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Trace element requirements and DRVs

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The Panel on Dietary Reference Values (DRVs) of the Committee on Medical Aspects of Food Policy (COMA) has completed its review of the current Recommended Daily Amounts (RDAs) of food energy and nutrients for groups of people in the United Kingdom which were set in 1979. The Panel has chosen to make fundamental changes in the nomenclature and derivation of RDAs by trying to set not one recommended level of intake, which is open to misunderstanding and has been misused in the past, but by defining a range of reference values for each nutrient. The history of the evolution of RDAs in the UK is described along with the main reasons which led COMA to convene this Panel to review them and the options which were available. The definitions of the new DRVs are given, comprising lower reference nutrient intake (LNRI), estimated average requirement (EAR) and reference nutrient intake (RNI). A description of how requirements for nutrients have been judged by the Panel in order to set each of these three new proposed reference values is given. The possible interpretations and uses of these new DRVs are also described.

INTRODUCTION

Historical background

The UK Recommended Daily Amounts (RDAs) of energy and nutrients have a long history. Following World War II, when nutritional aspects of the national food policy were based on the then unpublished US RDAs, the British Medical Association (BMA) decided to review the adequacy of the wartime and postwar diet. Their report included the first recommended allowances from Britain for a number of the essential nutrients (BMA, 1950).

By 1967 it had become apparent that a thorough review was necessary. The impetus for action was a formal request from the National Food Survey (NFS) Committee of the Ministry of Agriculture, Fisheries and Food (MAFF), who were concerned that in larger families intakes of calcium and protein were consistently below the BMA's recommendations. The Committee on Medical Aspects of Food Policy (COMA) took on this task and convened a Panel under the chairmanship of Dr Reg. Passmore for the purpose. The Panel's report was published in 1969 (DHSS, 1969), and drew heavily on the then Food and Agriculture Organization (FAO) and World Health Organization (WHO) recommendations for energy, protein, calcium, thiamin, riboflavin and niacin (FAO, 1957; 1962; 1965; 1967).

By 1977 it was clear that these 1969 Recommended Daily Intakes (RDIs) were again ageing rather quickly, and COMA set about reviewing them once more. Their conclusions were published in 1979 (DHSS, 1979) and are the current UK recommendations. In fact, the recommendations changed little, and so remain close to those of the FAO/WHO. The nutrients for which the UK now has RDAs are shown in Table 1. These are almost the same as those of the BMA in 1950 and of COMA in 1969, but it is perhaps more illuminating to show the 13 extra minerals and seven extra vitamins for which a US RDA has been set (National Research Council, 1989) but for which there is no UK RDA (Table 2). It should be emphasised that the restricted list for the UK is not due to an oversight by COMA, but is the result of different approaches to RDAs in the two countries.

Each of these nutrients was examined, but despite having access to more or less the same information as the American Committee on Dietary Allowances, COMA concluded that no RDAs should be set for them. Their reasoning was as follows: 'Deficiency of these nutrients is either rare, or associated with certain medical conditions, or has not been described or confirmed in man in the United Kingdom. With the exception of Vitamin B_{12} which is found almost entirely in foods of animal origin, these other nutrients occur in

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Table 1. Nutrients for which COMA has set RDA for the UK (DHSS, 1979)

Energy kcal MJ	Vitamin C
Protein	Vitamin A (retinol equivalent)
Thiamin	Vitamin D
Riboflavin	Calcium
Nicotinic acid equivalent	Iron

sufficient quantity in a large number of foods. Therefore in the light of present knowledge and in the context of the United Kingdom diet, RDAs for these nutrients have not been set' (DHSS, 1979).

Table 2. Nutrients for which there are US RDAs but no UK RDAs

US RDAs	
Vitamin E	Phosphorus
Vitamin K	Magnesium
Vitamin B_6	Zinc
Folic acid	Iodine
Vitamin B_{12}	Selenium
US SAFE AND ADEQUATE DAILY INTAKES	
Biotin	Fluoride
Pantothenic acid	Chromium
Copper	Molybdenum
Manganese	

Background to current review

Over the last decade the uses to which RDAs have been put, and the sophistication of the uses, have increased. However, the RDAs did not change. Consequently, a new COMA Panel was set up in 1987 to look at what changes in RDAs, if any, are necessary. Some of the indications for change at this stage are discussed below.

Firstly, it is important for governments, and others, to be able to assess diets throughout the country for the widest possible range of nutrients and other constituents. For some time it has been possible to estimate intakes of many nutrients beyond those in Table 1, either because the standard UK textbook of food composition gives typical values for a number of them (Paul & Southgate, 1978), or because their levels have been measured in the rolling programme of food and diet analysis conducted by MAFF (1988). But the intakes of these minerals and vitamins need to be assessed against some yardstick in order to know what they mean.

Secondly, in many cases UK researchers turn to the 1989 US report for their RDAs. This is not wholly satisfactory because diets and lifestyles are different in the two countries. In particular the philosophical basis of the US RDAs is also very different, which has led to very high recommendations (National Research Council, 1989), such that many people cannot reach some of them without taking supplements. So figures more appropriate for the UK would be very helpful.

Thirdly, even in 1979, and increasingly since then, surveys have shown average intakes of a few nutrients consistently below the 1979 RDAs. In particular the NFS has shown national average intakes of energy and iron below the RDAs. Low iron intakes have also been shown among British schoolgirls by the DHSS survey of schoolchildren's diets (DH, 1989); among young women in the MAFF study of 15–25-year-olds (Bull, 1985); and among British adults (Gregory *et al.*, 1990). It is difficult if Government surveys show that its own recommendations are not being met without appropriate action being taken. However, despite these dietary findings, in the recent Dietary and Nutritional Survey of British Adults, measures of iron status did not correlate with intake. As far as energy is concerned there is a worrying increasing trend in obesity (Gregory *et al.*, 1990). It would be wasteful of resources to plan diets rich in energy and iron if there is no need for them, so it is important for the RDAs to be based on a full assessment of the most recent evidence.

Fourthly, probably the most pressing need for reassessment arises from the Government's plans for food labelling. At present, the regulations do not allow claims for the presence of minerals or vitamins unless a reasonable daily intake of the food provides at least one-sixth of the RDA, nor claims that a food is a rich source unless it provides at least half the RDA. Except for iron, the regulations stipulate the RDA for moderately active men. The UK recommendation for folic acid is still used for such claims despite being deleted by COMA as technically unsatisfactory, and FAO/WHO RDAs are used for vitamin B_{12} and iodine (The Food Labelling Regulations, 1984). Requests for claims to be allowed for other nutrients cannot even be entertained without RDAs for their evaluation.

In addition, MAFF have published voluntary guidelines for the nutrition labelling of foods. Currently, these envisage allowing nutrients to be labelled where a normal serving would provide more than 5 per cent of an RDA, and, in the absence of UK values for so many nutrients, other RDAs have been stipulated. The European Community is harmonising its nutrition labelling, and the Codex RDAs (which are based on the US RDAs) are currently their first choice as a standard. In the absence of well-argued alternatives the use of such high RDAs for this purpose could mean that they would become widely accepted in the UK for other purposes including the evaluation and prescription of diets for which they were not intended and may not be appropriate. This could have a number of disadvantages (Buss, 1986).

Possible approaches

The uses for which RDAs are intended must influence the levels of intakes chosen. A primary use for efficient screening of populations for nutritional deficiencies requires comparatively low RDAs, as does the use in evaluating individuals' diets for possible problems. Also, practical guidelines for the prevention of overt deficiencies may require lower RDAs. Food labelling may require a different approach, but even here, high RDAs can be disadvantageous if they mislead consumers into believing that traditional diets are inadequate should they not provide 100 per cent of a labelling standard. After all, women and children do eat less than men, but it is the adult male RDAs that have traditionally been chosen for labelling.

Yet another approach may be required for RDAs that are meant to be prescriptive. Higher values may be set as targets at which people could aim. In practice, some of these may be difficult to obtain from ordinary mixed diets without supplementation but they have occasionally been proposed as a useful tool in public education.

DEFINITIONS

The Panel on Dietary Reference Values was set up in 1987 by the Committee on Medical Aspects of Food Policy (COMA). The Terms of Reference of the Panel were 'to review the Recommended Daily Amounts (RDAs) for minerals for groups of people in the United Kingdom'. The Panel recognised from the outset that this was such a major task that it could be completed only by the creation of Working Groups to consider various classes of nutrients and to report their considerations and conclusions to the Panel. One of these Working Groups dealt with minerals and it is in the context of minerals and trace elements that the deliberations of the Panel are presented here.

The current definition of the RDA for a nutrient in the UK is in the Report of the Committee on Medical Aspects of Food Policy (DHSS, 1979) and is '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 was framed in an attempt to make it clear that the amounts referred to are averages for a group of people and not amounts which individuals must consume. In the earlier report published by COMA (DHSS, 1969) the definition of Recommended Daily Intakes (RDIs) was 'the amounts sufficient, or more than sufficient, for the nutritional needs of practically all healthy persons in a population'. The word 'intakes' was used to emphasise that the recommendations related to foods as actually eaten.

In considering the options available this COMA Panel was conscious not only of these differences in UK definitions but also that other countries may use yet other different definitions. The Panel was, however, aware of the continuing potential for misuse and misinterpretation of any single figure, however defined. To minimise this and to help users to interpret dietary information on both groups and individuals the Panel decided to try to set a range of intakes based as far as possible on its assessment of the distribution of requirements for each nutrient. The Panel called these various figures Dietary Reference Values (DRVs), in contrast to the RDAs (DHSS, 1979) and the Panel adopted the title of the Panel on Dietary Reference Values.

The Panel considered that this change in approach and nomenclature would reduce the chance of misunderstanding the true nature of the figures as estimates of reference values not as *recommendations* for intakes by individuals or groups. These reference values can be deployed in a variety of ways, for instance as yardsticks for the assessment of dietary surveys and food supply statistics; to provide guidance on appropriate dietary composition and meal provision; or for food labelling purposes. The appropriate DRV varies with the purpose for which it is intended. The Panel was strongly of the opinion that all the values should be closely related to the biological parameters used to derive the figures. These values can also be used as the basis for recommendations in a number of areas in which the Panel had no specific expertise, e.g. agriculture, economics and sociology, which require the use not only of the reference values but of other sets of knowledge and judgements as well.

REQUIREMENTS

Requirements for a nutrient differ from one individual to another and may also change with alterations in the composition and nature of the diet as a whole, because such alterations may affect the efficiency with which nutrients are absorbed and/or utilized. Classically the requirement of an individual for a nutrient has been the amount of that nutrient required to prevent clinical signs of deficiency. While this must always be an important element in defining a requirement, it could be argued that societies should expect more than the basic need to avoid deficiency, and that some allowance should be made, where appropriate, for a degree of storage of the nutrient to allow for periods of low intake or high demand without detriment to health. Claims have also been made that at very high levels of intake some nutrients have especially beneficial or therapeutic effects but the Panel decided that these effects did not fall within their definition of requirement. The Panel did, however, try to give guidance on possible adverse effects of very high intakes.

The information from which estimates of requirements are made can be categorised as follows:

(a) the intakes of a nutrient needed to maintain a given circulating level or degree of enzyme saturation or tissue concentration;
(b) the intakes of a nutrient by individuals and by groups which are associated with the absence of any signs of deficiency diseases;
(c) the intakes of a nutrient needed to maintain balance noting that the period over which such balance needs to be measured differs for different nutrients, and between individuals;
(d) the intakes of a nutrient needed to cure clinical signs of deficiency;
(e) the intakes of a nutrient associated with an appropriate biological marker of nutritional adequacy.

The Panel found no single criterion to define requirements for all nutrients. Some nutrients may have a variety of physiological effects at different levels of intake. Which of these effects should form the parameter of adequacy is therefore to some extent arbitrary. For each nutrient the particular parameter which was used to define adequacy is specified in the Report. None of these criteria is perfect, but they were judged to be the best available on which to base DRVs so that they were relevant to prevailing circumstances. In some cases the evidence on which they were based was reliable experimental data, in others it was from associations, often epidemiological, and in others evidence may be limited to anecdotal data of variable persuasiveness.

Although information is usually inadequate to calculate the precise distribution of requirements for a nutrient in a group of individuals, it has been assumed to be normally distributed (Fig. 1). This gives a notional mean requirement or Estimated Average Requirement (EAR) with the inter-individual variability in requirements resulting in the distribution curve illustrated in Fig. 1. The Panel has defined the Reference Nutrient Intake (RNI) as point 'c' in the distribution, that is two notional standard deviations (2SD) above the EAR (point 'b'). Intakes above this amount will almost certainly be adequate. A further value at point 'a', two notional standard deviations (2SD) below the mean—Lower Reference Nutrient Intake (LNRI)—represents the lowest intakes which will meet the needs of some individuals in the group. Intakes below this level are almost certainly inadequate for most individuals.

At higher levels of consumption there may be evidence of undesirable effects. Guidance on such high levels of consumption is to be given in the report. The RNI remains equivalent to the 1969 RDI—that is, the amount sufficient or more than sufficient to meet the nutritional needs of practically all healthy persons in a population (DHSS, 1969), and therefore exceeds the requirements of most.

By setting the RNI at a notional +2 SD above the EAR the Panel were aware that this might, in theory, be perceived as leaving up to 2·5 per cent of the population inadequately provided for, but considered that this was unlikely to be so in practice. The estimates were based to some extent on dietary data and in any population choosing spontaneous diets it is likely that while the distribution stays roughly the same, the individuals comprising the extremes will vary, so that consistent intakes at the extremes are unlikely. Information is not usually available to determine the mean and SD with such precision and in such circumstances the Panel has chosen an intake that, as far as can be ascertained, is adequate for everyone. The risk of 2·5 per cent of the population not being adequately supplied by the RNI is therefore considered very remote.

For most nutrients the Panel found insufficient data to establish any of these DRVs with great confidence.

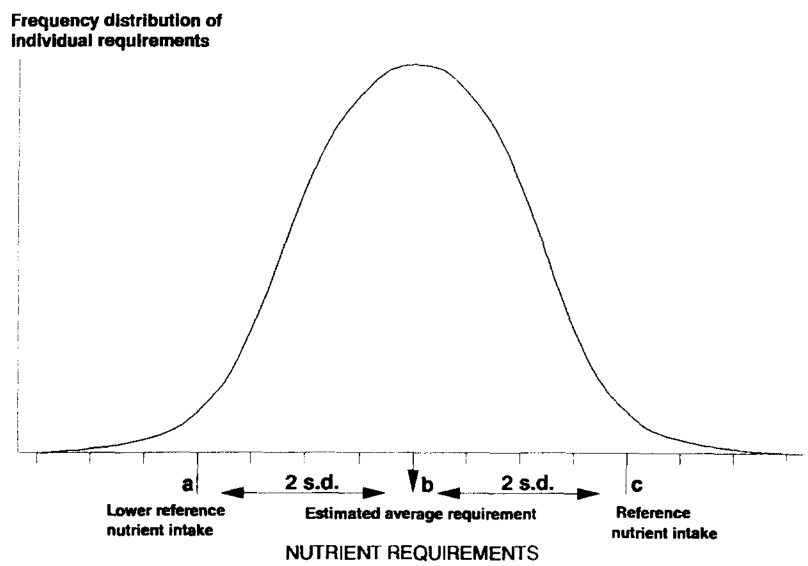

Fig. 1. Dietary reference values—definitions.

There are inherent errors in some of the data, for instance in individuals' reports of their food intake, and the day-to-day variation in nutrient intakes also complicates interpretation. Even given complete accuracy of a dietary record, its relation to habitual intake remains uncertain, however long the recording period. The food composition tables normally used to determine nutrient intake from dietary records contain a number of assumptions and imperfections. Furthermore, there is uncertainty about the relevance of many biological markers, such as serum concentrations of a nutrient, as evidence of an individual's 'status' for that nutrient. Thus uncertainties relating to the appropriate parameter by which to assess the requirement, to the completeness of the database for any nutrient, and to the precision and accuracy of dietary intake data lead to the need to make judgements on which to base recommendations.

Equally, when nutrient intakes are measured there is demonstrable inter-individual variation which is not necessarily related to the variation in requirements. Figure 2 demonstrates a distribution of intakes identical to the distribution of requirements where any individual's intake is not necessarily the same as his own requirement. An individual whose intake is at point 'a'—the LRNI—may be meeting his requirements for a nutrient, but it is highly probable that he is not. Similarly it is just possible, but very improbable, that an individual consuming a nutrient at point 'c'—the RNI—will be consuming insufficient amounts of that nutrient. Whatever parameter is used, the risk of deficiency in an individual at a given intake will vary from virtually zero at point 'c' to virtually 100 per cent at point 'a'. However no individual can determine whether they are deficient or not by measuring only their nutrient intakes, for without physiological or biochemical measures of their nutritional status, they cannot know whether their intake meets their own requirements.

If the distribution of intakes of a group of individuals is identical to that of their requirements for a nutrient it is probable that some with lower intakes will have higher requirements and *vice versa*. If there is no correlation between intakes and requirements in a group then an average intake equal to the EAR carries a substantial risk of deficiency in the group represented by the upper dotted line depicting risk (Fig. 2). In order to avoid this risk completely, the distribution of intakes in the group would have to be such that the lowest intakes exceeded the highest requirements. If, as is likely however, there is some correlation between intakes and requirements, then the higher that correlation the lower the risk. In fact, there may be relationships between intake and requirements on the basis of body size, which in part determines energy requirements and therefore energy (and food) intakes. The degree to which this occurs is not known. Furthermore, apparent requirements of individuals at prevailing intake levels may not represent basic requirements. The lower dotted line in Fig. 2 represents the Panel's assessment of the actual risk of deficiency in a group, taking account of these factors. If intake by an individual falls below the usual intake, there may be adaptive mechanisms which reduce the risk of deficiency but which may not be fully effective until a period of time has elapsed. This effect varies between different nutrients.

The RNIs apply to groups of healthy people and are not necessarily appropriate for those with different needs arising from disease, such as infections, disorders of the gastro-intestinal tract or metabolic abnormalities. The RNI for any one nutrient presupposes that those for energy and all other nutrients are fully met. The RNIs relate to the amounts actually consumed so

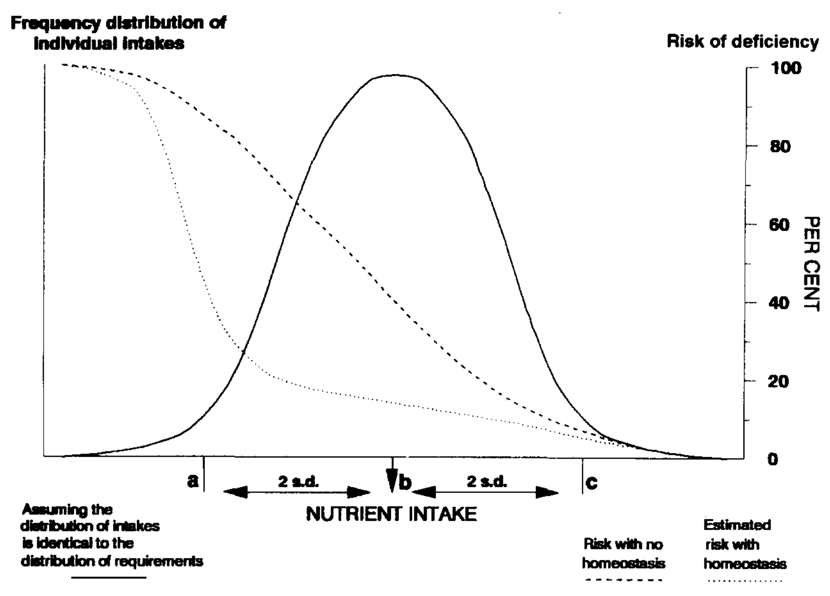

Fig. 2. Dietary intakes and risk of deficiency.

that when using the values allowance should be made for wastage that occurs in the food chain and during domestic processing and cooking.

THE USE OF DRVs

There are a number of potential uses of Dietary Reference Values (DRVs). For any particular use, one or other DRVs may be appropriate.

For assessing diets of individuals

The imprecision both of most estimates of individuals' nutrient intake and nutritional status, and thus of the estimation of the DRVs themselves means that utmost caution should be exercised in applying the figures to the interpretation (or assessment) of individual diets. Even with a perfect measure of an individual's habitual intake of a nutrient (a difficult goal), the DRVs can give no more than a guide to the adequacy of the diet for that individual.

If the habitual intake is below the LNRI, it is likely that that individual will not be consuming enough of the nutrient to maintain the function selected by the Panel as an appropriate parameter of nutritional status for that nutrient, and further investigation, including biological measures, may be appropriate.

If the intake is above the RNI, then it is extremely unlikely that the individual will not be consuming sufficient.

If the intake lies between the two, then the chances of the diet being inadequate (in respect of the chosen functional parameter for any nutrient) fall as the intake approaches the RNI (Fig. 2). Thus it is impossible to say with any certainty whether an individual's nutrient intake, if it lies between the LRNI and the RNI, is or is not adequate, without some biological measure in that individual.

For assessing diets of groups of individuals

When measures of individual diets are aggregated, one of the sources of imprecision is attenuated—that is intra-individual day-to-day variability. Assuming that the inter-individual variability is random, then in a sufficiently large group, this source of imprecision is also diminished. Thus the group intake will more precisely represent the habitual group mean intake then any of the individual measures will represent habitual individual intakes.

If the dietary data are robust enough, some information on percentiles of intake may be available. Thus it may be possible to say 'X per cent of the group had intakes below the RNI'. If X is zero then the risk of deficiency in the whole group is extremely small. As X increases further so the risk of deficiency in the group increases. If the data allow only the calculation of a mean or median intake for a group (as in the NFS), then, because of the nature of the relationship between intake and risk of deficiency, an average (or median) intake equal to the RNI can be taken to represent a very small risk of deficiency in that group.

For prescribing diets or provision of food supplies

When prescribing diets, the intention is to ensure adequacy of the diet. In this situation it is prudent to prescribe diets containing nutrients at the RNI—so that, if eaten, the risk of deficiency would be very small in any individual. In this circumstance, almost all individuals receiving such diets will consume in excess (sometimes considerably so) of their requirements. The same principles can be applied to provision of food supplies to institutes, nations etc.

For labelling purposes

National RDAs or RDIs have been used as a basis for providing information on nutrient contents of foods on their labels. This has the advantage of giving a useful denominator, which would seem to be easily understood by individuals who might otherwise be unable to interpret the information on nutrient content of food. For instance, the public may find it more valuable to know that a food contains X per cent of the RDA/RDI than Y mg in 100 g of the food.

However, as RDA/RDIs have usually been set at the upper end of the range of requirements, individuals might misinterpret information given in this form to imply that the RDA/RDI was equal to that requirement or to the average requirement for a nutrient, when in fact it is, with the exception of energy (which is not given on food labels in this form), always in excess of that.

The range of DRVs presented offers an opportunity to escape from this dilemma at least for some nutrients. The advantages of a system based on labelling with the EAR would be to maintain comparability between foods and provide a standard presentation. EARs for different ages and sexes can be used for different foods according to the likely consumers—at least for baby foods. In addition consumers would interpret the EAR as just that, and therefore unnecessary attempts to reach consumption levels certain to be in excess of requirements would not be provoked.

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