Protein deficiency in urban and rural areas: its measurement, size and nature

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Introduction

Urban diets differ from rural diets principally in two respects: (1) their total energy and protein content are smaller, but (2) they are more varied in composition. Since the total protein content is lower one expects the proportion of diets deficient in protein to be larger in the urban than in the rural area. The effect of lower energy content is likely to increase the incidence of protein deficiency. For even when the diet is adequate in protein, symptoms of protein deficiency may arise if it does not provide adequate calories for the synthesis of protein. As against this, the effect of greater variety in the urban diet might well be to reduce the proportion of protein-deficient diets in as much as the proportion of utilizable protein in the urban diet is likely to be larger than in the rural diet to compensate in part for its lower total protein content. It will be the object of this paper to analyse the dietary data for urban and rural Maharashtra and to estimate the incidence of protein-deficient diets in their relation to different dietary patterns. Implications of the analysis for closing the so-called protein gap will also be spelled out.

Material

Records of food consumption of 862 households in urban and rural areas in Maharashtra were collected during the 14th Round of the National Sample Survey (NSS) of India. The survey commenced in July 1958 and lasted for 1 year; the information was collected by interview over a period of 1 month. For a detailed description the reader is referred to Telang, Vidwans & Puntambekar (1962).

The recorded consumption for each household was converted into calories and proteins. Next, the number of nutrition units (a nutrition unit has the requirements of the 'reference' man) for calories and proteins were calculated for each household using the known information on age and sex of the members of the household and the latest scale for calorie and protein requirements (FAO, 1957, 1965). The material was tabulated in the form of bivariate distributions of calorie and protein intake in households on a nutrition unit basis. The values of protein tabulated were those of 'reference' protein of net protein utilization (NPU)=100. In converting dietary protein of each household into 'reference' protein, animal protein in the diet was assumed to have an NPU of 80 and vegetable protein to have an NPU of 50. (In the earlier paper the scale used for converting the household size in terms of nutrition units for protein was the 1957 scale, while the NPU values used for converting the dietary proteins into 'reference' protein were 100 for animal protein and 66 for vegetable protein.) Table 1 summarizes the material separately for urban and rural Maharashtra and the State as a whole.

Table 1. *Mean reference protein and calorie supply in households in Maharashtra, with standard deviations and coefficients of correlation*

	Urban Maharashtra	Rural Maharashtra	Maharashtra State
Mean protein intake per nutrition unit in terms of reference protein (g/d)	34·8	43·6	41·5
Standard deviation	15·2	20·2	18·7
% coefficient of variation	44	47	45
Mean calorie intake per nutrition unit (kcal/d)	2550	2940	2890
Standard deviation	970	1110	1120
% coefficient of variation	38	37	39
Coefficient of correlation	0·80	0·79	0·79

The other material used in the paper relates to protein requirements and is shown in Table 2 (FAO, 1965; WHO, 1965; Indian Council of Medical Research (ICMR), 1968).

Table 2. *A comparison of FAO and Indian Council of Medical Research (ICMR) scales on protein and calorie requirements*

Age (years)	kcal/kg		Reference protein (g/kg)		NDpCal%	
	FAO	ICMR	FAO	ICMR	FAO	ICMR
0—0·5	115	120	2·1*	2·1*	5·8	5·8
0·5—1	105	110	1·4*	1·4*	4·3	4·3
1—3	100	100	0·88	0·73	3·5	2·9
4—6	87	83	0·81	0·69	3·7	3·3
7—9	81	75	0·77	0·66	3·8	3·5
10—12	73	68	0·72	0·62	3·9	3·6
13—15B	70	61	0·70	0·59	4·0	3·9
G	62	56	0·70	0·59	4·5	4·2
16—19B	62	62	0·64	0·54	4·1	3·5
G	44	51	0·64	0·54	5·8	4·2
Adult male	48	51	0·59	0·54	4·9	4·2
Adult female	41	49	0·59	0·54	5·8	4·4
Pregnant female					5·6	5·4
Lactating female					5·9	4·9

* In terms of milk protein of NPU=80.

Statistics of requirements, like those of food consumption, are subject to several sources of error. Thus, experimental evidence shows that there is wide variation in the magnitude of each of the various components which go to make up the protein requirements even when the individuals are of the same age, sex, body-weight and living in good health under standard conditions. A margin of 20% is usually added to the average requirement to provide for this intrinsic variation between individuals. Protein requirements are also influenced by climatic conditions. One can obtain an idea of the magnitude of their influence from Table 2 by comparing the FAO/WHO scale, which is developed for application to average healthy individuals under average conditions, with the ICMR scale developed for application in India. In developing the latter the ICMR used the FAO/WHO estimates on nitrogen needs for different functions as a starting point and brought them up to date in the light of experimental evidence in the country. Where the Indian data were inconclusive ICMR adopted the figures used by FAO/WHO. Table 2 shows that ICMR recommendations are lower than the corresponding FAO/WHO figures for all age groups by 10–20% and on average lower by about 13%. This difference may be taken to mean that using the FAO/WHO scale for interpreting values for Indian intake when the ICMR scale based on Indian data is more appropriate may overestimate the size of the protein gap by 13% on average. In other words, protein requirements may be considered to have a degree of uncertainty amounting to some 10–15% from factors such as climate and physical activity. The third source of error is involved in the determination of NPU values. A good deal of progress has been made in recent years in predicting the quality of protein on the basis of the amino acid content of foods, but even so the error involved appears considerable and probably not less than the error arising from other factors mentioned above. In particular, NPU_{op} measured on the basis of the amino acid content of foods with egg as the reference probably underestimates the biological value by 10–15% (Payne, 1969). The values of NPU assumed here are therefore on the conservative side and probably underestimate the intake.

The difference between the ICMR and FAO/WHO scales becomes larger when the requirements are expressed in terms of net dietary protein calories (NDpCal%). This is due to the differences in calories needed per kg of body-weight according to the two scales. Notwithstanding the difference in the two scales, certain broad trends emerge. Both the requirements for protein and calories per kg body-weight are seen to decline with increasing age. However, calorie requirement declines more rapidly than protein. This is reflected in the values of NDpCal% which, contrary to what is generally believed, are larger for adults than for children, infants excepted. It is possible that while protein needs of young children are understated in both the scales the calorie needs are overstated. As time goes on we will undoubtedly witness further revisions in both scales and attempts to integrate requirement scales for protein and calories. In this paper we shall use the FAO/WHO scale, if for no other reason than to ensure that we do not underestimate the size of the protein gap at a time when so much attention has been focused on the problem.

Overall size and incidence of the protein gap

Size of the protein gap. An estimate of the overall size of the protein gap is given by the difference between intake and requirement and is set out in Table 3. It will be seen that the protein intake is about equal to requirement for urban Maharashtra but exceeds the requirement by about 20% for rural Maharashtra. Unlike calories, which are seen to be in short supply by about 15% in the urban area and are about equal to requirement in the rural area, there is no overall protein gap. However, protein, like calories, is unevenly distributed, with the rich taking enough and more and the poor what they can afford. A classification of calorie and protein consumption by expenditure by itself does not however make it possible to estimate these proportions of the population for urban and rural areas. To assess them one must turn

Table 3. *Levels of calorie and protein intake compared with respective requirements**

	Urban Maharashtra	Rural Maharashtra	Maharashtra State
Mean calorie intake per nutrition unit/d (kcal)	2550	2940	2890
Calorie requirement per nutrition unit/d (kcal)	3000	3000	3000
% calorie gap	−15	−2	−4
Mean reference protein intake per nutrition unit (g/d)	34·8	43·6	41·5
Reference protein requirement per nutrition unit (g/d)	35·7	35·7	35·7
% protein gap	−2	+22	+16

* Requirements shown in the table are at the retail level, i.e. the physiological level plus 10%.

to the distribution of the protein and calorie intake relative to the respective requirements.

Incidence of the gap. Ordinarily, in an adequately nourished population with no one calorie-deficient and assuming normal distribution, most households can be expected to have their calorie intake per nutrition unit higher than the critical limit given by the mean minus three times the standard deviation, i.e. $2700-3\times 200$, or 2100 kcal at the physiological level or 2300 kcal at the retail level (Sukhatme, 1961). It follows that in any observed distribution the proportion of households with calorie intake per nutrition unit below 2300 may be taken to provide an estimate of the incidence of the calorie gap in the population. Likewise, the proportion of households with protein intake per nutrition unit below 30 g of protein at the retail level can be taken to indicate the proportion of diets deficient in protein.

Table 4. *Incidence of protein and calorie deficiency in Maharashtra*

	Urban Maharashtra			Rural Maharashtra			All households		
	CD	NCD	% Subtotal	CD	NCD	% Subtotal	CD	NCD	% Subtotal
PD	35 (5·1)	6 (3·0)	41	18 (5·1)	4 (3·2)	22	23 (5·1)	5 (3·1)	28
NPD	11 (6·4)	48 (5·3)	59	8 (7·2)	70 (5·6)	78	9 (6·8)	63 (5·7)	72
	46	54	100	26	74	100	32	68	100

Figures in parentheses show values for NDpCal% of household diets.
CD, calorie-deficient; NCD, not calorie-deficient; PD, protein-deficient; NPD, not protein-deficient.

In Table 4 I have tabulated the values of these proportions for the bivariate distributions observed for Maharashtra. It will be seen that about one-third of the people in Maharashtra are calorie-deficient. The respective values for the urban and rural Maharashtra are 46% and 26% respectively. The proportion of diets which are protein-deficient is seen to be slightly smaller, being 28% for the State as a whole and 41% and 22% for urban and rural Maharashtra respectively. Broadly speaking, the incidence of the protein gap is seen to be nearly twice as large in the urban as in the rural area, but part of this difference must be ascribed to the use of the same requirement scales when in reality it is likely that calorie and protein needs of the urban population are lower than those of the rural population.

We can extend the analysis to estimate the proportion of people whose diet is deficient in both calories and proteins. This is done by calculating the proportion of households with calorie and protein intake below the respective critical limits. From Table 4 we find that this proportion is about one-quarter. The proportion is higher for urban than for rural Maharashtra, being one-third and one-sixth respectively.

Incidence of protein deficiency associated with inadequate calorie intake

In the analysis presented above it has been assumed that the utilizable protein in the diet is independent of the calorie intake. This assumption is not valid. There is abundant evidence to show that on a restricted calorie intake a man is not able to utilize the protein fully so as to meet his body needs. Equally, even without any restriction on calorie intake, intake of dietary protein higher than requirement does not appear to leave any benefit on protein balance (e.g. Calloway & Spector, 1954). Miller & Payne (1961) have shown that over and above the basal needs for metabolism a little over 6 calories is needed for the synthesis of 1 calorie of protein. Since a 'reference' man for India on average needs slightly less than 1400 kcal for basal metabolism it follows that the additional energy for anabolizing protein needed by a 'reference' man will be roughly $120 \times 6.2 = 750$ kcal. In other words, a 'reference' man will need to have a little over 2100 kcal at the physiological level, or approximately 2300 kcal at the retail level in order that he may be able to utilize fully the protein in his diet. This minimum value is approximately the same as the critical limit below which a man can be said to be calorie-deficient.

From Table 4 we see that nearly 10% of the total households, although receiving adequate protein, do not have adequate calories in the diet. Clearly this proportion must be added to the proportion of protein-deficient diets in order to obtain an estimate of the total incidence of protein undernutrition in the population.

The total incidence of protein undernutrition and relative shares of different diets therein

Let us classify diets according to whether they are deficient (D) or not (ND) in calories and proteins, as in the diagram below, and use A, B, E and F to denote the proportions of households in the four cells of the 2×2 classification

	CD	NCD
PD	A	E_1 ⋮ E ⋮ E_2
NPD	B	F

Then, the total incidence of protein undernutrition is given by

$$I = A + E + B. \quad (1)$$

Substituting from Table 4 we get

$$I = 28 + 9 = 37.$$

We see that whereas the incidence of protein deficiency when based on protein intake alone was 28%, it increased to 37% when the interrelationship between proteins and calories was taken into account. The respective values for the rural and urban areas of Maharashtra are seen to be

$$I \text{ urban} = 41 + 11 = 52,$$
$$I \text{ rural} = 22 + 8 = 30.$$

To leave out the contribution of diets which, although adequate in protein, are short of the needed calories for their utilization, thus amounts to underestimating the incidence of protein undernutrition by some 25%.

Table 4 shows that 60% of the total incidence of protein undernutrition can be traced to a diet A which is deficient in both protein and calories. Next in order of magnitude comes the share estimated at 25% of diet B, which is predominantly deficient in calories. The balance of 15% comes from diet E, which is predominantly deficient in protein. This picture of the relative shares of the different diets in the total incidence of protein undernutrition is seen to be about the same for urban and rural areas.

Although we have described E as representing a diet predominantly deficient in protein carrying an implication that it has adequate or more than adequate calories, not all households belonging to this cell will in fact have adequate calories in the diet. It is only households with calorie intake per nutrition unit exceeding the mean plus three times the standard deviation, or 3600, belonging to subcell E_2 of E in the diagram which can be considered as having adequate or more than adequate calories in the diet. The remaining households of cell E belonging to subcell E_1 will have a calorie intake which can be considered adequate on average only. It may be expected that individuals brought up on diet E_1 will develop subclinical signs of kwashiorkor and those brought up on diet E_2, representing the more severe cases, will be susceptible to kwashiorkor. A subdivision of cell E carried out in this way shows that the incidence of diets represented by E_2 amounts to about half of 1%. Further, this incidence is about the same in the urban and rural areas. If one were to take into account the standard error of the estimated proportion it would appear that the incidence of the more severe cases of protein-calorie deficiency is unlikely to exceed 1%.

Relative importance of low calorie and low protein intake in causing protein undernutrition

On a fixed adequate protein intake the calorie level is the deciding factor in protein retention and this level, based on the calculations by Miller & Payne (1961), turns out to be about the same as the value of the critical limit below which calorie deficiency arises. We can therefore express the incidence of protein undernutrition in such a way as to readily assess the relative importance of low calorie and low protein intake in causing protein undernutrition. Thus, combining the first and the third terms of equation (1) into one single term comprising all calorie-deficient households, we see that over 85% of the households which are protein-undernourished have diets deficient in calories. It would thus appear that by far the major part of protein undernutrition is the result of inadequate diet and the consequential undernutrition in relation to calories. Results of surveys conducted in Andhra, Madras and Bihar confirm these findings (Sukhatme, 1969, 1970).

Table 5. *Incidence of protein-calorie deficiency in preschool children in South India*

Age (1–5 years)	CD	NCD	
PD	22	0	22
NPD	54	24	78
	76	24	100

CD, calorie-deficient; NCD, not calorie-deficient; PD, protein-deficient; NPD, not protein-deficient.

Gopalan (1968, 1969) reports similar results. Table 5, based on his results, shows that the percentage of children with diets deficient in calories is over 70. By comparison the percentage of children with diets deficient in protein is only some 20. The incidence of frank signs of kwashiorkor in the children surveyed was 1–2% but there were no children with diets adequate in calories but deficient in protein. The influence of low calorie intake in causing protein deficiency thus appears to be even more predominant in the survey reported by Gopalan. The high incidence of calorie deficiency is evidently due to the preponderance of poor children in the community surveyed but this in no way detracts from the value of information the survey provides for assessing the relative importance of low calories and low protein in causing protein undernutrition and hence in developing measures to combat it. Gopalan's results are valuable for another reason. Protein deficiency primarily concerns the very young and it is the young who are covered in Gopalan's extensive survey of children in the south. His findings also do not have the weakness from which our findings suffer in that data available to us relate to households and not individuals.

That inadequate quantity of diet rather than the low protein content thereof is the principal factor accounting for the major part of protein undernutrition is also seen from the protein value of diets shown in Table 4. It will be seen that the diet represented by the term A, although deficient in both calories and protein, has NDpCal% equal to 5, which is about the value needed by adults in health. The principal need of individuals in this cell is for an increased quantity of diet which, along with more calories, will also bring more protein, possibly of better quality approaching the value of NDpCal% for the diet represented by cell F. The value of NDpCal% for the diet represented by the term B is more than adequate. The need of this cell is for more calories. For the diet represented by the term E the value of NDpCal% is however significantly lower than 5. The need of this cell is more and better protein. The need is particularly acute for individuals in subcell E_2 who, with NDpCal% of about 2, almost certainly may be expected to develop the pathological conditions associated with kwashiorkor. For the vast remaining majority who adapt themselves to available diet, low in calories and low in protein but with protein value about adequate for health, and who eventually establish some sort of equilibrium between body-weight, development and physical activity on the one hand and low intake of food on the other, the need is for more food of the type they are eating today.

That diets based on cereals and pulses commonly taken in India have a protein value adequate to cover protein needs of man at all ages has been shown by a number of workers (Payne, 1969; Aykroyd & Doughty, 1964). The exceptions are pregnant and lactating women who require a slightly higher concentration of utilizable protein than is present in the diet based on rice and pulses, though even here small supplements of milk can more than adequately cover needs. Infants are also exceptions since they cannot be given solid diet if they are weaned during the 1st year. Protein-rich foods of high biological value, such as milk and eggs, which along with better-quality protein also bring minerals and vitamins, have clearly a vital part to play. Further discussion is beyond the scope of this paper.

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Factors affecting the nutritional status of urban communities

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Introduction

Before embarking on the factors affecting the nutritional status of urban communities in developing and developed countries, it is important to examine briefly the status of their agriculture.