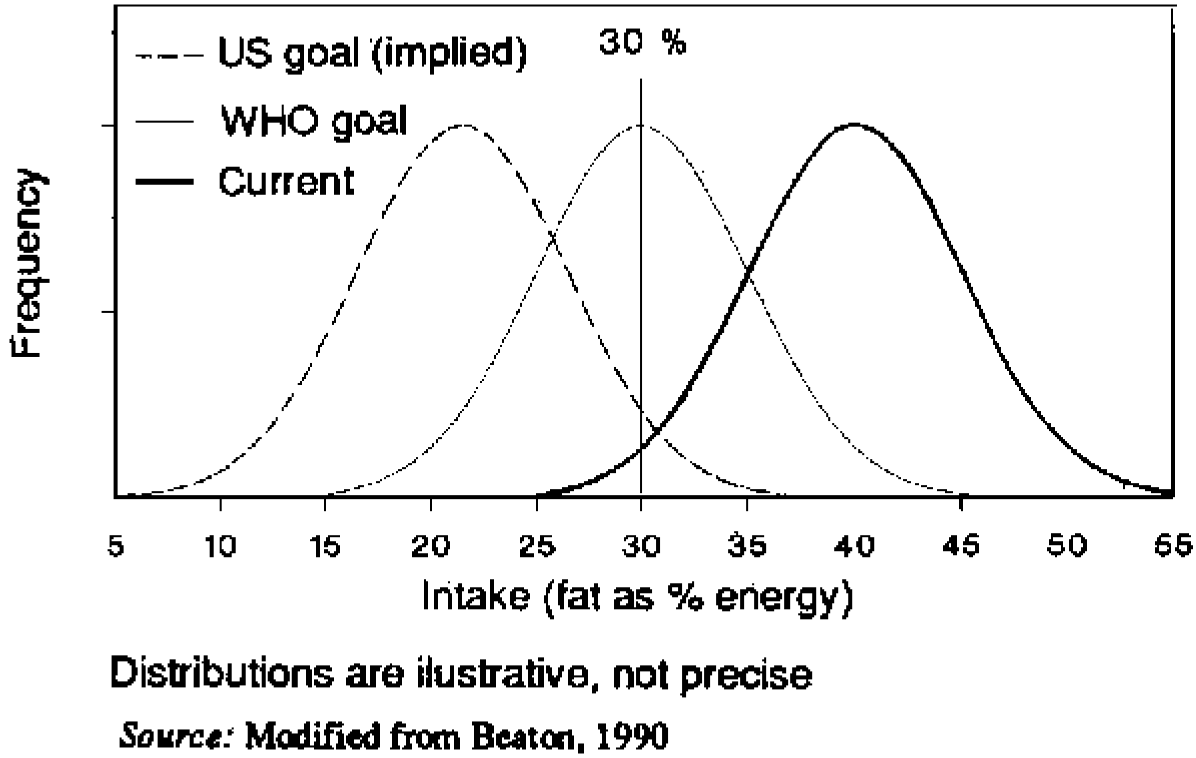
DIETARY GOALS: A NEW DEVELOPMENT

The foregoing has addressed the development and application of nutrient requirement estimates. By and large we have thought of requirements as levels of intake that can be related to defined human functions. For example, protein requirements are currently based on maintenance of nitrogen balance, and iron requirements are based on maintenance of haematopoiesis or of iron storage. However, with the accumulation of epidemiologic evidence relating diet and non-communicable diseases (e.g. WHO, 1990; National Research Council, 1989a), there has been an obvious need to offer statements of the level of nutrient intakes seen as desirable as well as levels we can tie to specific functions of the nutrient. There is a need also to respect existing food preferences and practices where these are not judged to be detrimental or seen to prevent achievement of another goal.

Hegsted (1975) issued a plea for the development of two sets of nutrient "recommendations", one based on requirement estimates and describing actual needs, and the other attempting to describe desirable dietary practices. Thus, although protein intakes appear to exceed protein requirements in most populations of the world, no one would suggest lowering existing intakes to the requirement level; there would be no advantage in doing so. It is a matter of intellectual curiosity that we have "recommended" a level of protein intake (the mean requirement plus two standard deviations of requirement) that few, if any, would advocate. In the FAO/WHO (1973) report, the terminology was changed to "safe level of intake" to circumvent this issue; but the new term creates problems for those in the field of toxicology.

Dietary fat intake is an example of a nutrient about which there is existing concern. Nutrient requirement reports have. addressed requirements for essential fatty acids, but they have not addressed requirements for fat or carbohydrate. Many have discussed the advantages of at least minimal amounts of fat in the diet in terms of facilitation of absorption of fat-soluble vitamins, supply of essential fatty acids and provision of energy densities consistent with ingestion of sufficient volume of food to meet energy needs (a perceived problem in very young children in some developing countries with low-fat, high-carbohydrate, bulky weaning foods). In addition, many reports have discussed the apparent disadvantages of diets high in fat in relation to cardiovascular disease and some types of cancer. A WHO committee (1990) reviewed the epidemiologic and experimental evidence relating population dietary composition and population incidence of non-communicable diseases and offered recommendations on population nutrient goals for fat (and saturated and polyunsaturated fatty acids), total carbohydrate (and complex carbohydrates and free sugars), protein, dietary fibre, fruits and vegetables (as sources of chemical constituents seen as beneficial) and salt. These recommendations were not set forth as requirement estimates. Rather, the report attempted to describe ranges of population mean intakes, often expressed as ratios to energy intakes, that were seen as being consistent with good health. For dietary components such as total fat, there appears to be a growing consensus about desirable concentrations in the diet (below 30 percent of energy). Unfortunately the consensus is less real than the simple numeric statements appear to suggest. The WHO (1990) report was explicit in referring its recommendations to the population mean intake. A recent United States report (National Research Council, 1989b) was equally explicit in suggesting that it is the intakes of individuals that should be below 30 percent, implying a substantially lower population mean intake (see Fig. 9).

***Fig. 9 - Comparison of goals for fat intake* (*existing and implied distributions*) *- Comparaison des apports recommandés de lipides - Comparación entre los objetivos recomendados en relación con el aporte de grasas* (*distribución existente e implícita*)**



Thus, we face some of the same issues in interpreting and applying the new dietary goals as have been discussed for nutrient requirements.

Perhaps an even greater confusion exists for nutrients that may have definable requirement estimates but are now being given quite different numeric recommendations in statements of dietary goals. Ascorbic acid is a case in point. We deal with it as a vitamin in requirement estimates, but when we address it in dietary goals we deal with it as a chemical having potentially beneficial properties in enhancing iron absorption and possibly influencing the action of other chemicals that initiate or promote cancer development. Thus a desirable level of intake may well be in excess of estimated requirements. A similar although even more complicated picture holds for vitamin A. Again in requirement reports its biological functions as a vitamin have been the focus. However, epidemiologic studies suggest that b-carotene, a precursor of vitamin A, or other carotenoids may have beneficial effects at higher levels of ingestion than inferred from vitamin A requirement estimates. Debate over how to deal with numeric recommendations for these two nutrients was in large part responsible for the refusal of the United States Food and Nutrition Board to accept and publish the report of its Recommended Dietary Allowances committee (which attempted to address "requirements"). Instead, the board arranged for preparation of a revised report which was eventually published (National Research Council, 1989a). In the meantime, an FAO/WHO (1988) committee published vitamin A requirement estimates that were consistent with, or slightly lower than, those that had proven to be controversial in the United States. This is cited as an example of the sort of issue that arises if committees are not careful to define what is meant ("requirement for what?") and if we confound the development of requirement estimates and the development of what are now being termed "dietary goals".

Such confusion is not necessary if users can understand and carefully interpret the emerging reports. There need be no contradiction between statements of requirements for vitamin A and dietary goals for vitamin A-rich foods as long as it is recognized that the goals should at least meet requirements but may also address other factors that argue for higher desirable intakes.

FUTURE CHALLENGES

The major challenge of the future is simply to promote understanding of what is already known. It behooves both international and national agencies to give as much attention to explaining appropriate and inappropriate uses of requirement reports as has been given to the development of those reports. That may imply also some structural changes in the format of information provided in the requirement reports, with much more emphasis to be placed on description of the mean requirement and likely distribution rather than just the "recommended intake". By trying to keep things simple we have done serious disservice. The applications of human nutrient requirement estimates are not simple!

Two specific types of application of requirements warrant further mention since they do not fall easily into the categories described above. Both involve the use of requirement estimates as reference points in the description of food quality.

The first is the development of nutrient: energy ratios. The implicit question is: "What concentration of nutrient in this food/this diet would serve to ensure that nutrient needs are met if the food/diet is consumed to satiation of energy needs?" Two distributions are involved here, the distribution of nutrient requirements and the distribution of energy requirements. This was discussed and appropriate statistical approaches were described in the FAO/WHO/UNU (1985) report on energy and protein requirements. However, nutrient: energy reference points are most often calculated as the simple ratio of the published nutrient requirement (generally the mean plus two standard deviations) divided by the published energy requirement for the same class of individual (the group mean). This is illogical. We know how to correct this error and, where there is a specific application for a nutrient: energy ratio, we now know how we should approach derivation of the distribution of protein: energy requirements. An example of an unusual application is found in an "epidemiologic" evaluation of infant protein requirements (Beaton and Chery, 1988).

The second, still unresolved, application of nutrient requirement estimates is as a reference point in food labelling (e.g. FAO/WHO/Ministry of Trade and Industry, Finland, 1988). The problem here is that for this application to be effective there must be a consistent conceptual framework for the approach used in labelling and the approach used in consumer education. It would be nice if there were also conceptual consistency between the labelling approach and the requirement estimates used as reference points. It is probably of minimal meaning to a consumer to state that a serving of a particular food provides x, y and z percent of the recommended intakes for nutrients A, B and C (extending that list to ten or more nutrients). The statement may be factually correct, but does it really help the consumer select foods for inclusion in a diet? The problem is exacerbated by the fact that only one reference standard can be used for labelling (e.g. recommended intakes for adult men or for some hypothetical average person), regardless of the age, sex and physiologic state of the consumer, except for those very few foods that are specifically intended for infant use and allow application of target-specific requirement estimates.

We do not conceptualize nutrient requirements in terms of single foods (except when that "food" is a formulated diet replacement). Rather we address the composition of the total mixed diet. Such a diet usually includes food items that may be low in one nutrient and perhaps high in another. How should the consumer interpret label declarations that show exactly that and little more? In the opinion of this writer, no one, to date, has devised a truly effective procedure for nutrient labelling. That remains a challenge for the future. Resolution of that challenge will draw on skills and experiences that go far beyond biology and statistics and enter deeply into the social sciences concerned with consumer behaviour and consumer use of information.

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