Nutrient adequacy and its correlation in a sub-Himalayan region of West Bengal, India

Sharmistha Bhattacharjee¹, Saikat Datta², Kuntala Ray¹, Dipta Kanti Mukhopadhyay³

Departments of ¹Community Medicine and ³Medicine, North Bengal Medical College, Darjeeling. ²Department of Community Medicine, College of Medicine and Sagore Datta Hospital, Kolkata, West Bengal, India

Introduction
Since earliest times, food and nutrition have always remained one of the darkest areas and the World has failed to tackle the situation completely. The 1996 World Food Summit brought back to center stage the issue of hunger and food insecurity as both cause and effect of poverty and slow growth. In the wake of this new push, reducing hunger and food insecurity also became one of the Millennium development goals, bringing with it the necessity by individual countries to measure progress in achieving the proposed targets.

A well-nourished population is important to a country’s long-term development and is a desirable outcome objective in itself. Unfortunately, the levels of child malnutrition in India are very high - 36.4% of urban Indian children are underweight, according to the National Family Health Survey 3 (NFHS3). Chronic energy deficiency in a similar proportion of adults suggests perpetuation of childhood malnutrition into adulthood.

The nutritional status of an individual is the outcome of a complex interaction of a broad range of host and environmental factors, the latter encompassing physical, biological, and especially sociocultural ones. It is thought that if people have access to sufficient quantity and variety of foods, they will meet their nutritional needs.

Address for correspondence: Dr. Sharmistha Bhattacharjee, Department of Community Medicine, North Bengal Medical College, Sushrutanagar, Darjeeling, West Bengal, India. E-mail: sharmistha.bhattacharjee@gmail.com

Abstract
Introduction: Nutrient adequacy is the level of intake of an essential nutrient in relation to the nutrient requirement for adequate health, which is expressed as the percentage of recommended dietary allowance. To develop an effective nationwide preventive program to combat malnutrition, it is necessary not only to assess the nature and magnitude of the problem of nutrient inadequacy but to identify factors affecting it especially at the household level. Objective: To estimate the prevalence of nutrient adequacy in a sample of households in a rural area of Darjeeling district and to find out the factors associated with nutrient adequacy. Materials and Methods: A community-based cross-sectional study was carried out from January 2014 to December 2014 in 821 households of Darjeeling district, India. The major dependent variable used in this study was the mean nutrient adequacy ratio of a household and the independent variables were number of family members, number of under-five children in the family, literacy of head of the family, literacy of the wife of the head of the family, income of the family, and percentage expenditure on food. Results: The prevalence of nutrient adequate households was found to be 35.3% among the study households. It was observed that the percentage expenditure on food had the highest contribution toward nutrient adequacy, followed by number of under-five children in the family and literacy of the wife of the head of the family. Undernutrition was found to be prevalent in 56.6% of the households. Conclusion: Majority of the study population had a diet less than the required amount and expectedly, undernutrition was also present in huge proportions.

Keywords: Household, nutrient adequacy, undernutrition

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Diet is one of the prime determinants of health and nutritional status. An inadequate diet, poor in both quality and quantity has been one of the reasons for high levels of malnutrition in children. In most of the settings, household is the basic unit for food consumption, and if there is sufficient food, individual members of the household can consume a diet with the recommended nutrient densities and meet their specific requirements. Assessing dietary adequacy in terms of quality and quantity at the household level is, therefore, important.

Adequacy implies that the food must satisfy the dietary needs of every individual, taking into account age, gender, body size, and physical activity level. To define quantitatively, nutrient adequacy is the level of intake of an essential nutrient in relation to the nutrient requirement for adequate health, which is expressed as the percentage of recommended dietary allowance (RDA).

The quantitative characterization of nutrient needs and its expression as nutrient adequacy have been considered as significant instruments of food and nutrition strategy in numerous countries and have engrossed the attention of global bodies.

To develop an effective nationwide preventive program to combat malnutrition, it is necessary not only to assess the nature and magnitude of the problem but also to identify factors affecting it especially at the household level. The present study aims to estimate the prevalence of nutrient adequacy in a sample of households in a rural area of Darjeeling district and to find out the factors, particularly those socioeconomic factors known to influence nutrition, associated with nutrient adequacy.

The decision to study only the effects of socioeconomic factors on nutrient intake was dictated by the consideration that the others are modifiable and can be readily manipulated to improve nutritional status. The factors included in the study were per capita income, education of both the head of the family and his wife, family size, and per capita expenditure on food.

**Materials and Methods**

A community-based cross-sectional study was carried out in Siliguri subdivision of Darjeeling district of West Bengal, India, from January 2014 to December 2014. The data employed in this study were collected from households in five villages under Matigara II Gram Panchayat, the villages under the field practice area of the Department of Community Medicine, North Bengal Medical College, West Bengal, India. Before starting the study, ethical approval was obtained from the Institutional Ethics Committee.

Since published data on nutrient adequacy in this part of the country were not available, the prevalence was assumed as 50% to yield maximum sample size. Sample size was calculated as 384 using the formula for single proportion

\[ n = Z^2 \left( \frac{1}{2} \right) P (1 - P)/\delta^2, \]

where \( Z_{1-\alpha/2} \) is the standard normal deviation at 95% confidence interval (1.96), \( P \) is the anticipated prevalence of nutrient adequacy (50%), \( \delta \) is absolute precision (5%). Considering the design effect of 2 and 10% nonresponse rate, the final sample size was 845.

Systematic sampling technique was used to select study households. First, all the 4280 households of the five villages in the rural field practice area were listed. Sampling interval was calculated by dividing the number of households by the sample size, which came out to be 5.1, rounded off to 5. Thus, every fifth household on the list was approached. On reaching the household, the family members were explained about the purpose of the study and their informed consent was taken.

Data were collected from the head of the family or any other responsible member by the investigators with the help of a validated, uniform questionnaire in the local vernacular. The questionnaire comprised of three different parts: Sociodemographic details, a dietary survey of the food consumed in the preceding 24 h and clinical exanimation, including anthropometric measurements.

Sociodemographic variables included age and sex of individual family members, religion, family income, and literacy status of the head of the family and his wife. Dietary survey included food intake by the family members in the 24 h preceding the survey. Food intake was converted into nutrient intake by employing the Indian food composition tables. Average calorie and protein requirements were estimated for each member of each household using the Indian Council of Medical Research (ICMR) standards.

The major dependent variable used in this study was the nutrient adequacy ratio (NAR) of a household. To estimate the nutrient adequacy of the diet, NAR was calculated for 10 nutrients (energy, protein, fat, Vitamin A, riboflavin, thiamine, Vitamin C, calcium, and iron). NAR was calculated for each nutrient as the ratio of daily individual intakes to standard recommended amounts for subject's sex and age category. Mean NAR (MAR) was calculated as described according to the formula below:

\[ MAR = \Sigma NAR \text{ (each truncated at 1)/number of nutrients}, \]

where \( NAR = \text{daily nutrient intake/recommended amount} \) of nutrient. The mean NAR measures whether a household is consuming more or less than, or the equivalent of, its need. A value of 100 specifies that the intake of nutrient is equal to the recommended intakes, and a value below 100 specifies lower than the recommended intake for one or more nutrients.

Per capita income of the family was calculated by dividing the total family income by the number of the family members. Anthropometry included height and weight measurement using standard protocol. Body mass index (BMI) was calculated by dividing weight in kg by square of height in meters. For children
under 5 years, the BMI was plotted against age in months in the new WHO growth chart and was interpreted accordingly.\textsuperscript{[11]} Undernutrition was considered if any adult member of the family had their BMI <18.5 or the BMI for any under-five child fell below -2SD of the WHO growth standards.\textsuperscript{[11]}

Completed questionnaires were collated and entered in MS Excel datasheet after proper data cleaning activities (validation, range, and consistency checks). Data were analyzed using SPSS for Windows, Version 16.0. Chicago, SPSS Inc. The categorical data were expressed in frequencies and percentages in tabular form; Chi-square test was applied for analysis.

Linear regression analysis was used for statistical analysis. In this analysis, mean NAR was used as the dependent variables, the predictor variables included number of family members, number of under-five children in the family, literacy of head of the family and his wife, per capita income of the family, and percentage expenditure on food.

**Results**

Out of the 845 households approached for the study, 24 participants refused to participate in the study (response rate 97.2\%). Thus, the sample population included 821 households with 4708 individuals, who were investigated for 1-day oral (24 h recall) diet survey. The mean age of the family members was 27.2 ± 10.2 years. The sociodemographic profiles of the families show that 89.6\% of families followed Hinduism in 60.2\% of the families. There were more than five family members, and 639 families had a per capita income less than Rs. 1500, where literacy was concerned; the heads of families were illiterate in 242 families whereas in 60.7\% families, the wives were illiterate.

It is evident from Table 1 that the mean NAR of a family was significantly associated with presence of literacy status of both head of the family and his wife, number of family members, per capita income, and percentage expenditure on food. The prevalence of nutrient adequate households was found to be 35.3\% among the study households.

Table 2 shows that mean NAR was positively associated with per capita income, expenditure on food, literacy status of head of the family and his wife, and negatively associated with family size and number of under-five children in the family. This model could be explained in 15.9\% of cases.

From the regression results, it was observed that the percentage expenditure on food had the highest contribution toward nutrient adequacy, followed by number of under-five children in the family, literacy of the wife of the head of the family. Other variables had negligible contribution toward nutrient adequacy.

The regression model for this purpose can be best expressed as follows: NAR = 93.313 + 1.380 (number of family members) – 3.0 (number of under-five children in the family) + 0.309 (literacy of head of the family) + 2.719 (literacy of the wife of the head of the family) + 3.901 (percentage expenditure on food).

Thus, applying the above model, approximately 13.2\% of the total variation in nutrient adequacy can be best explained.

Undernutrition was found to be prevalent in 56.6\% of the households [Figure 1]. Undernutrition in the family was associated significantly with mean NAR, percentage expenditure on food, family size, and literacy of the wife of the head of the family. The relation between undernutrition and per capita income of the family and educational status of the head of the family was not found to be statistically significant [Table 3].

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Table 1: Relation between mean NAR and characteristics of the study population (n=821)

| Per capita income (in Rs.) | Mean NAR | Tests of significance | Total |
|----------------------------|----------|-----------------------|-------|
| <1500 | 386 (60.4) | 253 (39.6) | 639 (100) | \( \chi^2=23.009 \) df=1, \( P=0.000 \) |
| 1500 or more | 145 (79.7) | 37 (20.3) | 182 (100) | \( \chi^2=6.946 \) df=1, \( P=0.008 \) |
| Percentage of expenditure on food | \( \chi^2=58.435 \) df=1, \( P=0.000 \) |
| <50% | 159 (88.8) | 20 (11.2) | 179 (100) | \( \chi^2=31.275 \) df=1, \( P=0.000 \) |
| 50% or above | 372 (57.9) | 270 (42.1) | 642 (100) | \( \chi^2=23.009 \) df=1, \( P=0.000 \) |
| Family size | \( \chi^2=23.009 \) df=1, \( P=0.000 \) |
| <5 | 174 (53.2) | 153 (46.8) | 327 (100) | \( \chi^2=31.275 \) df=1, \( P=0.000 \) |
| 5 or more | 357 (72.3) | 137 (27.7) | 494 (100) | \( \chi^2=23.009 \) df=1, \( P=0.000 \) |

Table 2: Linear regression analysis between mean NAR as dependent variable and other factors as predictor variables (n=821)

| Beta | SE | Significant | 95\% CI |
|------|----|-------------|--------|
| Adjusted \( R^2=0.132 \) | | | |
| Constant | 93.313 | 4.053 | 0.000 | 85.357-101.269 |
| Number of family members | -1.380 | 0.318 | 0.000 | -2.004-0.756 |
| Number of under five children in the family | -3.000 | 0.925 | 0.001 | -4.816-1.184 |
| Literacy of head of the family | 0.309 | 0.585 | 0.598 | -0.840-1.457 |
| Literacy of the wife of the head of the family | 2.719 | 0.733 | 0.000 | 1.280-4.159 |
| Per capita income of the family | 0.000 | 0.002 | 0.858 | -0.003-0.003 |
| Percentage expenditure on food | 3.901 | 1.605 | 0.015 | 0.750-7.052 |

Dependent variable: NAR; Predictor variables: Number of family members, number of under five children in the family, literacy of head of family, literacy of the head of the family, income of the family, percentage expenditure on food. NAR: Nutrient adequacy ratio; SE: Standard error; CI: Confidence interval
Figure 1: Prevalence of undernutrition among the study households
$n=821$

Table 3: Factors associated with undernutrition in the households (n=821)

| Undernutrition | Present | Absent | Total | Tests of significance |
|----------------|--------|--------|-------|-----------------------|
| Mean NAR       |        |        |       |                       |
| <100           | 317 (59.7) | 214 (40.1) | 531 (100) | $\chi^2=5.773$, df=1, $P=0.01$ |
| ≥100           | 148 (51.0) | 142 (49.0) | 290 (100) |                       |
| Per capita income (in Rs.) |        |        |       |                       |
| <1500          | 358 (56) | 281 (44) | 639 (100) | $\chi^2=0.441$, df=1, $P=0.51$ |
| 1500 or more   | 107 (58.8) | 75 (41.2) | 182 (100) |                       |
| Percentage of expenditure on food |        |        |       |                       |
| <50%           | 88 (49.2) | 91 (50.8) | 179 (100) | $\chi^2=5.210$, df=1, $P=0.02$ |
| 50% or above   | 377 (58.7) | 265 (41.3) | 642 (100) |                       |
| Family size    |        |        |       |                       |
| <5             | 148 (45.3) | 179 (54.7) | 327 (100) | $\chi^2=28.649$, df=1, $P=0.00$ |
| 5 or more      | 317 (64.2) | 177 (35.8) | 494 (100) |                       |
| Literacy of HOF (in completed years) |        |        |       |                       |
| No education   | 154 (63.6) | 88 (36.4) | 242 (100) | $\chi^2$ for linear trend=1.510 |
| <5 years       | 132 (41.6) | 185 (58.4) | 317 (100) |                       |
| 5 years or more| 179 (68.3) | 83 (31.7) | 262 (100) | df=1, $P=0.22$         |
| Literacy of wife of HOF (in completed years) |        |        |       |                       |
| No education   | 309 (62) | 189 (38) | 498 (100) | $\chi^2$ for linear trend=38.59 |
| <5 years       | 90 (71.4) | 36 (28.6) | 126 (100) |                       |
| 5 years or more| 66 (33.5) | 131 (66.5) | 197 (100) | df=1, $P=0.00$         |
| Total          | 465 (56.6) | 356 (43.4) | 821 (100) |                       |

Figures in parentheses indicate percentage. NAR: Nutrient adequacy ratio; HOF: Head of the family

Discussion

Nutritional status can be seen as the output of a health production function in which nutrient intake is one input, but in which other individual, household, and community variables also feature. Dietary intake in terms of caloric intake is often considered to be a strong proxy for nutritional status, even though it is one of the immediate causes of malnutrition.

The RDAs are standards for nutrient intake designed to meet the nutrient needs of virtually all healthy individuals and are often used as the basis for determining whether nutrient intake is adequate. In India, these guidelines have been developed by the ICMR.[8] Evidence suggests that nutrient intake is influenced by many sociodemographic attributes. Income is an important factor in determining nutrition and provides an index of the purchasing capacity of the family. In 1980, the World Bank stated in its report that the serious and extensive nutritional deficiencies that exist in almost all of these countries are “largely a reflection of poverty, people do not have enough income for food.”[14] With the improvement of household income, absolute expenditure on food is likely to go up, as is the caloric and protein intake of the household.[15] In the present study, both per capita income of the family and percentage expenditure of income on food was significantly associated with mean NAR. Likewise, in a study done among seniors in Ontario, Keller et al. concluded that income was a major contributing factor of nutrient inadequacy.[16]

The association between parental education and the dietary intake of a household has been dealt in many studies around the world.[17,18] It is expected that better-educated parents are able to provide more wholesome diets in their family due to their ability to identify the nutritious value of food. A study done by Galobardes et al. in Geneva showed that lower education contributed to determining differences in dietary habits and dietary intake.[19] Just as in the present study, better literacy status of the head of the household and his wife were associated significantly with a higher mean NAR. In two different studies done among Spanish and Indian children, educational status of the mother was found to be a major determining factor of nutrient adequacy.[20,21]

Family size affects the dietary intake of the family in such a way that the allocation of food per member is likely to decrease with the increase in the number of household members, which, in turn, may have a negative effect on per capita nutrient intake. In a study done in rural Bangladesh, family size was shown to have a negative effect on nutrient adequacy.[17] In the present study also, family size was adversely associated with mean NAR. However, in a study done in a marginal community of El Salvador, no association was found between caloric sufficiency and family size.[22]

Malnutrition is the result of inadequate dietary intake. The present study also states the same fact as is evident from Figure 1. Undernutrition was present in more than half of the households which can be corroborated with NFHS3 results which states undernutrition was more common in rural households.[23] Studies done among children and adults of North Bengal have reported very high prevalence of undernutrition.[24,25] The underlying reasons of malnutrition are multidimensional, including economic, social, and political factors.[26] Poverty has
been widely acknowledged as both a cause and consequence of malnutrition, but has been obscured and bypassed as the main determinant to tackle when choosing solutions to combat malnutrition in the developing countries. A study done in Philippines by Garcia and Pinstrup-Andersen found that in households with severely malnourished members, insufficient income was the most limiting factor. Quite contrarily, in the present study undernutrition was not significantly associated with per capita income of the family. This can be due to the fact that majority of the study households had a lower per capita income.

According to Anand and Harris, food expenditure per capita is a better and more dependable indicator of well-being than income. Surprisingly, in the present study, malnutrition was significantly more prevalent in the households with higher percentage expenditure on food. This can be explained by assuming that there was inter-familial maldistribution of food.

Maternal education plays an important role in determining nutritional status of children and the family, as a whole. The present study reveals that malnutrition was significantly higher in the households with an illiterate mother. In another study done in Iran, stunting in children was found to be significantly associated with lower maternal education. In studying the correlates of undernutrition in children under 3 years of age by Mahgoub et al., a negative relationship between the number of under three children in the family, family income, maternal education, and the nutritional status (underweight) of children was found.

Family size may have an inverse relationship with undernutrition present in the family. A larger family size was seen to be associated with an increased risk of severe acute malnutrition among under-five children in a case–control study done in Ethiopia by Amsalu and Tigabu. Corroborating with these findings, our study points out the fact that in families with 5 or more members, undernutrition was significantly associated. In a study in Bangladesh by Das et al., chronic malnutrition in 12–23 months of age was found to be associated with households having large family size, poor wealth index, and maternal illiteracy.

The limitation of the study was that intra-familial distribution of food could not be measured which may have contributed to undernutrition. In addition, the issue of food security was not addressed, which may have played a role in the underweight status. In addition, 24 h recall method of dietary survey, though widely accepted, has the inherent limitation that it depends on the reliability of household consumption estimates.

**Conclusion**

The present study has brought forth important and useful information regarding the pervasiveness of nutrient inadequacy and expectedly, undernutrition in the study area. Socioeconomic status and illiteracy were found to be the major predictors. Improved access to food and better nutrition for the rural population can only be achieved on a sustainable basis if these underlying causes are addressed. All these issues and challenges need to be addressed in a pragmatic and intersectoral manner to achieve better health for the nation and the community at the large.

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**Conflicts of interest**

There are no conflicts of interest.

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