THE FOOD AND NUTRITION SITUATION IN INDIA*—PART I

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1. INTRODUCTION

PART of India's population does not get enough food (undernutrition) and even a larger part does not get the right type of food (malnutrition) to sustain a healthy and active life. Estimates of the incidence of undernutrition and malnutrition vary. Speaking of undernutrition, the Famine Enquiry Commission (1945) concluded that some 30% of India's people were underfed even in normal times. On the other hand, based on the results of the National Sample Survey, others have concluded that the proportion of undernourished in India must be negligible (Farnsworth, 1959). The proportion of malnourished is admittedly higher than that of the undernourished. Writing about both together, Boyd-Orr (1950) concluded that "a lifetime of malnutrition and actual hunger was the lot of at least two-thirds of mankind in pre-war years". Since Boyd-Orr's statement referred to the world as a whole, it follows that the estimate of the proportion of undernourished and malnourished for India, according to him, was even higher than two-thirds in the pre-war years. This alarmingly high incidence of undernutrition and malnutrition, if true today, coupled with the accelerated and all-time high rate of population growth, assumes special significance in the context of future food needs to ensure adequate nutrition to India's people and of the prospects for raising them within a foreseeable future. As one of the most densely populated countries with limited resources in land to expand, India's food problem is of basic importance to many other countries and particularly to the development of the campaign to 'free-the-world-from-hunger' launched by the Food and Agriculture Organization of the United Nations (Sen, 1960). It would be our object in this paper to make a reappraisal of the food and nutrition situation in India and to assess the prospects of raising the needed foods

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within a foreseeable future. The task is not easy, since the available data on food consumption, calorie and nutrient intake and requirements need careful analysis before drawing even tentative conclusions. In Part I of the paper we shall give a method of assessing the incidence of undernutrition and malnutrition in the population, and use it to assess in broad numerical terms the extent and magnitude of hunger in the country. In Part II we shall attempt to estimate the amount of food supplies needed to ensure adequate nutrition for India's growing population, and briefly examine the prospects and possibilities for raising the needed food within a foreseeable future. As a background to this analysis we shall also examine the scope, limitations and sources of errors in the available data on food consumption and requirements.

2. Definition of Hunger

Following common practice we will use the term 'hunger' to cover undernutrition as well as malnutrition, and deal separately with the two in this paper.

Undernutrition refers to the inadequacy in the quantity of the diet. It is understood to mean inadequacy in calorie intake such that if allowed to continue for a long time there is either loss of normal body weight for the same physical activity or reduction in physical activity for the same body weight, or both. The definition is strictly appropriate to adults, not to children. For children, the inadequacy in calorie intake is determined in relation to satisfactory growth and physical development and the high degree of activity characteristic of healthy children.

Malnutrition refers to the inadequacy in the quality of the diet which if made good enables a person to lead a healthy active life. More precisely, it denotes inadequacy of a particular or several essential nutrients such that if made good, the clinical signs of specific deficiency diseases are eliminated and, further, with appropriate increase in the intake of nutrients the sub-clinical signs associated with poor health are also removed. The two conditions are naturally not mutually exclusive because it is likely that a person who is undernourished is also malnourished, though the reverse may not hold.

It follows from the definition of undernutrition that if for a long enough period of time the estimate of the intake of calories for the country is found to be lower than the corresponding requirement, one may conclude that during this period food supplies were inadequate to meet the needs of the people and that the people were underfed. The method provides an estimate of total calorie deficiency but does not allow any conclusion as to the number of people who have actually been underfed. Calorie needs vary with age, sex, weight, physical activity and environmental conditions. Consequently, more information in the form of the distribution of intake (x) relative to requirement (y) has to be available in order to estimate the proportion of the population which is undernourished. Given such a distribution for individuals in the population we can express the incidence of undernourished formally by means of

$$u = \int_{x/y<1} f\left(\frac{x}{y}\right) d\left(\frac{x}{y}\right) \qquad (1)$$

In a later section we shall develop a method of evaluating the above expression.

Considerations similar to those for calories hold for the essential nutrients in order to measure malnutrition. The difficulty however is that not only have no standards been yet evolved for any of the nutrients except proteins, but that there is also no agreement on any single measure of malnutrition. Even for proteins, as we shall show later, the allowances recommended are too tentative to provide an estimate of total protein deficiency and its incidence in the population. Protein moreover is only one of the many essential nutrients. Vitamins and minerals must also be taken into account in studying malnutrition. In the absence of an agreed method of combining the different nutrients into an overall measure of the quality of diet, we have of necessity to use an indirect approach to measure the extent of malnutrition in the population. We shall describe this approach in a later section.

3. Sources and Limitations of Available Statistics

3.1. *Food Balance Sheet*

Food balance sheet is a macro approach of collecting information on food consumption. Starting with production and adjusting for trade stocks and non-food utilization, it shows the food supply for individual commodities in a country at retail level in terms of per person per day national averages. It also gives the contents of food supplies available per person per day in terms of calories and nutrients. Thus, the estimate of calorie (or nutrient) supply per person per day at retail level derived from food balance sheet is given by

$$C = \sum (P+I+J_1-E-J_2-S-F-W-M)\ RN \frac{1}{(\text{Pop.})\ 365} \qquad (2)$$

where the summation is over commodities. For any commodity J_1 and J_2 represent the stocks at the beginning and at the end of the consumption year; I and E represent the imports and exports, respectively, during the consumption year; P stands for the production during the year; S, F, W and M represent statistics of non-food utilization, standing for seeds, feeds, waste and amounts used in manufacture for purposes other than food, respectively; R represents the extraction factor to fit with the form in which the commodity is measured at the retail level, and N the corresponding content of calories (or nutrient). Clearly, the accuracy of the calorie and nutrient supply estimates depends not only on the accuracy with which the statistics of production, trade and stocks are known but also on the accuracy with which the statistics of non-food utilization and those of the conversion factors and of population are available.

Of these, the statistics of trade are of acceptable accuracy in India. The basis for adjustment of stocks is inadequate but if a food balance sheet is constructed as an average over a period of years, this factor may not unduly affect the accuracy of the average. The statistics of seed rates and of areas sown, and in consequence the amounts used as seed, are known fairly accurately for most crops; but the amounts used for feed, lost in storage and transport between farm gate and retail level and used in the manufacture of inedible foods, are little more than intelligent guesses. Together, $S + F + W + M$ are estimated to account for $12\frac{1}{2}\%$ of the gross production. But admittedly the figure is tentative and open to revision. On the other hand, relative to production P, the magnitude of $S + F + W + M$ is small. In other words, whereas an error in the estimates of items of non-food utilization may make a difference to the end total, a similar error with regard to P could completely falsify the picture.

The quantity within brackets in (2) is called the gross food supply. For determining the net food supply we need to know the extraction rate R for different commodities as, for example, rice from paddy, oil from oilseeds, flour from wheat, etc. An accurate estimate of R is difficult to make since the extraction practices vary considerably from one part of a country to another. Thus, rice is consumed as brown, home pounded, parboiled, unmilled or white-milled rice, with extraction rates varying from some 75, to 62% and even less. Besides, estimates of the proportion of rice consumed in different forms are lacking. Hence, R has necessarily to be determined on the basis of limited information which may not be representative of the total supplies in the country. The same holds for N. To continue with the example of rice, the protein content is known to vary from 8·5 to 6·4% and the fat content from 1·4 to 0·4% depending on the form in which rice is consumed. Consequently, the use of extraction rates customarily adopted in India such as 0·67 for rice and of nutrient conversion factors based on limited local information or tables such as those prepared by Aykroyd, Patwardhan and Ranganathan (1951) can at best provide a rough approximation to the true values. Further the estimates of calorie and nutrient supplies depend on the accuracy of the population figures. These can be taken as reasonably accurate for census years, but extrapolation for post-census years may introduce appreciable errors. In fact, the results of the 1961 population census just published have shown that the population during the preceding decennium increased at some 2%, whereas a growth rate of some 1·6 to 1·7% was actually used in constructing the food balance sheets for years immediately preceding 1961, with the result that the estimate of calorie supply has had to be revised downwards by some 100 calories.

Such are the errors to which the food balance sheet estimates of calorie and nutrient supplies are subject. It is difficult to see how these errors in the different components of the expression (2) accumulate to influence the accuracy of the final calorie and nutrient supply estimates. Clearly, some of these errors would cancel each other while others may accumulate as a result of successive transformations. What appears undisputed however is that the principal error in the estimation of gross supplies, and hence of the final figure for the calorie and nutrient supplies, is contributed by the estimates of production of the individual commodity.

This brings us to the status of food production data for India. Report on area and yield rate form the basis of determining them. Where land is cadastrally surveyed with each plot measured for acreage and the reporting agency is numerically adequate and trained, and where, further, adequate and effective rationalized supervision by an independent agency is provided for, as in fact is the case with the land records system in most of the States, area statistics can be held to be satisfactory. We do of course hear criticisms that the land records agency in the villages with the multifarious duties assigned to them oftentimes neglect their work of field inspection. The remedy lies in strengthening the agency and the supervision over it. Carefully conducted spot checks have in fact shown that the system works satisfactorily and the resulting statistics are broadly reliable (Sukhatme and Panse, 1951; Sukhatme and Kishen, 1954). As for yield rates, there is only one method of obtaining them accurately, namely, crop cutting surveys in randomly selected fields. India has set a pioneering example in introducing such surveys on a nationwide scale for major food crops. Minor crops remain to be covered in some of the States, but they contribute a relatively small portion to the total food grains production and consequently an error in the estimate of their production may not appreciably influence the end result. On the other hand, estimates for vegetables, fruits, milk, meat, fish and eggs are largely conventional, being based for the most part on market surveys carried out some years back, and those surveys were by no means rigorous scientific sample surveys. Household diet surveys collected in different parts of the country since 1935 (ICMR, 1951; Pandit and Rao, 1960) have however provided sufficient confirmatory evidence to show that the available estimates of production of vegetables, fruits, milk, meat, fish and eggs are unlikely to be wide off the mark. Indeed, sample surveys on the catch of marine fish (Sukhatme, Panse and Sastry, 1958) and those on some of the fruits and on milk yield conducted in certain States and on utilization of food grains, have provided sufficient supplementary material to adjust and improve upon the conventional estimates furnished by the market surveys.

Panse (1961 *b*) has used these supplementary data which are available in unpublished form in ICAR to revise the food balance sheet for India for 1956–59 (FAO, 1961). He leaves out however some of the vegetables, forest fruits, tubers and produce from kitchen gardens for which no worthwhile estimates could be made, although in the interpretation of the food balance sheet he allows for the omission. For the sake of completeness, we have made allowances, albeit arbitrary, using data available in some States, notably Maharashtra. The food availability for the period 1956–59 so estimated, together with the calorie and protein content, are shown in Table I. As can be seen, India had on the average a calorie supply of some 1,950 to 2,000 calories per person per day during 1956–59, a vegetable protein supply approximating 45 g., and an animal protein supply of some 6 g. per caput per day.

3.2. *Household Food Consumption Surveys*

Household surveys supplement food balance sheet data by providing information on the distribution of food within a population and on the factors influencing it. Broadly, there are two methods of conducting them under Indian conditions: (1) interviewing households on the quantities of foods obtained or consumed with the help of a recall list, and (2) weighing all foodstuffs before preparation of meals. The first is by far the more practicable method to use but it is also liable to large errors since households, especially in the rural areas where farmers largely use the foods grown by them, may not recall the precise quantities

TABLE I

Per Caput Daily Food Supplies in India (1956–1959)

Food Items	Quantity (g.)	Calories	Proteins (g.)
Cereals	375	1324	30·8
Roots and Tubers	30	28	0·4
Pulses and Nuts	65	203	12·5
Sugarcane (Gur)	45	158	0·5
Vegetables and Fruits.. ..	80	30	0·9
Meat	4	6	0·5
Eggs	1	1	0·1
Fish	7	4	0·6
Milk	140	118	5·2
Oils and Fats	11	97	..
TOTAL CALORIES ..		1970	
ANIMAL PROTEINS ..			6·4
VEGETABLE PROTEINS ..			45·1
TOTAL PROTEINS ..			51·5

of the foods obtained or consumed and may also be influenced by prestige and similar considerations in giving information to the interviewer. The second method is more promising from the point of view of accuracy, inasmuch as the accuracy of the data is independent of memory provided the weighment is made promptly. On the other hand, with this method the households are even more likely to be influenced by prestige and may buy or use foods different from those normally used, although the chance that households, especially from lower income groups, would do so for any length of time, is small. Besides, not all the selected families may co-operate in the time-consuming operation of weighment to the same extent as they might in the interview method.

Ideally, in view of the seasonal variation in the availability of food, food consumption surveys should extend over a full year. The longer the reporting period however the less is the accuracy with which the households can recall the details nor will they co-operate in weighing foodstuffs for such long periods. Short periods on the other hand lead to inclusion of events factually outside them although the chance that families may co-operate improves. The solution lies in combining the interview method with the objective method of weighment and distributing the survey over time. This however is exceedingly difficult to accomplish on a nationwide scale. What is feasible is to conduct such surveys confined to small segments of the population as has been done by ICMR over the last three decades among the poorer sections of the population (Aykroyd, 1948; ICMR, 1951). Over a period of years such surveys may provide a valuable record of information more especially if the households in the surveyed segments are chosen on a sampling basis.

The difficulties of collecting accurate data on food consumption on a nationwide scale using the interview method are best illustrated by the results of the First Round of the National Sample Survey (NSS) (Ministry of Finance, Government of India, 1952). In this survey, the NSS sought to estimate not only consumption but also production of food crops. The NSS estimate of the latter was 39 million tons while the estimate of production of food grains derived from its consumption estimate and allowing for utilization came to 69 million tons. The NSS report dismissed the former as being a gross underestimate without giving any reasons as to why there should be grossly inconsistent estimates of the same entities based on the same survey. On the other hand, if one were to accept the NSS estimate of consumption, it would imply a calorie consumption of some 2,400 per person per day compared against an estimated supply of less than 2,000 derived from the food balance sheet. It is hard to believe that India was the best-fed country in the Far East during the 1950's, which it would be if one accepted the NSS estimate of consumption.

The methodology of NSS survey in its first round has been the topic of several published reports and papers (Godgil, 1953; Dandekar, 1953; Raj, 1961; Panse, 1961 *a*). We do not therefore consider it necessary to re-examine it here beyond noting that in our view it is not surprising that the NSS should have grossly overestimated consumption. Not only was the period of reference too long, namely one year, but in most cases it was far removed from the time of the enquiry. The questions for such a long period of enquiry were also worded in such a way that the respondent could not proceed to answer them by recalling all the factual items and adding them together. What the respondent probably gave was what he thought he should normally consume at a meal or during the day to meet his needs. Possibly the investigator multiplied this figure to provide a plausible annual figure which approached requirement more than actual consumption. Many of these defects have been removed in the food consumption surveys conducted by the NSS since 1950 (The Cabinet Secretariat, 1959). For example, whereas the reference period in the first round conducted during 1949–50 was twelve months, it is now one month and even less in some of the surveys. Again, care is taken to ensure that the reference period is close to the time of the enquiry. The survey work is also decentralized among the States. This has not only helped to intensify supervision of field-work but has also helped in cutting down on the delay in the tabulation and publication of the results. As an example, the State of Maharashtra has tabulated and studied the NSS results of food consumption collected in the course of its 14th round during 1958. Unfortunately, the results of the later rounds as published by the NSS for the whole of India have been reported in terms of imputed expenditures and not quantities. It is to be hoped that the Centre as well as the States will follow suit the example of Maharashtra and make their results available in terms of quantities.

It should be added that although the methodology used by the NSS has undergone a change for the better, these improvements themselves may not suffice to eliminate the biases to which we have referred above, because consumption of foods especially in the rural areas comprises largely the consumption of home-grown foods and this is not an accountable operation such as for example the purchase of foods in the cities. It is for this reason that any enquiry into consumption of foods especially in the rural areas needs to be supplemented by an enquiry on a subsample of households which provides for the measurement of the quantities used for consumption by the investigator entering the kitchen, as is being done in the case of the dietary surveys conducted by ICMR. Nevertheless, we believe that when the results of the later rounds of the NSS come to be published, these would help to throw a good deal more light on the levels and patterns of food consumption in the population. In particular, we see no reason why the results of the later rounds cannot be used to provide acceptable estimates of the ratios between the consumption of certain food-stuffs and the distribution of such ratios in the population. As an example, the proportion of calories derived from cereals, starchy roots and sugar and the proportion of animal proteins to total proteins which, as we shall show later, are significant indicators of the nutritional quality of diet, ought to be less susceptible to errors than are the absolute calorie and protein levels. Equally, it should be possible to use the data collected in these rounds to bring out relationships between food consumption levels and the factors influencing them such as income, as is being done by the Cabinet Secretariat in its reports of the later rounds of food consumption surveys. For our appraisal of the food and nutritional situation in India we shall draw upon (i) the data of household dietary surveys based on the objective method of weighing collected by ICMR; (ii) the data collected by NSS in its subsequent rounds in so far as they are available to us in unpublished form from the State of Maharashtra; and (iii) the food balance sheet for India.

3.3. *Calorie Requirements*

The second type of data needed for the appraisal of undernutrition is that on calorie requirements of the population. We need to know not only the average per head calorie requirement but also the variation around it. The former is needed to test the adequacy of the calorie consumption level, the latter to estimate the proportion of the people who are undernourished. Dietary allowances for calories recommended by the Nutrition Advisory Committee (NAC) of India (Patwardhan, 1960) provide the required information.

The Indian allowances are based on the FAO (1957) approach involving the calorie requirement of the reference adult and then applying corrections for the various factors influencing requirements such as age, weight, activity, etc. The Indian reference man is an adult of 25 years of age weighing 55 kg., and the reference woman is 25 years old weighing 45 kg. Both the reference man and woman are assumed to live a healthy life of moderate activity requiring a total energy expenditure of approximately 2,800 and 2,100 calories respectively. The former generally corresponds to the observed value of the food consumed by a healthy man of the reference type, but the latter is recognized not nearly as approximate as in the case of the reference man and is probably on the high side. The criteria used for defining requirements for infants, children and adolescents are those used by FAO in its report on calorie requirements, but the actual allowances suggested are in keeping with the results of observations on Indian subjects. The same applies to the allowances suggested for pregnant and lactating women. There is however a distinct lack of sufficient observations on Indian subjects to work out recommendations for corrections for age over 25 years. For this reason the NAC of India have provisionally accepted the recommendations of the FAO Committee with regard to age correction,

Table II sets out the calorie requirements recommended by NAC for males and females of different age groups for India. The table also gives the percentage distribution of population between the different age groups as revealed in the last census and shows the average per caput requirement for India obtained by multiplying the actual requirement for each age and sex group by the proportion of the people in the respective groups. The requirements shown for women in the age groups 16 to 45 include an adjustment for allowances recommended

TABLE II

Calorie Requirements at the Physiological Level as Recommended by NAC (1958)

Age Group	Population %		Requirement per person/day*%	
	Male	Female	Male	Female
– 1	3·3		450[a]	
1– 3	7·5		1200	
4– 6	7·8		1500	
7– 9	7·5		1800	
10–12	7·0		2100	
13–15	3·3	3·2	2500	2100
16–19	4·0	3·9	3150	2200[b]
20–29	8·7	8·4	2800	2200
30–39	7·1	6·5	2700	2150
40–49	5·2	4·6	2650	2050
50–59	3·3	3·1	2450	1800
60–69	1·7	1·7	2250	1650
70–	1·1	1·1	1950	1450
Average per person per day ..			2100	

* Rounded to the nearest 50.

(*a*) after deduction of food received from mothers.

(*b*) includes allowances for pregnancy and lactation.

by NAC for lactation and pregnancy based on the known specific birth-rates and infant mortality.

As can be seen, the average per caput calorie requirement at the physiological level, according to the NAC at the moderate level of physical activity, works out to approximately 2,100. Considering that there is a serious lack of information on the total energy expenditure of healthy active persons in the different age groups, and that the application in practice of the different correction factors such as for age, weight, activity, etc., is necessarily limited because they are based on the experiences in countries with conditions different from those in India and further that the assumed values of the determining variables are necessarily provisional, the requirements in Table II can be considered as no more than approximate. On the other hand, the dietary allowances recommended by NAC, like the FAO reference scale, are based on the best knowledge at present available, and the limitations imposed on their application in practice are perhaps no greater than those arising from insufficiency of information in estimating consumption levels. We have stressed this fact in order that the reader may appreciate the tentative nature of the conclusions reached in this paper regarding the incidence of undernutrition in the population and the future food needs of the country.

Finally, we refer to one more source of errors. Calorie requirements, as shown in Table II, refer to the physiological level, that is to calories from foods actually consumed. On the other hand, intake figures available in practice often refer to the retail level. Allowance has therefore to be made for losses during storage in the kitchen, losses through cooking, wastage on plates and food fed to pet animals. It is difficult to make an allowance for these losses with any accuracy. The FAO Committee on Calorie Requirements concluded from the limited data available to it that these losses are unlikely to exceed 10% of the calories at the retail level for most countries. The losses due to wastage on plates are perhaps low or negligible in India, but those due to spoilage under poor and humid conditions in homes would undoubtedly be larger than those in the more developed countries. In keeping with the spirit of the recommendation of the FAO Committee we shall assume these losses to be of the order of 7 to 10%. In other words, the average per caput requirement at the retail level for India would be of the order of 2,250 to 2,300 calories.

As for the variation in the calorie requirements, Patwardhan gives data to show that the total energy expenditure among adults may vary from some 2,200 calories for an eight-hour heavy work to some 750 calories for sedentary work. These probably represent extreme limits and show that there are perhaps not more than a few people with energy requirement on work falling outside these limits. Nevertheless, these figures show how even a small deviation from the basic assumption that the physical activity of the population is the same as that of the reference adult, may lead to considerable variation in the average per caput calorie requirement of the population. There are moreover other residual factors which must cause variation in the calorie requirements of adult men of reference type. Harries *et al.* (1961) have made an extensive examination of the available data on energy expenditure among adults, and concluded that there not only exist truncation at the lower end of the distribution of energy expenditure but that the standard deviation of the total energy expenditure among the adult population of the UK is probably of the order of 500 calories. Where, as in India, the requirement of the average reference man is smaller than that in UK, they conclude that the standard deviation is likely to be smaller. We estimate this to be of the order of 400, based on the evidence published by Patwardhan and by the FAO Committee on Calorie Requirements which observe that "a range of daily expenditure requiring between 2,400 and 4,000 would appear to include most men". This estimate would reflect the variation due to physical activity and residual variables among reference men, and is the one which we shall use later in estimating the incidence of undernutrition in the population.

3.4. *Protein Requirements*

Among the nutrients which determine the quality of the diet, proteins are probably of the greatest practical interest. The task of defining protein requirements has however proved exceedingly difficult, firstly because of the large differences in the nutritive value of the different proteins, and secondly because of the lack of adequate evidence on human subjects of the protein needs. Nevertheless, the FAO Committee on Protein Requirements (1957 *b*) has put together all the available material and attempted to establish "tentative standards for average minimum protein requirements".

Because of the different kinds of proteins, the Committee decided to express requirements in terms of what it calls 'reference' proteins, *i.e.*, proteins of high nutritive value, such as those contained in milk, eggs, meat, etc. Available evidence indicates that proteins in milk, eggs, and meat are much superior in amino-acid pattern to that of vegetable proteins, and also they resemble more closely those constituting human tissues.

Two criteria guided the Committee in defining the average minimum protein requirements: (i) the maintenance of nitrogen balance in the case of healthy adults, and (ii) the satisfactory growth in the case of children. However, for practical application the Committee recommends not the average minimum requirements but what it calls "protein allowances". These allowances are derived from the average minimum requirements by adding to them an arbitrary increment of 50% in order to allow for individual variation, and further by using an appropriate multiplier to convert 'reference' proteins in terms of the actual quality of the dietary proteins available to the people. The multiplier is the inverse of the protein score, as determined by the content of the limiting essential amino-acid in the dietary pattern as compared with the pattern of the reference protein.

Table III gives the average minimum requirements for the 'reference' protein per kilogram of body weight for different age groups as recommended by the FAO Committee. It also shows norms of body weights for satisfactorily growing children and for healthy adults under Indian conditions (Panse, 1961 *b*), together with the corresponding average mimimum requirements of the 'reference' protein. The last row of Table III shows the average per caput requirements obtained by multiplying the requirements of each age and sex group by the proportion of the people in the different groups given in Table II. As will be seen, the average per caput per day minimum requirement comes to 18 g. Allowing for the additional requirements of pregnant and nursing mothers at the rates specified by the Committee, part of which is already reflected in the requirements of infants below one, this average revised upwards comes to about 19 g. per day.

Table IV gives protein allowances in terms of the dietary protein available to the people as recommended by NAC of India (Patwardhan, 1960) and as derived from the average minimum requirements for 'reference' proteins based on FAO recommendations. For simplicity in calculation, we have assumed that all animal proteins are reference proteins, which does not appear to be an unreasonable assumption to make under Indian conditions where milk provides the bulk of animal proteins. Rough calculations indicate that the biological value of the vegetable proteins available in the Indian diet is approximately two-thirds of the reference proteins so defined. Noting that the vegetable proteins form seven-eighths of the total proteins, we thus get a figure of some 40 g. of dietary protein as representing an adequate per head daily allowance under Indian conditions, according to the FAO recommendations. Assuming that the dietary proteins are equitably distributed

TABLE III

Average Minimum Requirements for the Reference Protein for the Indian Population

Age	Requirement in g. per kg. of body weight		Norm of body weight in kg.		Average minimum requirement in g. per head	
	Male	Female	Male	Female	Male	Female
< 1	1·60		6		10 (6)[a]	
1– 3	1·10		12		13	
4– 6	0·75		18		14	
7– 9	0·70		24	23	17	16
10–12	0·70	0:75	31	31	22	23
13–15	0·75	0·50	41	39	31	20
16–19	0·50	0·40	48	43	24	17 (22)[b]
> 20	0·35		55	45	19	16 (20)[b]
Average per head per day					18 19[b]	

(*a*) Average requirement after deducting food received from mothers.
(*b*) Average requirement per person after including allowance for pregnancy and lactation.

TABLE IV

Protein Allowance for Indian Population in Terms of Available Dietary Based on FAO and NAC Recommendations

Age	FAO		NAC (1944)		NAC (1958)	
	Male	Female	Male	Female	Male	Female
			(in g. per head per day)			
< 1	22 (14)[a]		22 (14)[a]		22 (14)[a]	
1– 3	29		43		43	
4– 6	32		60		60	
7– 9	38	36	62		62	
10–12	50	52	78		78	
13–15	70	45	102	98	102	98
16–19	54	38 (46)[b]	95	86 (91)[b]	95	86 (90)[b]
> 20	43	36 (43)[b]	82	67 (75)[b]	55	45 (55)[b]
Average ..	40		72		59	
			74[b]		62[b]	

(*a*) Average allowance after deducting food received from mothers.
(*b*) Average allowance per person after including allowance for pregnancy and lactation.

over all age groups, the allowances needed for the different groups based on FAO recommendations are shown in column 2 of Table IV. For comparison, the allowances recommended by the NAC of India in 1944 are also shown beside the revised allowances recommended by NAC in 1958.

The comparison of the FAO allowances with the revised NAC allowances shows that there is broad agreement between the allowances recommended for adults and for infants below one, but the allowances for other groups differ rather considerably. If one were to compare the NAC revised allowances of 1958 with the allowances recommended by it earlier in 1944, one finds that the principal change has been to revise downwards by 33% the allowances for adults over 20. This downwards revision was carried out because experimental evidence on human subjects showed that the nutritive value of vegetable proteins of low biological value could be improved considerably if vegetable proteins were taken from mixed diets. For other age groups however the observational evidence is still seriously lacking, and for this reason the NAC decided not to revise the protein allowances earlier recommended in 1944. This explains the reason for the rather large difference between the average protein allowance per caput per day recommended by the NAC, which works out to some 62 g., and that based on FAO recommendations, which works out to approximately 40 g. It seems probable that as more evidence becomes available, the NAC allowances for children would be further revised downwards. On the other hand, the FAO allowances may turn out to be underestimates of the actual needs, as more evidence accumulates. This latter possibility would seem to be supported by Table I which shows that protein supplies available per person per day in India, which include some 45 g. of vegetable protein and 6 g. of reference protein, are more than adequate to meet the average needs of a person, according to FAO standards. And yet, protein malnutrition though not serious is known to be a major problem in India, especially among children.

There also appear other limitations on the use of protein allowances, whether based on FAO or NAC recommendations, as a guide in judging the adequacy or otherwise of the dietary proteins available in a country. The quality of proteins primarily depends upon the amino-acid pattern thereof. Available evidence indicates that the safety margin allowed in working out the average minimum requirements of the individual essential amino-acids is large. Indeed, in most cases the value defined as the average minimum is the largest of the values recorded on healthy adult subjects. Further, an examination of the data on the minimum requirements of essential amino-acids recorded by the different workers shows that there is not even a broad agreement between their observations. Whatever figures one may adopt as minimum average requirements of essential amino-acids, the available dietary for countries like India show that the essential amino-acids in it are several times more than considered as the minimum needed. And finally, no satisfactory explanation has been given for arbitrarily increasing the average minimum requirements by 50% in order to calculate the allowances. By its very definition, for about half the population, the requirement should be below the recommended average minimum and above it for the remainder of the population. If therefore one were to interpret the arbitrary increase of 50% to mean a coefficient of variation of 25%, among nutrition units for proteins less than 5% of the population will need an allowance exceeding the one calculated by increasing the minimum average requirement by 50%. It would thus seem that, both on account of the divergence between the allowances recommended by FAO and NAC, as also because the allowances probably represent upper limits to allow for individual variation, they do not provide a sound basis for judging the inadequacy of the level of dietary proteins available in the country nor for assessing the incidence of protein malnutrition in the population.

4. Current Level of Diet and Its Adequacy

4.1. *Features of the Indian Diet*

The salient features of the Indian diet are seen from Table I. As can be seen, the diet is characterized by: (i) preponderance of cereals which account for two-thirds of the average calorie intake; and (ii) a marked deficiency of protective foods especially animal products which account for less than 7% of the calorie intake. The heavy dependence on cereals for energy purposes and the scarcity of animal products in the diet are primarily due to the poverty of the people. This is brought out in Table V which shows the level of calorie and protein supply by level of expenditure for Maharashtra State, India. The Survey was conducted in 1958 as part of the 14th Round of the National Sample Survey of India, and covered the entire State with a population of about 40 millions. Besides the average total calorie supply, Table V gives the calorie supply derived from cereals as also the percentage of the latter to the former. Table V shows that at the low levels of total expenditure the calorie supply is extremely small and that it is primarily derived from cereals which form the cheapest source of energy for the low-income people. However, as income improves, the calorie supply

TABLE V

Calorie and Protein Supply by Expenditure Level—Maharashtra State, India, 1958*

Item	Monthly *per capita* expenditure in Rs.							Average
	0–8	8–11	11–13	13–18	18–24	24–34	>34	
Total calories	1,120	1,560	1,850	2,190	2,440	2,530	3,340†	2,100
Calories derived from cereals	940	1,300	1,510	1,740	1,860	1,800	2,150	1,590
Percentage	84	83	82	79	76	71	64	76
Total proteins in g. ..	30·7	45·0	52·8	60·4	66·3	71·7	85·7	59·7
Animal proteins in g. ..	1·0	1·8	2·3	2·9	6·1	7·1	11·9	4·5

* I am indebted to Mr. M. A. Telang, Director of Statistics, Maharashtra, for these data collected in the course of the 14th Round of the NSS.

† This value appears unduly high. It is stated that this is partly due to the exclusion from the household size of guests and labourers taking meals.

also improves and the dependence on cereals gets less, although even in the high-income groups it still forms some two-thirds of the total calorie supply. The gradation is similar for total proteins and animal proteins. As income improves, the supply of total proteins as well as of animal proteins is seen to improve. But the latter, even up to the total expenditure level of Rs. 18 per person does not amount to even 3 g. per day. The significance of this observation can be grasped only when one realizes that over 60% of the people in Maharashtra live on an income level below Rs. 18 per head.

Preponderance and deficiency are however relative terms. The best way to illustrate the features of the Indian diet is therefore to compare it with the diet of other countries. For reasons of convenience the world can be divided into two groups of relatively poor and rich countries. The former, called Goup I in this paper, comprises the Far East including India, the Near East, Africa and Latin America excluding the River Plate countries of Argentina and Uruguay; and the latter, called Group II, consists of the remainder, namely, Europe, North America and the River Plate countries and Oceania. The diets for these two groups along with that for India and the world as a whole are shown in Table VI. As can be seen, the rich countries not only consume the same or larger amounts of cereals, starchy foods and sugar than India but five times as large a quantity of animal products comprising meat, fish, eggs and milk. The contrast is brought out even better in terms of calorie and nutrient supplies per person per day. As we saw, India consumes about 2,000 calories per person per day, compared with a somewhat higher intake of 2,100–2,200 for the Group I countries, and of over 3,000 calories per day for the Group II countries. Sharper still is the contrast between the animal protein intake. India consumes hardly 6 g. of animal proteins including those from milk per person per day as against some 44 g. consumed by the rich countries. The disparity in fats is also large, in the ratio of about 1 to 4. Perhaps the only satisfactory feature of the Indian diet is its vegetable protein content which except for the lowest income group is seen to compare favourably with that of the rich countries.

4.2. *Evidence of Undernutrition*

Table VII compares the current levels of calorie supplies with the corresponding requirements for India, the poor countries taken as a whole, the rich countries taken together and the world as a whole. As can be seen, the calorie supplies for the rich countries are not only sufficient to meet their average needs but in fact exceed them substantially.

TABLE VI

Current Consumption Levels for INDIA, GROUP I Countries, GROUP II Countries, and the WORLD as a Whole

Item	India	Group I	Group II	World
FOOD GROUPS	Grams per person per day at retail level			
Cereals	375	389	328	370
Starchy roots	30	189	316	227
Sugar	45[1]	29	88	47
Pulses and Nuts	65	53	16	42
Vegetables and Fruits ..	80	169	362	227
Meat	4	30	152	67
Eggs	1	4	33	12
Fish	7	24	34	27
Milk	140	79	573	228
Fats and Oils	11	12	47	22
CALORIES	1970	2150	3060	2420
% CALORIES FROM CEREALS + STARCHY ROOTS + SUGAR	77	78	57	70
TOTAL PROTEINS	51	58	90	68
ANIMAL PROTEINS	6	9	44	20
FATS	27	34	106	56

[1] Gur equivalent.

The position is just the reverse for the poor countries and markedly so for India. Admittedly, the calorie needs of India's people are smaller than those of the people in Europe, North America and Oceania. Even so, the gap between the supply level and requirement is far too wide to be justified on grounds of differences in age distribution, stature and climate. To accept such low levels of consumption for India and for the underdeveloped countries in general is, in the words of Wright (1960), "to condemn the poor countries to a permanent and possibly increasingly serious state of undernutrition".

TABLE VII

Calorie Supplies Compared with Corresponding Requirements

(Per caput per day at retail level)

Region	Calorie Supplies	Calorie Requirements*	Calorie Supplies as % of Requirements
India	1970	2300	87
Group I ..	2150	2300	93
Group II ..	3050	2600	117
World ..	2400	2400	100

* Rounded to the nearest 100.

Specifically, Table VII shows that the gap for India is some 300 calories. The magnitude of the gap is enough to indicate that an appreciable proportion of the population suffer from undernutrition. As Table V shows, the deficiency clearly falls heavily on the poorer sections of the population and may be suffered by the majority of the people. The calorie supply is seen to stabilize itself only after the income per head reaches Rs. 18 per month. The point regarding the inadequacy of the calorie supply in the lower income groups can be illustrated by similar data from the *All India Surveys of Agricultural Labour* (Ministry of Labour, Government of India, 1954, 1960) but we do not propose reproducing them in this paper. It will suffice to mention that these surveys showed that in practically every part of the country the consumption of food grains by families with lower income groups was considerably below the consumption by families with a somewhat higher income living side by side and doing similar work. It was abundantly clear that there are a large number of agricultural labour families in India who for want of income live on quantitatively inadequate diets and who thus remain underfed even in staple food grains.

By contrast, we find that in the rich countries there is no insufficiency of calorie supplies even in the lowest income groups. This is best illustrated in Table VIII for the U.S.A. and the U.K. (U.S. Department of Agriculture, 1957; U.K. Ministry of Agriculture, 1957). As

TABLE VIII

Calorie Supply by Income Level

	United Kingdom, 1955				
	Weekly income of head of household (£)				
	0–6	6–9	9–15	15–24	24 and over
Calories per caput per day ..	2,627	2,676	2,635	2,657	2,675

	U.S.A. Spring 1955								
	Household disposable income (dollars/year)								
	0–1,000	1,000–1,999	2,000–2,999	3,000–3,999	4,000–4,999	5,000–5,999	6,000–7,999	8,000–9,999	10,000 and over
Colories per caput per day:									
Urban	2,870	2,760	2,900	3,010	3,030	3,110	3,200	3,080	3,260
Rural non-farm	3,110	3,160	3,330	3,260	3,330	3,270	3,250	3,490	3,360
Rural farm	3,570	3,770	3,740	3,640	3,650	3,630	3,530	3,620	3,650

Table VIII shows the calorie supply while increasing with income is not appreciably influenced by the latter on anything like on the scale noticed in India. Further, the level of calorie supply for even the lowest income groups in the U.S.A. and the U.K. is seen to be higher than the average requirement.

4.3. *Incidence of Undernutrition*

The foregoing evidence suggests that an appreciable part of the population of India is underfed. To estimate this proportion we must turn to expression (1), but its evaluation presents a difficulty owing to lack of information on the distribution function $f(x/y)$ for individuals. The available data relate to intake of households, not individuals. For example, calorie intake distributions for groups of households expressed in terms of consumption units using the conversion factors of the League of Nations (Aykroyd, 1951) and information on the variation in calorie requirements among 'consumer units'* are readily available. The most extensive data on the intake distributions of households comes from the surveys conducted by ICMR over a fourteen-year period on some 12,500 households using the technique of actual weighing of foodstuffs during house-to-house visits for periods varying from 7–21 days. These surveys, which constitute a unique record of the dietary studies conducted in India, have been extensively drawn upon by a number of authors to present a picture of the status of nutrition in the low income households of the country (Aykroyd, 1948; ICMR, 1951; Mitra, 1953; Patwardhan, 1952). Unfortunately, the original material, household by household, has never been published. The published data relate to individual surveys of *groups* of households and the published distributions of calorie intake likewise relate to surveys of groups of households and not individual households. As an example, the "Frequency Distribution of Calorie Intake Observed in Diet Surveys on 3,209 Families from Different Regions in India" used by Patwardhan (1952) to describe Indian diets, is in reality the distribution of the 139 dietary surveys conducted during 1935–42, the number of families shown as frequency against any given calorie interval being the number of families covered by the surveys whose average calorie intake per consumer unit falls within the specified class interval. In other words, the distribution as presented by Patwardhan does not reflect the within-component variance of families covered in each survey. The same

* The term 'consumption or consumer unit' as used in this paper refers to calories, the calorie requirement of the 'consumer unit' being that of the 'reference' man, 2,800 for India.

remark applies to the distributions of calorie intake studied by Mitra and Aykroyd. While data on the average values for individual surveys, and their distribution was perhaps adequate to meet the immediate purpose of assessing levels and composition of diets, the important information on the variation among families covered in each study was missed in presenting data, and this constitutes a serious limitation to the usefulness of this otherwise excellent source of information for estimating the incidence of undernutrition in the population. It is evident that the utility of the statistical concept of the analysis of variance was not adequately realized at the time when the data from these surveys were summarized for estimating the average calorie intake and its composition by source of food among poor sections of the population. Nevertheless, we shall in what follows present a method of estimating the proportion of undernourished households in the country, assuming that information on the distribution of households by calorie intake on consumer unit basis and on the variation in energy expenditure among consumer units is available. We shall also, in so far as feasible, use the method to assess the incidence of undernutrition using the distribution of the groups of households presented by Aykroyd and Mitra, but bearing in mind the limitations of these data pointed above. We hope that as nutrition workers come to appreciate the value of the concept of analysis of variance they will re-examine the original data for individual households and use the method for a fresh assessment of the incidence of undernutrition in the country using the calorie requirement scale as now recommended by NAC in presenting distributions of calorie intake of households on consumer unit basis.

Let

X = total calorie intake of a household.

Y = total calorie requirement of a household based on age, sex, and activity level and other physiological characteristics of the members in the household.

R = total calorie requirement of a household adjusted for age and sex of the members in the household, assuming their activity level corresponds to that of the 'reference' man.

C = calorie requirement of the 'reference' man for India, namely, 2,800 calories.

Then

$\frac{R}{2800}$ = number of consumer units in a household for the activity level of the 'reference' man.

$\bar{X} = 2800 \cdot \frac{X}{R}$ = calorie intake of the household per consumer unit.

$\bar{Y} = 2800 \cdot \frac{Y}{R}$ = calorie requirement of the household per consumer unit.

It follows that while Y completely specifies the total requirement of a household, R does not, owing to the omission from the latter of the contribution due to physical activity and other residual factors. We may therefore write

$$\bar{Y} = 2800 \cdot \frac{R + P + E}{R} = 2800 \left(1 + \frac{P + E}{R}\right)$$

$$= 2800 + p + e \qquad (3)$$

where P and E represent, respectively, the deviations from R due to physical activity and residual variables and p and e are the corresponding values per consumer unit.

Consider now the distribution function

$$g\left(C\frac{\bar{X}}{\bar{Y}}\right) \qquad (4)$$

Clearly, (4) corresponds to (1) except that it relates to households instead of individuals. It follows that

$$u = \int_{\bar{x}/\bar{y}<1} g\left(C\frac{\bar{X}}{\bar{Y}}\right) d\left(\frac{\bar{X}}{\bar{Y}}\right) \qquad (5)$$

measures the proportion of households in which undernutrition exists. $\bar{Y}$ is however not known but the range of variation in $\bar{Y}$ is known. We can, therefore, assuming independence between $\bar{X}$ and $\bar{Y}$, for practical evaluation replace (5) by

$$u' = \int g(\bar{X})\, d(\bar{X}) \qquad (6)$$

the integral being evaluated over the range $\bar{X} < C - 3\sigma_{\bar{Y}}$ where $\sigma_{\bar{Y}}$ is the standard deviation of $\bar{Y}$ on a 'reference' unit basis and reflects the variation due to component $p + e$ in $\bar{Y}$. Since the average number of consumer units per household in India by ICMR is a little over four, $\sigma_{\bar{Y}}$ will have on the average a value approximately 200. Ordinarily in an adequately nourished population one would expect, assuming normal distribution, no more than 1% of the households below this level. The proportion of households with intake less than 2,200 per consumer unit can therefore be taken as an estimate of the proportion where undernutrition exists.

For interpreting the distribution of groups of households available for Pre-Partition India, the standard deviation of requirement per consumer unit will be smaller, since each group covered not one household but on the average some 15 households. Allowing for the size of the group and the intra-class correlation within it, the standard deviation is inferred to be a little over 100. It would therefore follow that most groups of households will need to take more than 2,400 calories per consumer unit per day in order to meet their requirement as recommended by NAC. In actual fact, we see from Table IX that about 55% of the groups of households took less than 2,400 calories per consumer unit. One cannot but consider this to be real evidence of widespread hunger in the surveyed households. The latter however mainly included households from a low-income stratum of India estimated at about two-fifths of India's population. There will undoubtedly be some households with inadequate calorie supplies in the middle-income groups of the country but no estimates of the proportion of such households are available. It would appear, however, generalizing from the evidence furnished by Table IX, that about a quarter of India's households were underfed during 1935–48. This estimate is necessarily very rough, owing to lack of information on the representative character of the households. In actual fact, the proportion of underfed households may be larger than is obtained from (6), since one would expect *a priori* a positive correlation between intake and requirement, though perhaps small. In consequence the proportion of households undernourished may even be slightly larger than 25%. It is interesting to note that this estimate is not appreciably different from the one made by the Famine Enquiry Commission (1945), which concluded that even in normal times about 30% of India's people go hungry.

It may be argued that the data on which this conclusion is based refer to the period 1935–48 and that the consumption levels have since probably improved. This however does not appear to be the case;

TABLE IX

Distribution of 843 Groups of Households Surveyed in Pre-Partition India by Calorie Supplies per Consumer Unit

Calories	Per cent. frequency
Under 1,001	1·3
1,001—	3·0
1,251—	4·6
1,501—	10·0
1,751—	14·0
2,001—	13·6
2,251—	14·2
2,501—	13·4
2,751—	11·0
3,001—	7·2
3,251—	3·4
Over 3,500	4·3
	100·0

Table X shows the average daily intake of food-stuffs per consumer unit as revealed by surveys conducted by the Indian Council of Medical Research (ICMR) during 1935–48 and those carried out during 1955–58. Although the families surveyed during 1955–58 were not the same as those surveyed in the earlier period, the two groups are stated to be broadly comparable and, further, each included a large number of families from different parts of the country (Pandit and Rao, 1960). Table X shows that there has been no appreciable quantitative change in the diet of the people during the last fifteen years. The estimate which we made in the previous paragraph regarding the proportion of the people who are undernourished would thus seem to hold good even today.

This conclusion is also borne out by the data for the 14th Round of the NSS collected during 1958 for the State of Maharashtra. Table XII sets out the distribution of households by calorie supplies per consumer

TABLE X

Average Daily Intake of Food-stuffs in Ounces per Consumer Unit as Revealed by Surveys in India

Food Groups	1935–48	1955–58
Cereals	16·62	16·59
Pulses	2·26	2·39
Leafy Vegetables	0·85	0·71
Other Vegetables	4·10	3·20
Ghee and Oils	0·92	0·52
Milk	3·31	2·81
Meat, Fish and Eggs	0·94	0·47
Fruits and Nuts	0·58	0·21
Sugar and Jaggery	0·67	0·71

unit collected in the course of this survey. Allowing for the losses between retail and physiological levels at some 7%, one would expect, following the approach developed above, that most households in Maharashtra ought to have a calorie intake per consumer unit higher than 2,350 if there are to be no undernourished households in the State. In actual fact, Table XI shows that some 40% of the households fall below this value. This estimate of the incidence of undernourishment is higher than the one derived earlier from the dietary surveys based on the method of weighing food-stuffs. Part of the difference can be explained by the fact that this estimate relates to Maharashtra only. Part might also be due to the fact that the dietary surveys may not necessarily be truly representative of the low income section of the population which we have assumed to be some two-fifths of the total population. Again, a part of the difference may be due to the omission from the earlier estimate of the undernourished households from the middle income group, while a part may be due to the unknown nature of errors in the NSS data collected by the interview method. Whatever the reasons, the estimate does seem to confirm the earlier findings that at least one in four of India's households is undernourished.

TABLE XI

Distribution of 855 *Households in Maharashtra by Calorie Supplies per Consumer Unit* (1958)

Calories	Per cent. Frequency
900	2·4
900–	4·4
1300–	9·7
1700–	14·7
2100–	16·3
2500–	16·6
2900–	12·9
3300–	9·0
3700–	5·5
4100–	3·5
4500 Over	5·0
	100·0

It is interesting to use the foregoing approach to analyze the situation in the developed countries. Table XII presents two calorie distributions on a consumer unit basis, one for rural families of the North-Central Region of the U.S.A., from the food consumption survey conducted in 1952 (Orshansky *et al.*, 1957), and the other from a nationwide survey conducted in 1955 (U.S. Department of Agriculture, 1957). Both were based on the recall method using the week preceding the interview as the reference period. In a well-developed country one would expect most households to have sufficient calorie supplies. The calorie requirement per consumer unit for the U.S.A. at the retail level is approximately 3,500 and the standard error per household on the basis of its average size of 2·5 consumer units can be placed at approximately 300 calories per consumer unit. One would therefore expect most households to have calorie supplies exceeding 2,600 per consumer unit. The data shown in Table XII accord with these expectations and show that the proportion of underfed in the U.S.A. is negligible. In a well-fed country however one would expect that not only would there be no one underfed

TABLE XII

Distribution of Households by Calorie Supplies per Consumer Unit per day, U.S.A.

Calories	North Central Region U.S.A., 1952		U.S.A., 1955			Total
	Rural farm %	Rural non-farm %	Rural farm %	Rural non-farm %	Urban %	%
Under 2,000	2	3				
2,000–2,499	3	6	5	10	14	12
2,500–2,999	12	14				
3,000–3,499	19	22	9	10	14	12
3,500–3,999	22	19	11	17	17	16
4,000–4,999	27	25	27	28	28	28
5,000–5,999	15	11	21	18	14	16
6,000 and over			27	17	13	16

but that the average intake would equal the average requirement and, further, that the variance of intake would also be equal to the variance of requirement. The data for the U.S.A. show that the calorie supply purchased per consumer unit exceeds the requirement at the retail level by 500 and, further, that the number of households exceeding the requirement *plus* three times the standard error per household on a consumer unit basis approximates 30% for the North-Central region, and indeed approaches 50% for the nation as a whole. This would indicate that a large proportion of people in the States is overeating. It is of course possible that the requirement is underestimated. Some evidence in support of this hypothesis has been reported by Harries and Hollingsworth (1953). Alternatively, the intake may have been overestimated. Possibly all three situations exist.

5. MALNUTRITION

There is no single yardstick to measure malnutrition. Proteins, vitamins and minerals all enter into it, but their requirements for a balanced diet have not yet been established. Only indirect indicators can therefore be used to measure the extent of malnutrition. Some of the more important indicators are (i) the content of animal proteins, (ii) the proportion of animal proteins to total proteins, and (iii) the proportion of calories derived from cereals, starchy roots and sugar. When the intake of animal protein or its proportion to total proteins is low, or the proportion of calories derived from cereals, starchy roots and sugar is high, the diet is considered unbalanced and of poor quality.

Table XIII gives the values of these indicators for India and for the Group I and Group II countries. It shows that compared to the

TABLE XIII

Values of Indicators of Malnutrition for India, Group I and Group II Countries

Country	Animal Protein g. per head per day	% Calories from Cereals, Starchy Roots and Sugar	% Animal Protein to Total Protein
India	6	77	12
Group I ..	9	78	16
Group II ..	44	57	49
World ..	20	70	29

Group II countries the diet in the Group I countries is characterized by a very low level of animal proteins and the diet in India even markedly so. The percentage of animal proteins to total proteins in the Indian diet is seen to be 12% as against a value of 16% for the Group I countries, 49% for the Group II countries and 29% for the world as a whole. The diet in India and in the Group I countries is heavily dependent on cereals, starchy roots and sugar which contribute nearly four-fifths of the total calories. In contrast, in the Group II countries their contribution is seen to be less than three-fifths.

Whether an intake so high as 44 g. of animal proteins in the Group II countries with the associated high intake of other nutrients is desirable for India's population is a debatable question. Nevertheless, there is a considerable body of indirect evidence which suggests that the low level of animal proteins in the Indian diet is seriously inadequate.

One example of this evidence would be to show side by side the composition of diets, say 50 or 100 years back, for the developed countries like the U.K. and to compare it with the composition of diets in India as of today. Table XIV presents such data for the U.K. and India.

TABLE XIV

Trend in the Composition of Diet in the United Kingdom

(Kg. per caput per year)

	U.K. 1880	U.K. 1954–55—1956–57	India 1954–55—1956–57
Cereals	137	88	130
Starchy Roots ..	134	98	11
Meat	41	68 }	2
Eggs	5	12 }	
Liquid Milk ..	97	149	40

The data are indicative of the tremendous shift which has taken place in the dietary habits of the U.K., with heavy emphasis on animal products compared with that on cereals and starchy roots as in 1880. By contrast, the intake of animal products including milk, in India, even today is much below that of the level of 1880 in the U.K. While, admittedly, there are climatic and other differences between the U.K. and India, these differences in diet are significant in the light of the improvements in health which have taken place in the U.K. during the last 50 years or so, *e.g.*, expectation of life in the U.K. has increased from 54 in 1910 to 70 years in 1956, while the corresponding improvement in India, though impressive, still does not bring expectation of life there to more than about 40 years. Infant mortality in India is three to four times higher than in the U.K. Comparable statistics of morbidity are not available, but unquestionably an Indian has much less resistance to diseases than the average person in the U.K., owing largely to the very low intake of protective foods. Although part of this improvement is undoubtedly due to the general advances in public health, there is general agreement that better diets in the more developed countries have contributed to this improvement. The striking improvement

TABLE XV

Trends in Physical Conditions of the Japanese People Compared with those in Per Caput Animal Protein

	1948	1950	1951	1952	1954	1955	1956	1957	1958
Average weight (kg.)—									
Total Population	39·9	40·0	40·2	40·2	40·7	41·1	41·6	42·1	42·6
Children (1–19 years) ..	28·4	28·2	28·2	28·1	28·9	29·2	29·5	30·1	30·9
Average height (cm.)—									
Total Population	137·4	137·3	137·6	138·3	139·5	140·1	140·9	141·4	142·1
Children (1–19 years) ..	122·5	121·8	121·8	121·0	124·2	124·7	125·5	126·3	127·6
Animal Protein (g.)	13	17	19	23	22	22	23	23	24

in the physical conditions of the people in Japan since the War and the simultaneous improvement in the quality of their diet through larger intake of animal proteins, as shown in Table XIV, provide another example of such evidence (Ministry of Health, Japan, 1961).

A good example of the influence of diet on the work output of man is reported from Costa Rica (Stearns, 1950). While an average Costa Rican has apparently sufficient calories to eat, it was found that the Costa Rican worker lacked the stamina and working efficiency as measured by his capacity to carry stones for building the highway. The figures in Table XVI show that the carrying capacity increased some fourfold between 1943 and 1946. Although part of the increase was due to training, the principal share was stated to be due to the change in the workers' diet which provided for a large intake of protective foods based on the experience in the United States.

TABLE XVI

The Influence of Diet on the Working Efficiency in Costa Rica

Year	Cubic metres of stone moved per worker
1943	240
1944	338
1945	1,025
1946	1,157

For direct evidence of malnutrition we must turn to the evidence of the numerous dietary and clinical studies reported from different parts of India. Of the deficiency diseases reported in these studies a syndrome known as Kwashiorkor, attributed to protein deficiency, is perhaps the most widespread in the country. As an example, a recent study of some 5,000 children under 5 years of age conducted with the assistance of WHO showed that some 2,000 of them suffered from states of protein malnutrition ranging from serious retardation in growth and extreme emaciation, particularly in the post-weaning period, to other associated signs of protein deficiency like nutritional oedema and reduced serum-albumin. The explanation of the apparent contradiction between the sufficiency of per caput supplies of proteins and the widespread incidence of protein malnutrition is not far to seek. During the first few months when the infants are breast-fed they probably get enough proteins with adequate quantities of energy and other nutrients from their mothers' milk. But as the infants grow older the amounts they receive become increasingly inadequate. Usually at this stage they receive some supplement in the form of rice, like Kangi. The appropriate supplement would obviously be cow's milk, but the majority of the families can hardly afford it in the quantities needed by the infants. The result of supplementing breast milk with rice water is that infants do not get adequate nutrients essential for their growth. The trouble increases further when the child is put on solid foods, mainly rice, as in South and East India, with little supplement from other nutritious foods. This further impairs body growth and leads to symptoms associated with deficiency of essential nutrients, even though actual deficiency diseases may not make their appearance. The digestive capacity of the children is also impaired with the presence of factors like worm infections, which in their turn lead to further diseases of multiple character which arise from continuously increasing insufficiency of good quality assimilable proteins and other associated nutrients at the right age when children need them most. With such a poor start in life, oftentimes beginning at birth and even earlier due to the failure to meet extra demands for good quality proteins and other nutrients imposed by pregnancy and lactation on mothers, and arising from insufficiency of good quality proteins in the children's diets, it is only to be expected that the children grow into underweight adults, lack resistance to disease and are prone to fall ill.

There is abundant though indirect evidence of small-scale experiments of social feeding with milk which shows that children getting adequate good quality proteins along with other nutrients show improved health and vigour compared to children who after weaning usually are put on supplements of rice and similar foods. As an example, it is reported that Indian children brought up in Canada on the higher standard of living there grow faster than their kinsfolk in India. Again, even within the country children of middle and high-income classes getting adequate supplies of good quality proteins show much improvement in health and vigour compared to children in the low-income groups. School lunch programs which include adequate good quality proteins in the form of milk, and similar programs of feeding in maternal clinic, also bear this out.

Other deficiency diseases include Beriberi, caused by lack of thiamin; night blindness and Bitot spots du- to deficiency of Vitamin A; pellagra caused by the deficiency of Vitamin B; and anemia, associated with iron deficiency which is known to affect adversely the health of expectant mothers and the well-being of children. Even if these deficiency diseases as such do not make their appearance in large numbers, the state of malnutrition which just falls short of serious diseases is known to appear on a wide scale in the population, with its consequential effects on health, efficiency and longevity in the population. For detailed evidence the reader is referred to the *Review of Nutritional Surveys* by ICMR (1961).

While it is clear from the foregoing that there exists widespread malnutrition, it is not easy to estimate its incidence in the population for want of a yardstick to measure it. A method analogous to that in the case of undernutrition could be suggested to assess the proportion of people who suffer from deficiency of specific nutrients like proteins for which standards are available. As an example, one can work out the distribution of households by their intake of dietary proteins expressed in terms of reference proteins on nutrition unit basis, and calculate the incidence of protein malnutrition by reference to the NAC standards, assuming that the variation to be expected among nutrition units for proteins in a healthy population is 25%. However, as we saw, protein malnutrition arises mainly from lack of good quality assimilable proteins to those needing them most. Only a distribution of protein intake for each age group can therefore provide a basis for estimating the incidence of protein malnutrition, but such data are not available. In this situation the most one can do is to estimate the incidence, not of the deficiency of specific nutrients but of malnutrition as a whole, by reference to the nutritional quality of diets in well-fed countries using suitable indicators for the purpose.

The indicator we propose to use to measure the incidence of malnutrition is the proportion of calories derived from cereals, starchy roots and sugar. It is by no means a fully satisfactory indicator of the quality of diet. For example, it can hardly be considered a satisfactory indicator of the quality of diet in Japan which enjoys a fairly high intake of animal protein compared to India but takes most of its proteins from fish which has a low calorific value compared to other animal products. Again, in countries where starchy roots are preponderant in the diet, as is the case in many countries in Africa, the incidence of malnutrition is likely to be larger than where cereals make a major contribution to the calories in the diet. Nevertheless, it is one of the best available indicators of the quality of diet and has been so recommended by the ECOSOC Committee on Levels of Living. It also has a statistical advantage that being in the form of a ratio it is less susceptible to biases than indicators in the form of absolute levels like animal protein content.

TABLE XVII

Distribution of Households According to the Percentage of Calories from Cereals, Starchy Roots and Sugar in Maharashtra (1958)

Per cent. calories from cereals, starchy roots and sugar	Per cent. frequency		Total
	Rural	Urban	
< 50	1·1	10·8	5·8
50–	0·7	4·4	2·2
55–	0·9	3·1	1·7
60–	1·6	10·5	4·1
65–	4·7	10·5	6·5
70–	6·5	21·5	10·3
75–	11·3	15·0	11·6
80–	21·3	11·6	18·0
85–	24·3	10·2	19·6
90–	22·4	2·2	15·9
95–	5·2	0·2	4·3
	100·0	100·0	100·0

Table XVI shows the distribution of this indicator for households in Maharashtra compiled from the data collected in the Fourteenth Round of the National Sample Survey. Household surveys in well-fed countries with a moderate average value of around 0·50 for this indicator, such as the U.K., indicate that the standard deviation of this indicator per household is of the order of 0·10. This means that whatever the form of distribution, at most 10% of the households in the U.K. would exceed 0·80. Table XVII shows that over 55% of the households in Maharashtra exceed this value. If therefore one were to accept the

U.K. as providing a standard of nutritional quality of diet to which Maharashtra would seek to raise the level of the quality of her diet, then by reference to the U.K. one might say that some 55% of the people are malnourished. Naturally, any estimate of malnutrition of this nature suffers from two serious limitations. Firstly, the estimate would depend upon the indicator chosen to describe the nutritional quality of the diet; and secondly, it would vary with the standard chosen. Nonetheless, in our view it gives a broad idea of the order of magnitude of the incidence of malnutrition in the country.

To sum up, one in every four of India's people appear to be underfed. The incidence of malnutrition is more difficult to assess. If conditions in Maharashtra are any indication of the extent of malnutrition in other parts of the country, which we believe they are, then it would appear that relative to the nutritional standards enjoyed by the well-fed countries, two out of every four are malnourished. The undernourished are usually malnourished. It would thus appear that 200 to 250 millions of India's population are either undernourished or malnourished.