NUTRITION

Suggested Guide for Interpreting Dietary and Biochemical Data

INTERDEPARTMENTAL COMMITTEE on NUTRITION for NATIONAL DEFENSE

These provisional standards were submitted by the Committee of Consultants to the Interdepartmental Committee on Nutrition for National Defense and were accepted by the committee. The standards were arrived at after long consideration and a pooling of the experience and knowledge of the consultants. This guide merely indicates the extensive evidence upon which the standards are based.

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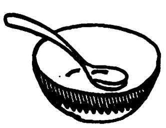

Three procedures of value in surveys to assess the nutritional status of a population are clinical assessment, biochemical studies of blood and urine, and collection of dietary information. The conduct of surveys presupposes the availability of some standards of reference for interpreting the results obtained. With the initiation by the Interdepartmental Committee on Nutrition for National Defense (ICNND) of a program of nutrition surveys it was essential to define some tentative standards for use in assessing the data in terms indicative of the practical significance of the observations. Although evaluation of the dietary and biochemical data only is considered in this paper, it is evident that all three methods are necessary for a logical overall evaluation of a particular situation. Major disagreements among the three approaches, if consistently found in population groups (as opposed to individuals) and if not explained by recent changes in dietary intakes, must be regarded as a strong indication of error in the assessment.

The Recommended Dietary Allowances of the National Research Council Food and Nutrition Board (*1*) or the somewhat similar standards proposed by other official bodies, such as the Canadian Council on Nutrition (*2*) and the British Medical Association (*3*), often have been employed in the evaluation of dietary surveys in this country as well as in other parts of the world. As indicated by the statement of the Food and Nutrition Board, "The allowances are designed to maintain good nutrition in healthy persons in the United States." They were not designed as standards for assessing survey results. They are not necessarily applicable to situations of stringency or limited food supply. Since the latter conditions are likely to exist in many situations, it is evident that use of the NRC allowances in assessing nutritional adequacy is unrealistic and impracticable. It is the aim of this paper to present provisional standards for use in interpreting nutrition surveys made by the methods detailed by the ICNND in its Manual for Nutrition Surveys. This purpose is quite different from that of the standards referred to previously.

A major difficulty in attempts to utilize the NRC recommended allowances in the assessment of dietary information is that they are not uniformly related to minimal needs. For example, it would probably be generally agreed that intakes of only 50 percent of the allowances for ascorbic acid, iron, and calcium in adult men have entirely different implications than do similarly low intakes of thiamine, riboflavin, protein, or calories. Thus the commonly used method of reporting the proportion of the population consuming 50, 75, and 100 percent or some other arbitrary division of the allowances does not determine the relative severity of the inadequacies in the diet.

In many situations where resources are limited the most useful service a nutrition survey can make is to point to the critical nutritional areas in which large gains in health and efficiency can be obtained. It is obvious that correction of problems in these areas should be attacked before efforts are made to provide the less urgent benefits which might be obtained from other dietary changes. A cogent example would be the consistent finding in practically any area of the world, including the United States, that, relative to the NRC recommended allowances, calcium is a "principal deficiency." Since this so-called "deficiency" is not demonstrable in measurable terms of health, and no benefit to man of an increased calcium intake has as yet been conclusively demonstrated, it is doubtful whether specific efforts are justified in most regions to meet the supposed deficit. Rather, efforts and expenditures should be directed to more tangible problems.

Undoubtedly many individuals will consider the proposal that intakes which are much below the NRC recommended allowances are "acceptable" as a weakening of the nutritional baseline. We do not believe this to be true. Nutritional research has increasingly emphasized the importance of obesity, atherosclerosis, and other degenerative diseases, and is placing suspicion upon overnutrition of various kinds. It may be noted that many of the less abundantly fed populations are relatively free of those diseases which are a major cause of death in the United States. Optimum nutrition is undoubtedly obtained by an intake of neither too little nor too much of each specific nutrient. Although no attempt has been made in this report to set the upper limits on desirable intakes, this consideration should receive increasing emphasis in the future. The present standards have regarded "adequacy" as above the level at which objective evidence of health improvement does not occur. The standards in this guide are an attempt at an objective evaluation of the data currently available as derived from clinical, experimental, and epidemiological evidence.

The term "high" is used in these standards in the sense of high for the prevention of recognizable clinical deficiencies or definite biochemical evidence of deficiency. Good or satisfactory would be advocated by many to replace this term. Nutrient consumption and biochemical values in the high range will be found in many countries which enjoy a high level of health and productivity. However, the precise health advantages which attend these high levels are the subject of much difference of opinion and little conclusive evidence. There is no implication that intakes in this range are sufficiently high to be detrimental.

The dietary intakes, blood content, or urinary excretion levels designated as "deficient" are those which may be expected to be associated

Goldberger Award to Vilter

The 1960 Joseph Goldberger Award for outstanding work in nutrition was awarded to Dr. Richard W. Vilter, professor of medicine, Cincinnati College of Medicine. Dr. Vilter led a World Health Organization survey of the causes of anemia and nutritional deficiency diseases in Egypt in 1954, and made a similar study in Guatemala and Panama in 1955 at the request of the Pan American Sanitary Bureau.

with definite, although not necessarily severe, physical impairment due to insufficiency of a nutrient in a measurable proportion of individuals. It is recognized that there are probably substantial quantitative differences in the nutritional requirements of individuals. These differences, combined with the errors of sampling and of laboratory determination and the substantial differences among physicians in the appraisal of various physical abnormalities, may be expected to prevent a high correlation between the dietary, biochemical, and clinical evaluation of individuals. Repeated study by all three methods should tend to eliminate such discrepancies. If the various standards proposed are realistic, there should be a measure of agreement of the three methods when applied to population groups over reasonable periods of time.

It should be emphasized that these guidelines are proposed for the express purpose of evaluating and interpreting dietaries in relation to nutritive state. Therefore, the purpose is quite different from that of the NRC recommended allowances in some instances.

Dietary Standards

Since the primary interest of the Interdepartmental Committee on Nutrition for National Defense was directed toward the nutritional status of the armed forces in various countries, the dietary standards for the interpretation of nutrient intake data were designed to apply to adult males, physically active, with an average height of 67 inches (170 cm.) and weight of 143 pounds (65 kg.) living in a temperate climate and consuming a varied diet. Wherever evidence is available to justify and allow modification because of age, body size, activity, climate, type of food, and other factors, such modifications should be made.

Table 1. Average percentage of nutrients lost during cooking

Food items	Thiamine	Riboflavin	Niacin	Ascorbic acid
Meats	35	20	25	--------
Meats plus drippings	25	5	10	--------
Eggs	25	10	0	--------
Cereals	10	0	10	--------
Legumes	20	0	0	--------
Vegetables—leafy green and yellow	40	25	25	60
Tomatoes	5	5	5	15
Vegetables, other	25	15	25	60
Potatoes	40	25	25	60

Calculations of dietary information collected should make appropriate allowance for nutrient losses during food preparation and storage. Despite recognition that such losses vary depending upon differing preparation and cooking methods in use in different cultures, and that local values should be used whenever they are available and reliable, the values in table 1 were regarded as reasonable approximations in the absence of more specific data. These values have been taken directly from the Army Technical Manual, TM 8-501 (*4*), and represent losses with good cooking practice with U.S. Army ration components.

From the good agreement between calculated values for the raw food and analytic values for the cooked food samples from the army messes in most countries surveyed by ICNND, it would appear that cooking losses are not so great as those indicated in table 1. The calculations in the survey reports assume valid values for the composition of the local foods. However, knowledge of nutrient composition is often fragmentary. Additional studies on the composition of raw and cooked foods would usefully extend knowledge basic to evaluation by dietary studies.

Table 2 presents the suggested standards for the evaluation of nutrient intake. Although within the space allotted it is not possible to document fully the reasons for these suggested values, the basic facts are presented for each nutrient.

Thiamine. The minimum need of thiamine may be considered as reasonably well established since studies on animals and man are in essential agreement. Clear-cut evidence of thiamine deficiency has been obtained at levels below 0.2 mg. per 1,000 calories (*5–7*). Epidemiological evidence suggests a similar figure (*8*). Evidence of unsaturation is available at intakes of about 0.3 mg. per 1,000 calories (*9*). Although there is good evidence of a relationship between thiamine need and caloric expenditure, it is not entirely clear that this is uniform at all levels of caloric intake. It is accepted that

Table 2. Suggested guide to interpretation of nutrient intake data for physically active young adult males

Nutrient	Deficient	Low	Acceptable	High
Niacin (mg./day)	<5	5–9	10–14	≥15
Riboflavin (mg./day)	<.7	0.7–1.1	1.2–1.4	≥1.5
Thiamine (mg./1,000 calories)	<.2	0.2–0.29	0.3–0.4	≥.5
Ascorbic acid (mg./day)	<10	10–29	30–49	≥50
Vitamin A (I.U./day)	<2,000	2,000–3,499	3,500–4,999	≥5,000
Calcium (gm./day)	<.3	0.30–0.39	0.4–0.7	≥.8
Iron (mg./day)	<6.0	6–8	9–11	≥12
Protein (gm./kg. body weight)	<.5	0.5–0.9	1.0–1.4	≥1.5

fat in the diet spares thiamine, although the data on man do not permit quantitation of the effect. Refinement of the estimate to allow for the thiamine-sparing effect of fat has not been attempted, but its possible importance should not be ignored in the interpretation of data.

Niacin. The requirement for niacin for animals and man is approximately 10 times the thiamine requirement. From the composition of pellagragenic diets Frazier and Friedemann (*10*) estimated 7.5 mg. of niacin per day as a minimum requirement. Pellagra has been produced experimentally on diets very low in tryptophan (200 mg.) which contained about 5 mg. of niacin (*11*). On the other hand, pellagra was not observed with diets supplying similar amounts of niacin when relatively good sources of tryptophan were present (*12*) or in a North Carolina population consuming an average of 5 mg. daily (*13*). Evidence of tissue unsaturation has been found with diets low in tryptophan and containing 8 to 10 mg. of niacin. The kind and amount of dietary protein is thus of importance. Approximately 60 mg. of tryptophan may be considered roughly equivalent to 1 mg. of niacin. The availability of niacin in various foods may also vary (*14*, *15*), and contribute to the well-known epidemiological relationship between corn diets and pellagra.

Riboflavin. Evident signs of riboflavin deficiency have been produced at levels of intake below 0.6 mg. per day, and progressive tissue unsaturation, as measured by urinary excretion, may be noted at levels below 1.1 to 1.3 mg. per day (*16*, *17*). Although on the basis of the known functions of riboflavin one might expect the requirement to be related to caloric expenditure, the evidence is not so convincing as it is with thiamine, and there is some evidence to the contrary. The minimum level of 0.7 mg., listed as "deficient," is somewhat at variance with the data from Formosa (*18*), where there was clinical evidence of deficiency with intakes approximating 0.9 mg. per day and also from some of the data from the ICNND nutrition surveys.

Since there is experimental evidence that the composition of the diet influences the riboflavin requirement in animals and man (*19*, *20*), additional studies under varying environmental conditions are needed. Possibly such factors as exposure to sunlight, availability of riboflavin in foods, and intestinal synthesis may be of importance. It may also be noted that in growing animals the riboflavin requirement appears to be about one and one-half times the thiamine need, a relatively higher level than that indicated here.

Despite these presently recognized uncertainties, it is held that the level adopted is a useful approximation for the interpretation of the practical significance of survey findings.

Ascorbic acid. An intake of 30 mg. per day of ascorbic acid is considered adequate to prevent all evidence of deficiency (*21*, *22*). Whether higher levels are beneficial is controversial (*23*). In view of the lability of ascorbic acid to cooking and storage losses, a somewhat larger allowance above the minimum need than that provided for other nutrients can be justified.

An intake of 10 mg. of ascorbic acid per day will prevent frank scurvy in most adults. The data from six of the first ICNND surveys (*24*) indicate that serum ascorbic acid levels were definitely reduced when the daily dietary intake was in the range of 15 to 23 mg., and they were apparently associated with an increase in gingival pathology.

Vitamin A. A minimum need of 20 International Units of preformed vitamin A or 40 I.U. (24 micrograms) of beta-carotene (one I.U. equals 0.6 micrograms of beta-carotene) per kilogram of body weight per day is indicated. These values yield figures of approximately 1,300 I.U. of vitamin A, or 2,600 I.U. of beta-carotene per man per day. From their studies Hume and Krebs (*25*) estimated that 1,300 I.U. is the approximate requirement of preformed vitamin A in man and that 2,500 I.U. provides a reasonable margin of safety.

Hume and Krebs concluded that 3,000 I.U. is the minimum dose of beta-carotene to meet the vitamin A requirement but considered 7,500 I.U. as a desirable intake because of variability of carotene absorption. It should be noted that, in general, studies on requirements indicate a ratio of activity of vitamin A to carotene of 1 to 4, whereas by usual definition the ratio is 1 to 2. The absorption and utilization of carotene probably falls as its intake is increased. Furthermore, carotene absorption varies from food to food with methods of preparation and is influenced by fat and antioxidant content of the diet and probably other factors. Thus it may be impossible to specify accurately a single value for vitamin A requirements in terms of carotene under various conditions.

The present recommended allowances (*1*) for vitamin A are based on an assumption that the diet will supply approximately one-third of the activity as preformed vitamin A and the remainder as carotene. This is a condition which is not often fulfilled, especially when one is concerned with wide varieties of national and local patterns of diet. Whether further refinements will be useful or can be formulated remains to be seen. We believe that a fairly wide margin between minimal and acceptable levels is justified since, if good sources are available, a high intake is rather easily achieved.

Dietary sources of vitamin A are often seasonal. In view of body storage of this vitamin and the long time required for depletion, an intermittent intake is not necessarily bad, unless intervals of real depletion occur. Intermittent or seasonal intakes may be the most economic method of meeting the needs. On the other hand, this pattern results in a more precarious situation than that of a continuous supply, and, in areas where such seasonal variations exist, definitive studies of vitamin A status are indicated.

Calcium. All data upon which previous calcium allowances are based came from balance studies. It now appears that these are not a reflection of calcium need (*26–28*). In people accustomed to low calcium diets, balance is achieved at levels of intake of 0.3 gm. per day or lower. Since no biochemical test is available to estimate calcium status and the clinical syndrome of calcium deficiency has not been produced experimentally in man, there is no satisfactory means of estimating the minimum need. Epidemiological evidence indicates that people remain in good health and do not demonstrate, insofar as is known, calcium deficiency upon diets containing about 0.3 gm. of calcium per day. No valid means are available for the translation of data from studies upon experimental animals into quantitative human needs. The values for calcium are, therefore, the most tentative of all which have been presented.

Iron. In normal men, the daily iron loss approximates 1 mg. An absorption of approximately 10 percent is ordinarily found, leading to an apparent requirement of 9 to 12 mg. per day (*29*). It should be apparent that such figures may simply be a reflection of the necessary mechanics required to maintain balance in a person consuming about 10 mg. per day. There is evidence that iron is conserved by both decreased excretion and increased absorption as body stores fall. Thus, there appear to be efficient mechanisms for protection against iron deficiency in the normal male, and maintenance of hemoglobin and protection against iron deficiency is found at intakes much below 9 to 12 mg. per day. Due to growth, pregnancy, or periodic iron loss through menstrual bleeding, the situation in children and women may be quite different. There is abundant evidence that iron requirements are increased by infestation with parasites which lead to blood loss. These factors may be important in a military force. Clearly, in male populations evidence of malnutrition due to iron deficiency must come primarily from evidence other than the dietary intake, that is, hematological or biochemical data.

Protein. In normal adults nitrogen balance is readily achieved with high quality protein at approximately 0.3 gm. per kilogram of body weight per day and with many vegetable diets at 0.5 gm. per kilogram of body weight per day (*30*). It should be noted that, contrary to the situation with calcium, balance figures are more meaningful because of the rapid adjustment which the body makes to changes in the protein intake. Nevertheless, the difficulties of interpreting balance studies in terms of health and need are widely recognized. It is also impressive that syndromes typical of protein deficiency are rare in adults even in areas where protein intakes are low by U.S. standards. This is consistent with the fact that a daily intake of 3,000 calories from a cereal source signifies an intake of some 60 gm. or more of protein. Such an intake approaching 1 gm. per kilogram of body weight per day is rather easily achieved provided the calorie intake is sufficiently high.

Calories. The standards for the evaluation of caloric intakes are the same as those of the Food and Nutrition Board of the National Research Council (*1*), which were adapted from the report of the Food and Agriculture Organization Committee (*31*). They have been thoroughly discussed in those publications. Physical activity and needs for temperature maintenance are major factors determining energy needs but are difficult to evaluate. There is evidence that the standards may overestimate the needs of certain groups. The data of Konishi and co-workers (*32*) indicate that in military troops the change in caloric intake was not proportional to the body weight in kilograms raised to the 0.73 power (wt.$^{0.73}$), the base used for estimating need. It is difficult to assess whether the populations upon which standard data have been based are of ideal weight. Furthermore, it is known that there is an adaptation to restricted caloric intake (*33*) both by lowered metabolism and by decreased ability and desire to work. Adjustments are made for age and environmental temperature. The effect of climate depends not only upon the temperature, but also on the amount of exposure, the clothing worn, housing, and other factors.

Because of the grossness of the estimates of these several factors in determining dietary needs, attempts to evaluate the adequacy of caloric intake in a nutrition survey should rest largely upon physical appearance and physical measurements, rather than on the intake data. Military personnel with restricted feeding habits and relatively standardized workloads and environments offer opportunities for extension of studies of these factors.

Biochemical Standards

Urinary excretion. The collection of urine samples over a 24-hour period is virtually impossible in most field studies, and shorter periods of collection are essential if urinary samples are to be obtained. There are three possible baselines for the evaluation of the data: a timed sample, urinary volume, or urinary creatinine. Although the relation of these three parameters to the excretion of vitamins or their metabolites deserves more complete investigation, in one study (*34*) in which they were compared as baselines for riboflavin excretion, urine volume was found to be the least desirable. Timed collections and creatinine excretion were consistent with each other and essentially of equal value. As would be expected, the percentage variability between samples decreased as the volume of the sample increased.

Thus, the most desirable sample should be one collected over the longest period of time. On the other hand, the accuracy of the estimate was not greatly increased by an 8- or 12-hour collection as compared with a 6-hour collection. There is reason to believe that thiamine and N′-methylnicotinamide excretion also follow this general pattern. Under the practical conditions of the field it is often impossible to obtain accurately timed specimens; hence the use of urinary creatinine as a reference base probably assures the most consistently dependable results.

In the interest of practicability the standards presented here were initially formulated for a 6-hour collection period. Ordinarily, the examinees are requested to void urine at midnight, and the morning sample at 6 a.m. is collected. If a timed sample is not obtained, the morning sample representing a reasonably long collection period will be the most suitable and possibly will be less influenced by variations in nutrient intake at meal times. Timed samples have generally proved impractical in the field and most of the data collected on surveys by ICNND teams have been interpreted on the basis of creatinine reference. The values presented in table 3 were based upon an expected creatinine excretion of 1.5 gm. per 24 hours for the "standard" man weighing 65 kg. Studies on the use of casual urine specimens in evaluating excretion rates of thiamine, riboflavin, and N′-methylnicotinamide (*34–36*) demonstrate that this method, although not ideal, is useful in nutrition surveys.

N′-methylnicotinamide. The values in the deficiency range of 0.2 mg. per 6 hours or 0.5 mg. per gram of creatinine are based largely upon the work of Goldsmith and co-workers (*11,37*). Such levels were found in subjects receiving approximately 5 mg. of niacin and 200 mg. of tryptophan daily at the time they developed clinical symptoms of pellagra. At slightly higher tryptophan intakes (250 to 300 mg.) similar levels of excretion have been observed in some subjects without the development of clinical symptoms (*12*).

The excretion of niacin metabolites increases rapidly with intakes above 8 to 10 mg. per day (*11*), and excretions in the acceptable range are compatible with intakes of 12 to 16 mg. per day (*38*) on an average hospital diet (*12*).

Some normal individuals apparently fail to excrete appreciable amounts of N′-methylnicotinamide in the postabsorptive state. Large excretions have been noted in prolonged fasting or muscle wasting. The wide deviations observed in subjects given the same diet in the studies referred to previously should be noted. The interplay of tryptophan and niacin metabolism is well known and a multiplicity of end products result. For practical reasons, surveys in the field are usually limited to a measurement of N′-methylnicotinamide. Analysis for a more extensive series of end products might yield more precise information.

Riboflavin. Extensive studies upon the urinary excretion of riboflavin at different levels of intake are available. Excretions of the order of 50 micrograms (mcg.) per day have been associated with clinical symptoms of deficiency (*16*) and the urinary excretion is about 10 percent of the intake up to an intake of approximately 1.1 mg. per day. Excretion then rises rapidly at higher intakes and may amount to approximately 30 percent of the intake. Thus, excretions between 50 mcg. per day (10 to 12 mcg. per 6 hours) and 120 mcg. per day (30 mcg. per 6 hours) apparently represent unsaturation. Such factors as negative nitrogen balance and physical activity may be associated with variations in excretion. Individual variation in excretion is itself relatively great, as is the variation from sample to sample on the same individual. As has been indicated in the discussion of dietary standards, there is need to determine the applicability of these values to dietary and environmental conditions other than those under which they have been obtained (*37*, *39*).

A word of warning is germane regarding application of these particular standards to nutrition survey data. These levels of riboflavin excretion were derived from a study in which a specific riboflavin method was employed. They cannot legitimately be applied to the interpre-

Table 3. Suggested guide to interpretation of urinary vitamin excretion data for physically active young adult males

Urinary metabolite	Deficient	Low	Acceptable	High
N′-methylnicotinamide:				
mg./6 hours	<0. 2	0. 2–0. 59	0. 6–1. 5	≥1. 6
mg./gm. creatinine	<. 5	0. 5–1. 59	1. 6–4. 2	≥4. 3
Riboflavin:				
mcg./6 hours	<10	10–29	30–99	≥100
mcg./gm. creatinine	<27	27–79	80–269	≥270
Thiamine:				
mcg./6 hours	<10	10–24	25–49	≥50
mcg./gm. creatinine	<27	27–65	66–129	≥130

NOTE. The urinary values are based on an average creatinine coefficient of 23 and a man weighing 65 kg., who would be expected to excrete 1.5 gm. of creatinine per 24 hours.

tation of data obtained by other less specific methods of analysis. This comment applies generally to attempts to apply any of the "standards" which are here proposed; methodological comparability is essential or erroneous conclusions may be drawn. The standards only apply when the appropriate experimental techniques are used.

Thiamine. Thiamine excretion is apparently related linearly to intake except at very low levels, although the curves obtained in different laboratories have not been comparable. The relation to clinical symptoms is less clear. Excretion may also be characteristic of an individual (*37*). Intakes of 0.2 mg. per 1,000 calories have been associated with excretions of 5 to 20 mcg. or less per day (*40*, *41*) and an excretion of 40 mcg. per day with intakes of 0.35 mg. per 1,000 calories (*42*). On the basis of these controlled experiments, the standards for urinary excretion appear somewhat generous relative to the proposed dietary standards for thiamine, but are supported by results from survey data (*43*). Excretions above 100 mcg. per day are not considered to be compatible with deficiency (*44*).

Blood and Serum Analysis

Hemoglobin and hematocrit. According to Wintrobe (*45*), the average hemoglobin value for normal young men should be 16 gm. percent and the corresponding hematocrit should be 47 percent. Values from 14 to 18 gm. percent for hemoglobin and 40 to 54 percent for hematocrit are considered to be within the normal range. Milam and Muench (*46*) found for white adult males in North Carolina average hemoglobin values of 14.25±1.2 gm. percent and 95 percent of the distributions to be between 11.88 and 16.62 gm. per 100 ml. Values for Negroes in the same region were slightly lower. The values in table 4 have been proposed as lower limits based upon these data as obtained from occidental peoples. A correction for the effect of altitude (*47*) is also proposed. Such corrections have been made in hemoglobin data obtained during the ICNND surveys in Ethiopia and in Peru. The occurrence of low hemoglobin levels is not a sufficient criterion for the diagnosis of iron deficiency without further characterization of the anemia. Parasitism must always be considered as a possible factor, and race and altitude may also require consideration.

Women normally have hemoglobin levels 1 to 1.5 gm. lower than men. Children under 14 years also have levels below the levels found in men and these normally vary with age. Pregnant women normally exhibit hemoglobin concentration changes which vary with the different stages of pregnancy. The standards proposed for men do not apply to women and children.

Serum proteins. The values proposed for serum protein levels also represent somewhat arbitrary figures based upon the distribution of serum proteins in normal persons (*48*). In

Table 4. Suggested guide to interpretation of blood data for physically active young adult males

Blood constituent	Deficient	Low	Acceptable	High
Hemoglobin (gm./100 ml.):				
Sea level	<12. 0	12. 0–13. 9	14. 0–14. 9	≥15. 0
5,000 feet (1,500 M.)	<12. 3	12. 3–14. 2	14. 3–15. 5	≥15. 6
12,000 feet (3,700 M.)	<13. 3	13. 3–15. 4	15. 5–17. 1	≥17. 2
14,000 feet (4,500 M.)	<14. 4	14. 4–16. 7	16. 8–18. 9	≥19. 0
Hematocrit (percent):				
Sea level	<36	36–41	42–44	≥45
5,000 feet (1,500 M.)	<38	38–43	44–46	≥47
12,000 feet (3,700 M.)	<42	42–48	49–55	≥56
14,000 feet (4,500 M.)	<46	46–52	53–64	≥65
Total serum protein (gm./100 ml.)	<6. 0	6. 00–6. 39	6. 4–6. 9	≥7. 0
Serum ascorbic acid (mg./100 ml.)	<. 10	0. 10–0. 19	0. 20–0. 30	≥. 40
Serum vitamin A (mcg./100 ml.)	<10	10–19	20–49	≥50
Serum carotene (mcg./100 ml.)	[1]	20–39	40–99	≥100

[1] See discussion of carotene in text under Blood and Serum Analysis.

view of the many factors associated with nutritional edema (*33*) other than the serum protein level, a close correlation with the occurrence of edema cannot be expected. The total serum protein may be normal, but the albumin to globulin ratio may be abnormal because of an elevated globulin (*49,50*). If protein malnutrition is suspected, the measurement of serum albumin is indicated (*51*).

Ascorbic acid. Voluminous data show that the serum ascorbic acid level generally reflects the dietary intake. The absence of measurable ascorbic acid from the serum is compatible with scurvy, but is not diagnostic. Clear-cut evidence of malnutrition or ill health due to lack of ascorbic acid when serum levels are above 0.2 mg. per 100 ml. is lacking (*21–23*). Serum levels of ascorbic acid will stabilize at different intake levels (*52–54*). In view of the wide variations in ascorbic acid content of different samples of the same food and the variable losses in preparation and storage, the serum levels may be considered as more satisfactory evidence of ascorbic acid status than dietary data.

Although one cannot ignore the effect of various kinds of stress such as surgery, trauma, and illness in altering the serum ascorbic acid level, much of this stress effect is due to a concomitant reduction of dietary intake.

Vitamin A. In surveys of presumably well-nourished individuals most serum vitamin A levels are found to fall between 30 and 50 mcg. (100 to 160 I.U.) per 100 ml. with a few values between 20 and 30 mcg. (66 to 100 I.U.) and some above 50 mcg. per 100 ml. of serum (*55*). (One I.U. is equivalent to 0.3 mcg. of vitamin A alcohol, or 0.344 mcg. of vitamin A acetate (*56*).) In controlled studies in which adults were fed a vitamin A-free diet (*25*) the serum levels gradually decreased over many months to approximately 10 to 40 I.U. (3 to 12 mcg.) per 100 ml. It has been stated that evidence of night blindness usually appears when the serum level is between 50 and 66 I.U. (15 and 20 mcg.) per 100 ml. (*55*). However, Hsu (*57*) did not find clinical deficiency signs until the vitamin A serum level reached 6 I.U. per 100 ml. In Indonesia de Hass and co-workers, investigating xerophthalmic infants and children, found serum values of 7.0 to 10.3 I.U. of vitamin A in contrast to values of 12.2 to 26.9 I.U. in similarly aged subjects without xerophthalmia (*58*). Yarbrough and Dann (*59*) studied dark adaptation and blood vitamin A in a nutrition survey in North Carolina and found that although the blood levels ranged from 7 to 101 I.U. per 100 ml., 96.7 percent of their subjects had normal vision. Most workers will probably agree that a level of 50 I.U. (15 mcg.) per 100 ml. represents no serious depletion. It is suggested that a finding of 5 percent or more of the subjects with levels below 33 I.U. (10 mcg.) or 15 percent below 66 I.U. (20 mcg.) per 100 ml. is evidence of vitamin A deficiency in a population.

In view of the considerable storage of this vitamin in the body, the long time required for depletion, and the seasonal distribution of vitamin A food sources which often occurs, little correlation of blood data with dietary studies can be expected in many areas. Considerable reliance must thus be placed upon the biochemical and clinical evidence. More data upon the serum vitamin A levels in areas where vitamin A deficiency is an actual problem are needed.

Carotene. Nutritional status with regard to vitamin A cannot be evaluated from serum carotene levels alone. The level in the serum reflects the recent dietary intake and gives useful information concerning food habits, particularly in areas where the intake of preformed vitamin A is low. The values for serum carotene in well-nourished men fluctuate widely. Gillum and co-workers (*60*) found values which ranged from 25 to 405 mcg. per 100 ml. with a mean value somewhat over 100 mcg. The values proposed are considerably lower than those suggested by Bessey and Lowry (*61*) and Sinclair (*62*), but are similar to those suggested by the data of Williams (*63*) and Clayton (*64*).

Discussion and Conclusion

Most of the data upon which these provisional standards are based have been obtained in the United States and Europe, generally in controlled experiments. The effect of other environmental factors and the possible interrelationships between nutrients are relatively unexplored. It may be expected that data obtained from nutrition surveys in various parts of the world which are assessed by uniform methods will contribute materially in this area. In other words, the application of these provisional standards to survey data provide a practical appraisal of the validity of the standards themselves. No nutrition standards can be considered as final or fixed at this time, and the quantity and quality of the work upon which they are based is variable. Thus, they are considered as working standards with the expectation that they will be modified as the justification becomes apparent.

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NOTE: References to the ICNND Manual for Nutrition Surveys and reports of surveys in each of 12 countries are cited on pages 685–686.

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