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# Do Dietary Diversity Indices Reflect the Nutritional Status of School Aged Children?

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## Abstract

*Dietary Diversity, with foods from all food groups is necessary to meet the requirements for essential nutrients which lead to good health. This study examines whether different dietary diversity indices have relationship with the nutritional status of school children aged 6 to 12 years, in two different regions of India: Wardha district, Maharashtra and Koraput district, Odisha. Dietary diversity was calculated using three methods: Individual food scores calculated using 24 hour diet recall ($FS_{24hr}$) data; household dietary diversity using Berry's index (DDI) and food scores calculated using food frequency data ($FS_{FFQ}$). Anthropometric indices were used to assess the nutritional status of school aged children. The Nutrient Adequacy Ratio (NAR) and the Mean Adequacy Ratio (MAR) were calculated as indicators of nutrient adequacy. The relationship between NAR, MAR and three different diversity indices, dietary diversity and anthropometric indices were analyzed. Overall, 38% of 6 to 12 year school aged children were found to be undernourished. The NAR was <70% for all nutrients except protein, energy, thiamine and niacin and MAR was found to be <70% of requirement with mean of 60.5% in both locations. The dietary diversity was found to be relatively better in Wardha when compared with Koraput. The mean diversity indices in both the locations were $FS_{24hr}$ 7.56, DDI 89 and $FS_{FFQ}$ 62.9. Overall most of the nutrient adequacy and mean adequacy were correlated with all three dietary diversity indices when both locations were studied together. However all three dietary diversity indices failed to show any relationship with nutritional status of school children aged 6-12 years from both locations taken together.*

**Keywords:** *Dietary diversity, food scores, anthropometric parameters, nutritional status*

## Introduction

Dietary diversity is widely recognized and accepted as a determinant of nutritional outcome[1]. It has been long accepted as a key element of high quality diet[2-4]. The dietary guidelines for recommended food intake of most countries across the globe have been formulated keeping dietary diversity as the basis to ensure adequate intake of essential nutrients. Consuming different foods in a day significantly contributes to the mean probability of nutrient adequacy, independent of the energy intake[5]. In developing countries, lack of food diversity is a major problem among poor populations as their habitual diet is predominately cereal-based and dominated by starchy staples[6]. The focus of a large body of research has been on balanced and diversified diets especially in relation to nutritional deficiencies and their consequences[7].

Some studies highlight low dietary diversity as the primary cause for under-nutrition[8,9]. The methods used to measure dietary diversity differ widely between studies[6]. Many researchers have studied dietary diversity by using dietary scores calculated by simple counting of food groups and relating these scores with health indicators. FAO[10] recommends the 24-hour diet recall method to calculate dietary diversity. Food frequency is also used to calculate dietary diversity[11]. Taking frequency of food intake at different points of a year also helps to capture aspects of seasonal variability in diet. Berry's index (Simpson's index) is a Dietary Diversity Index (DDI) that is used to evaluate dietary diversity in terms of number as well as distribution and quantity of consumption of different food items[12,13]. This index is mostly used in large sample studies.

Agricultural production diversity is positively associated with dietary diversity, and dietary diversity is in turn correlated with nutritional outcomes in children[1,11,14-16]. About 58 per cent of rural households in India are dependent on agriculture[17]. A large percentage of the rural population is also undernourished. A report of the National Nutrition Monitoring Bureau (NNMB) covering 10 states of India showed that 33 % of school aged children 5 to 9 years and 40 and 42 % of 10 to 13 year school aged children in Maharashtra and Odisha respectively were undernourished[18]. A Farming System for Nutrition (FSN) study under the research programme on Leveraging Agriculture for Nutrition in South Asia (LANSA) is currently ongoing in Wardha district of Maharashtra and Koraput district of Odisha state in India, both of which are high burden states, to examine the feasibility of crop and animal husbandry interventions and their impact on nutritional outcomes[19].

A detailed baseline survey was undertaken in 2014 in selected villages in the two districts as part of the FSN study, to assess the nutrition status of the population, food sourcing and consumption patterns. The objective of the present paper is to examine whether dietary diversity calculated using three different methods reflects the nutritional status of 6 to 12 year old school aged children.

## Materials and Methods

### *Study area*

Eight villages in Wardha district in Maharashtra and eleven villages in Koraput district in Odisha were selected for the study. These locations were purposively selected due to their characteristic contrast with regard to agro-climatic and socio-economic conditions, land holding status, agricultural practices and food consumption pattern. Though both sites are rain-fed farming areas, Koraput is characterised by subsistence farming, while Wardha is dominated by commercial crop cultivation. Both the sites are also characterized by high levels of under-nutrition[19]. There were 148 children in the school age group of 6 to 12 years in Wardha and 271 children in Koraput.

### *Nutritional Status*

#### Anthropometric parameters

The height and weight of individual children aged 6 to 12 years were measured using standard equipment (Seco weight balance and stadiometer) by investigators trained in the methodology of the National Institute of Nutrition (NIN), Hyderabad. Z scores were calculated using Anthroplus (2007) software of the WHO. The prevalence of under nutrition was categorized according to age / sex specific Body Mass Index (BMI) recommended by the WHO using Standard Deviation classification.

#### Food Intake pattern

Food intake pattern was studied using i) information on frequency of different foods consumed based on monthly recall, collected from all households during three consecutive time periods at four monthly intervals in a year (2014) in order to capture the seasonal variation and ii) one-time 24-hour diet recall method: subsamples of 300 households were selected from each district. The calculated data was compared with Recommended Dietary Intake (RDI) given by Indian Council of Medical Research[20].

#### Nutrient Adequacy Ratio

The Nutrient Adequacy Ratio (NAR) was calculated for 11 nutrients including energy using 24-hour diet recall data. The NAR for a given nutrient is the ratio of a child's intake to the Recommended Dietary Allowances[20] for the child's sex and age. As an overall measure of the nutrient adequacy, the Mean Adequacy Ratio (MAR) was calculated. NAR was truncated at one so that a nutrient with high NAR could not compensate for nutrient with a low NAR[21].

$$MAR = \frac{\sum NAR\ (each\ truncated\ at\ 1)}{Number\ of\ nutrients}$$

#### Dietary Diversity

Three methods were used to calculate the dietary diversity, the first using data from the one-time 24-hour diet recall survey and the other two using the 3 rounds of food frequency data:

1. Food scores using 24-hour diet recall method ($FS_{24hr}$): The food intake collected once using 24-hour diet recall method was used for calculating the foods consumed per day as given by FAO[22]. The foods were categorized into 13 food groups as recommended by Indian Council of Medical Research[20]. Simple counting of food groups was done to arrive at food scores and scores ranged from 1 to 13.

2. Berry's Index (DDI): The value of monthly consumption was calculated for each of the three rounds using the frequency and quantity of food consumed. A uniform modal price (most frequently occurring price for a food item across households) was used for calculating the value of the food item consumed by each household. This amount was added up for the three rounds and the share of each food item in the total value of foods consumed was derived. DDI was calculated using the formula:

$$DDI = \frac{1}{\sum_i^n (s_i^2)} X\ 100$$

where,

DDI: Dietary Diversity Index for a household

$S_i$ : Share of value of i[th] food stuff out of total value of food consumed calculated using the formula:

$$s_i = \frac{VF_i}{\sum_1^n VF_i}$$

$VF_i$ : Value of i[th] Food stuff

Higher DDI implies higher is the diversity in a household's food basket.

3. Food scores using food frequency ($FS_{FFQ}$): The frequency of consumption for the different food groups was recorded for a reference period of preceding one month i.e. daily, twice or thrice a week, once a week, fortnight and occasionally. The following scores were given: consumed daily: 7, twice or thrice a week: 3, once a week: 1, fortnightly: 0.5, monthly: 0.25 and occasionally: 0, following Hooshmand and Udipi[11]. The scores were added to get the food diversity score for the household. Food diversity scores ranged from 1 to 91, (i.e. if all 13 food groups are consumed daily the maximum score will be 91).

### *Statistical methods*

SPSS (IBM Version 20) and Stata (12.1) were the statistical packages used to study the associations. A 'bivariant Pearson's correlation' was applied to understand the relationship between NAR, MAR and dietary diversity; and dietary diversity and nutritional status.

## Results and Discussion

### *Nutritional Status*

About 37.9% of school aged children 6-12 years were under nourished in both the locations taken together, with 47.3% under nourished children in Wardha and 32.8% in Koraput. The children had mean BMI Z scores of –1.69 which shows that overall the children are on the borderline of under nutrition. Table I shows the summary of BMI Z scores and prevalence of under nutrition in school aged children.

### *Food intake pattern*

Both Wardha and Koraput have cereal based diet. In Koraput, the mean consumption of cereals mainly rice at 456 g/day was 165 % higher than the recommended amount; in Wardha, mean consumption of cereals (wheat followed by rice) at 246 g/day, was less than the recommended level. Ragi or finger millet is consumed in Koraput daily but in lower quantities. Figure 1 shows the average consumption of food groups by 6 to 12 year children compared to recommended levels.

About 44g/day of pulses and legumes were consumed by the children in Wardha and Koraput, against 60 g/day of recommended amount. When compared, children of Koraput have higher intake of vegetables than Wardha although lower than the recommended levels. Consumption of milk and milk products, fruits, meat, fish and poultry consumption was found to be in very negligible amounts. Sugars were consumed in higher quantities in Wardha (23g/day), 6% more than the recommended levels.

### *Nutrient Adequacy*

Table II shows the Nutrient Adequacy Ratio (NAR) and Mean Adequacy Ratio (MAR) of individual nutrients in school aged children 6-12 years. As both the locations have cereal based diet, NAR of calories and nutrients like protein, thiamine and niacin was >70% and that of fat and vitamin A was >50% of recommended

**TABLE I**

**Summary of Anthropometric Characteristics and Prevalence of Under Nutrition in School Aged Children (6-12 years)**

| Category | Wardha (n=148) | | Koraput (n=271) | | Total (n=419) | |
|---|---|---|---|---|---|---|
| | Mean | ±SD | Mean | ±SD | Mean | ±SD |
| BMI Z scores | -1.85 | 1.11 | -1.60 | 0.96 | -1.69 | 1.02 |
| Thinness % (BMI Z scores < -2 SD) | 47.3 | — | 32.8 | — | 37.9 | — |

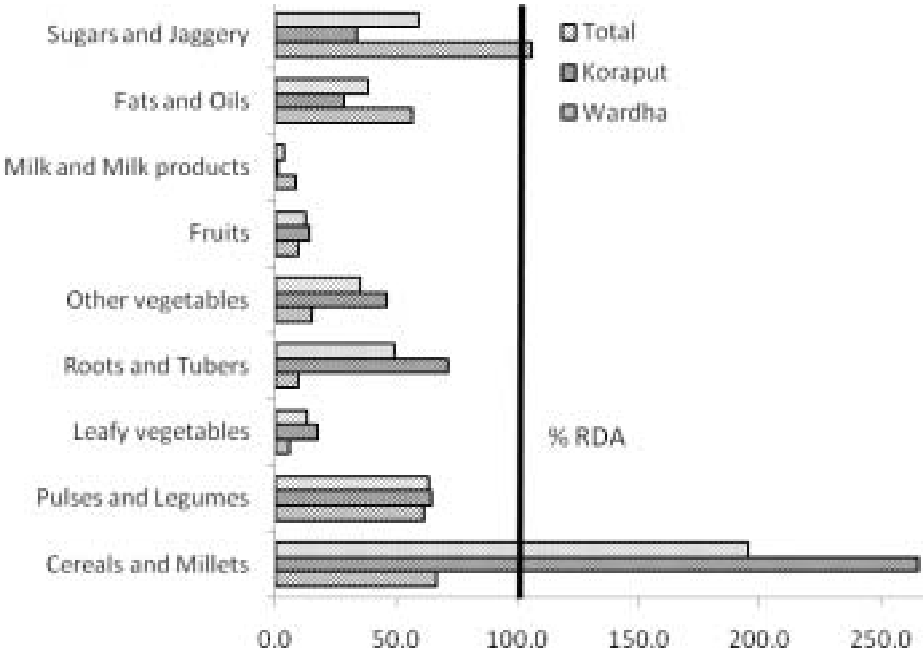


**Figure 1**

**Average food group consumption (g/day) in 6 to 12 years school aged children**

levels. MAR in both the locations was <70% of recommended levels showing that the mean adequacy of nutrients from diet is very less.

### *Dietary Diversity Indices*

Dietary diversity calculated using three methods showed that dietary diversity in Wardha is relatively better than in Koraput. Food scores calculated using 24-hour diet recall was 8.1 in Wardha and 7.3 in Koraput out of 13. Overall both the locations have approximately 8 food groups in their daily diet; Dietary diversity calculated using Berry's index (DDI) was 89 out of 100; $FS_{FFQ}$ was 63 out of 91. Table II shows the different mean dietary diversity scores.

### *Relationship between NAR, MAR and Dietary diversity indices*

Table III shows the correlation between the three diet diversity indices and NAR and MAR. It is observed that in Wardha, all nutrients other than thiamine are significantly correlated with the dietary diversity score calculated using 24-hour diet recall ($FS_{24hr}$). This can be attributed to wheat being the staple cereal consumed. As NAR and MAR were calculated using 24-hour diet recall data, $FS_{24hr}$, it showed significant correlation with most of the nutrients.

**TABLE II**

**Mean Adequacy Ratio (MAR), Nutrient Adequacy Ratio (NAR) and Dietary Diversity Scores**

| Particulars | Nutrients | Wardha (n=148) | | Koraput (n=271) | | Total (n=419) | |
|---|---|---|---|---|---|---|---|
| | | Mean | ±SD | Mean | ±SD | Mean | ±SD |
| NAR (%) | Protein | 91.9 | 16.6 | 97.19 | 9.36 | 95.3 | 12.7 |
| | Fat | 61.7 | 26.2 | 43.17 | 24.88 | 49.7 | 26.8 |
| | Energy | 71.2 | 23.1 | 92.25 | 14.68 | 84.8 | 20.7 |
| | Calcium | 28.9 | 15.8 | 47.60 | 25.71 | 41.0 | 24.4 |
| | Iron | 65.0 | 26.3 | 54.12 | 23.02 | 58.0 | 24.7 |
| | Vitamin A | 51.2 | 29.9 | 53.23 | 37.66 | 52.5 | 35.1 |
| | Thiamine | 93.7 | 22.6 | 76.20 | 22.02 | 82.4 | 23.7 |
| | Riboflavin | 46.1 | 45.6 | 54.09 | 24.25 | 51.3 | 33.6 |
| | Niacin | 76.8 | 23.8 | 80.92 | 19.59 | 79.5 | 21.2 |
| | Folic acid | 31.7 | 16.9 | 27.73 | 15.15 | 29.1 | 15.9 |
| | Vitamin C | 32.2 | 25.7 | 55.75 | 33.04 | 47.4 | 32.6 |
| MAR (%) | | 58.9 | 19.7 | 61.43 | 16.81 | 60.5 | 17.9 |
| Dietary | $FS_{24hr}$ | 8.06 | 1.52 | 7.28 | 1.53 | 7.56 | 1.57 |
| Diversity | DDI | 94.0 | 3.0 | 86.0 | 5.0 | 89.0 | 6.0 |
| | $FS_{FFQ}$ | 70.63 | 3.58 | 58.81 | 3.84 | 62.99 | 6.78 |

NAR - Nutrient Adequacy Ratio; MAR - Mean Nutrient Adequacy Ratio

Combined dietary diversity index calculated using Berry's index (DDI) showed significant correlation with NAR for most of the nutrients except protein, vitamin A, niacin and folic acid. In the case of dietary diversity calculated using food frequency ($FS_{FFQ}$), apart from vitamin A and riboflavin adequacy, all other nutrients showed significant correlations with NAR.

The overall mean adequacy ratio of nutrients was found to be significantly correlated with $FS_{24hr}$ and DDI.

**Relationship between Dietary Diversity Indices and nutritional status of school aged children**

Dietary diversity calculated using 24-hour diet recall and food frequency did not show any relationship with the BMI Z scores of school aged children 6-12 years of Wardha and Koraput taken together, as seen from Table IV. Only in the case of Wardha, dietary diversity score calculated by Berry's index showed positive correlation with BMI Z scores; implying that if the dietary diversity increases, the BMI Z scores also

**TABLE III**

**Correlation between NAR, MAR and Diet Diversity Indices**

| Nutrients | | Wardha (n=148) | | | Koraput (n=271) | | | Total (n=419) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $FS_{24hr}$ | DDI | $FS_{FFQ}$ | $FS_{24hr}$ | DDI | $FS_{FFQ}$ | $FS_{24hr}$ | DDI | $FS_{FFQ}$ |
| NAR | Protein | 0.218** | 0.042 | -0.125 | 0.01 | 0.124* | -0.034 | 0.055 | -0.069 | -.206** |
| (%) | Fat | 0.493** | -0.049 | 0.209* | 0.426** | 0.033 | 0.055 | 0.491** | 0.226** | 0.333** |
| | Energy | 0.299** | -0.044 | 0.008 | 0.026 | 0.082 | -0.085 | 0.01 | -0.292** | -0.426** |
| | Calcium | 0.347** | -0.178* | 0.284** | 0.331** | -0.028 | -0.046 | 0.210** | -0.274** | -0.289** |
| | Iron | 0.179* | 0.01 | -0.003 | 0.229** | -0.042 | -0.167** | 0.249** | 0.117* | 0.119* |
| | Vitamin A | 0.490** | 0.018 | 0.205* | 0.405** | -0.011 | 0.101 | 0.409** | -0.022 | 0.049 |
| | Thiamine | 0.103 | -0.173* | -0.044 | 0.200** | -0.083 | -0.064 | 0.234** | 0.161** | 0.264** |
| | Riboflavin | 0.327** | -0.184* | 0.101 | 0.356** | -0.113 | 0.015 | 0.286** | -0.160** | -0.066 |
| | Niacin | 0.195* | -0.123 | -0.012 | 0.054 | -0.004 | -0.069 | 0.084 | -0.084 | -0.103* |
| | Folic acid | 0.248** | -0.192* | 0.037 | 0.374** | -0.051 | 0.017 | 0.343** | 0.019 | 0.113* |
| | Vitamin C | 0.365** | -0.139 | 0.223** | 0.400** | -0.037 | 0.043 | 0.271** | -0.264** | -0.240** |
| MAR (%) | | 0.391** | -0.139 | 0.127 | 0.476** | -0.133* | -0.042 | 0.412** | -0.0139** | -0.045 |

** $p<0.01$, * $p<0.05$

increases *i.e.* health status improves. However, DDI has the limitation of being a household level index.

## Discussion

Balanced diets and dietary diversity are gaining more importance nowadays, the underlying principle being that variety/diversity will ensure adequate intake of essential nutrients and hence promote good health[23]. Studies have proved that food scores built from food groups prove to have stronger relationship with health outcomes[2,24]. An association between dietary diversity and nutritional status of preschool children[1,11,15] has been established by different studies.

From the present study it has been observed that school aged children in both locations consume cereal based diets and have less dietary diversity. It was also clear that most of nutrient

**TABLE IV**

**Correlation between Dietary Diversity and Nutritional Status of School aged Children**

| Dietary Diversity indices | Wardha (n=148) | Koraput (n=271) | Total (n=419) |
|---|---|---|---|
| $FS_{24hr}$ | 0.007 | -0.067 | -0.065 |
| DDI | 0.211** | -0.067 | -0.076 |
| $FS_{FFQ}$ | 0.055 | 0.058 | -0.066 |

** $p<0.01$

adequacy ratios were correlated with the dietary diversity when data from both locations are pooled together; however all three dietary diversity indices do not show any relationship with the nutritional status of school aged children. When both locations are studied separately, dietary diversity calculated using Berry's index (DDI) showed a relationship with nutritional status only in Wardha. However nutrient adequacy was not seen to correlate with dietary diversity calculated using Berry's index and the index indicates household dietary diversity and does not reflect consumption by the school age child. All three dietary diversity indices failed to show any relationship with the nutritional status of 6 to 12 year school aged children. Some other studies[16,25,26] have also shown that there is no association between dietary diversity and nutritional indicators in children. Bukania *et al* [27] reported that child nutritional status was dependent on household food security (availability of food) and not dietary diversity. Dietary diversity at household level also does not necessarily translate into the diversity of diet at individual level but can be seen as a measure of access to a diverse food basket for individuals. There are various other factors at individual level (other than dietary diversity) like individuals' preferences, absorption rate (that is affected by hygienic practices), physical activity and physiological status and social practices around gender that may influence nutritional outcomes[28].

The different methods to measure dietary diversity have their limitations. Berry's index has been used mainly to study economic food diversity[12]. It uses food prices and income as economic factors influencing demand for diverse foods[29]. Many studies have explained the association of dietary diversity with health outcomes with the help of food scores. But Bukania *et al*[27], report that food scores may lead to an underestimation of food insecurity. The other disadvantage of using food scores is that they do not consider quantities of individual foods consumed.

## Conclusion

The limitation of using a single 24-hour diet recall round with sub sample data to calculate dietary diversity is that it gives a snapshot of the village or community at one time point; potential bias of under and over reporting will cloud the true dietary diversity of the location. To find statistical association between dietary intake and health status of an individual, data on food intake for larger number of days are required; for a group on the other hand, data on relatively smaller number of days of food intakes are required[30-32]. Further, a single 24-hour recall may not accurately reflect the usual intake of an individual, since the lack of variety on a given day does not mean that there is no diversity. It has been suggested that there is a need to pursue efforts to improve the measurement approaches; a better understanding is also needed of the best method to use for different purposes[6]. These findings suggest that dietary diversity indices are not an effective indicator which reflects the nutritional status of 6 to 12 year school aged children.

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