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Food variety—a good indicator of nutritional adequacy of the diet? A case study from an urban area in Mali, West Africa

A Hatløy[1], LE Torheim[1] and A Oshaug[1]

[1]*Institute for Nutrition Research, University of Oslo, Box 1046 Blindern, N-0316 Oslo, Norway*

Objective: This study assesses whether a simple count of food items and food groups can predict the nutritional adequacy of the diet in an economically poor country.
Design: A three-day weighed record of children.
Setting: Koutiala town, in Southeastern Mali.
Subjects: Seventy-seven children, 13–58 months of age. One child was excluded owing to an extraordinarily low food variety.
Intervention: The study was conducted in April–August 1995. Data from this study were used to create two different indices: Food Variety Score (FVS), a simple count of food items, and Dietary Diversity Score (DDS), a count of food groups. Mean Adequacy Ratio (MAR) was calculated as an indicator for nutrient adequacy, and used to validate FVS and DDS.
Results: Mean (s.d.) FVS was 20.5 (3.8) and mean (s.d.) DDS was 5.8 (1.1). A positive correlation was found both between FVS and MAR (Pearson 0.33, $P < 0.001$) and DDS and MAR (Pearson 0.39, $P < 0.001$). With cut-off points for FVS at 23 and for DDS at 6, the indices have high ability to identify those with a nutritionally inadequate diet. MAR increased with increasing FVS and DDS. FVS needs to be at least 15 or DDS at least 5 to give a satisfactory MAR.
Conclusion: Although a simple count of food items or food groups cannot give a full picture of the adequacy of the nutrient intake, the results from this study show that the food scores can give a fairly good assessment of the nutritional adequacy of the diet, particularly if combined. Such indicators are important for identification of vulnerable groups in areas where people normally eat from a shared bowl, which makes detailed dietary intake studies difficult, time consuming and expensive.
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Descriptors: Africa; dietary assessment methods; dietary diversity; food variety; Mali; mean adequacy ratio

Introduction

The nutrients essential to meet nutritional requirements are not all found in a single food item (with the exception of human breast milk in the first months of life) but come from a diet composed of a number of foods (Hsu-Hage & Wahlqvist, 1996). Healthy diets are said to be those that are the most varied. Diverse diets have been shown to protect against chronic diseases such as cancer (Vecchia *et al*, 1997), as well as being associated with prolonged longevity (Kant *et al*, 1995) and improved health status (Hodgson *et al*, 1994). Several dietary guidelines have long emphasised the value of eating a variety of foods (Sandstrom *et al*, 1996; Drewnowski *et al*, 1997). A measure of the nutritional quality of the diet may therefore be its diversity.

Relatively few studies have assessed dietary variety or addressed its effect on the total diet (Drewnowski *et al*, 1997). The few existing studies have mainly been carried out in rich countries (Krebs-Smith *et al*, 1987; Kant *et al*, 1991; Drewnowski *et al*, 1997). Conventional dietary studies are time consuming and costly, and under certain conditions almost impossible to conduct. There is therefore a need for simple, low-cost methods for the assessment of the nutritional quality of diets. The challenge is to find tools that are precise enough to give the information needed and simple enough to be used in large field-surveys. The challenges are even bigger when dealing with an illiterate population eating from shared bowls, as is the situation in many African countries. Proper methods are lacking for this kind of survey.

This paper assesses the association between food variety/dietary diversity scores and the nutritional adequacy of the diet of children in areas where traditional dietary assessment methods are difficult, expensive and time consuming.

Correspondence: A Hatløy
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Study area and subjects

The study area

The study was conducted in Koutiala town in Southeast Mali, towards the borders of Burkina Faso and Ivory Coast. According to the census of 1987 (Bureau Central de Recensement, 1990), the town had around 48 000 inhabitants. Rainfall is mainly adequate, and the area is self-sufficient in cereals. A variety of fruits and vegetables are cultivated, and wild-growing plants are eaten widely (Nordeide *et al*, 1996). Because of its relatively favourable climatic situation and its agricultural resources, the region has long been considered a relatively privileged area where malnutrition was not considered as a priority health problem. However there has been seen an increasing level of malnutrition in the region during the past years (Bouvier *et* *al*, 1995), and the question of the nutritional quality of the diet is relevant.

Subjects
Seventy-seven children less than 5 years of age participated in this study, 42 girls and 35 boys (see Table 1). The criteria for participation were that the child was weaned and had not yet reached the age of 5 years. One child was excluded from the analysis because of an extremely low food variety—only four different food items had been eaten during the three-day registration period (sorghum, sugar, oil and fruit juice). As all the other children had an intake of at least 13 different food items during the registration period, this child was an extreme outlier.

The study participants were randomly selected from the 12 administrative sectors (AS) of Koutiala town. The number of children drawn from each AS was proportional to the number of inhabitants. The first household in each AS was chosen randomly from a list of inhabitants obtained from the town hall, and the subsequent households were chosen randomly by taking the neighbour household next-door at left-hand side. If a household had more than one eligible child, the child to be studied was chosen randomly.

The study protocol was approved by the Malian National Research Institute (Centre National de la Recherche Scientifique et Technologique). Verbal consent was obtained from the survey participants after the nature of the study had been fully explained to them.

Methods

Dietary assessment
Four trained local research assistants under continuous supervision of a nutritionist collected the dietary data. The data collection took place between April and August 1995, a period that corresponds to the end of the dry season and beginning of the rainy season.

The food intake was weighed over three consecutive days for 67 of the children and over two days for 9 of the children. Because no statistical significant difference was discovered between the two groups in food variety and dietary diversity, all the children were pooled. All foods and beverages consumed were weighed using Soehnle kitchen scale (2.5 g accuracy, 0–5 kg). Each ingredient was weighed during the preparation of a meal to collect the recipes of the dishes consumed.

In order to weigh the diet consumed, individual portions were served to the children in separate bowls. This practice differs from the usual eating habit of Malian children, who normally eat from a common plate with other family members. The bowl was weighed empty, and each food items was weighed when added. After the child had eaten, the leftovers were measured, and the child's net intake could be calculated. The research assistants spent about 9 hours per day in the household. If something was consumed while the research assistant was not present, the food was identified and the quantity estimated.

Daily intakes of food and nutrients were computed using a food database for Mali (Nordeide, 1997) and a software system developed at the Institute for Nutrition Research, University of Oslo.

Food Variety Score
Food Variety Score (FVS) was defined as the *number of different food items* eaten during the registration period. All food items were given the same weight. The method was modified from Krebs-Smith *et al* (1987) and Drewnowski *et al* (1997). The total number of foods included in FVS was 75, independently of the quantity consumed. This included all the food items shown in Table 2, and also about 40 additional foods consumed by less than 10% of the children.

Diet Diversity Score
A Diet Diversity Score (DDS) was defined as the *number of food groups* consumed by each child, modified from Kant *et al* (1991, 1995). The score included eight groups: staples, vegetables, milk, meat, fish, egg, fruits and green leaves. The maximum score was 8, one point given for each group consumed during the registration period.

Nutrient adequacy
To estimate the nutrient adequacy of the diet, a Nutrient Adequacy Ratio (NAR) was calculated for the energy intake and 10 nutrients (Table 3). The NAR for a given nutrient is the ratio of a subject's intake to the current recommended allowance for the subject's sex and age category (Madden *et al*, 1976; Guthrie & Scheer, 1981). The NAR of energy and protein intake of the children is based on the average daily energy requirements, and safe level of protein intakes on the basis of age and sex (WHO, 1985). The NAR of the percentage contribution of energy from fat is based on recommended energy distribution from the Nordic Recommended Dietary Allowances (Sandstrom *et al*, 1996). The NAR of the average daily intake of selected vitamins and minerals was calculated on the basis of the American Recommended Dietary Allowances (National Research Council, 1989).

As an overall measure of the nutrient adequacy, the Mean Adequacy Ratio (MAR) was calculated as described by Madden *et al* (1976):

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

We have used the average of the 10 NARs mentioned in Table 3 (except thiamin, which was adequately consumed by all the children). NAR was truncated at 1 so that a nutrient with a high NAR could not compensate for a nutrient with a low NAR.

Data analysis
Statistical Package for Social Sciences (SPSS, 1997) was used to conduct all the statistical analyses. As MAR and FVS were close to normally distributed (DDS with only eight values was not tested for normality), parametric statistics were used. Because the intakes of most of the nutrients were not normally distributed, nonparametric statistics were used in the analysis of the nutrients and NAR.

FVS and DDS were evaluated for sensitivity and specificity with MAR as the 'gold standard' of nutritionally adequate intake. Sensitivity is the proportion of positives that are correctly identified by the test, while specificity is the proportion of negatives that are correctly identified by the test (Altman, 1997). Positives were here defined as FVS or DDS below a given cut-off point. Different cut-off points were tested to find the levels of FVS and DDS that would give a high sensitivity without losing too much specificity. Those with a nutritionally inadequate diet, here defined as

MAR below a certain cut-off point, and FVS or DDS below the cut-off point were defined as true positives. Those with a nutritionally adequate diet, or MAR greater than the cut-off point, and FVS or DDS above the cut-off point were defined as true negatives.

Linear regression was used to estimate MAR scores for different levels of FVS and DDS.

Results

Food variety and dietary diversity

All the children had eaten some kind of cereal, mainly sorghum, rice, millet or maize (Table 2). All except one child had oil in their dishes. Other items eaten by more than 90% of the sample were onion, tomato puree, beef cube and 'soumbala'—a product made of fermented grains of *Parkia biglobosa* (Nordeide *et al*, 1996) (all ingredients used in sauces); in addition, sugar was also used by more than 90% (Table 2). In total, 66% of the children had consumed at least one milk product during the registration period. The fish used by more than 80% of the children was mainly small pieces of dried, smoked fish used as spice in the sauce. The first part of the study (April to June) was carried out in the mango season, when 76% of the children studied had eaten mangoes, while only 13% of the children in the last part (August) had eaten mango (data not shown). Green leaves, dry or fresh, were eaten by 74% of the children. Leaves from baobab were the most frequently used (Table 2).

Table 1 Summary of the subjects' characteristics. Children less than 5 years of age (Koutiala, April–August 1995). (Values are mean (s.d.))

Characteristics	*Girls*[a] ($n=41$)	*Boys*[a] ($n=35$)	*Total* ($n=76$)
Age (months)	35 (9)	36 (13)	35 (11)
Weight (kg)	12.1 (2.0)	12.6 (2.6)	12.3 (2.3)
Height (cm)	89 (7)	91 (10)	90 (9)
Food Variety Score[b]	20.8 (3.7)	20.1 (4.0)	20.5 (3.8)
Dietary Diversity Score[c]	5.9 (1.0)	5.7 (1.1)	5.8 (1.1)
Mean Adequacy Ratio	0.78 (0.11)	0.77 (0.10)	0.77 (0.10)

[a]No statistical differences between the sexes.
[b]Food Variety Score (FVS): number of all food items used in the study period (0–75).
[c]Dietary Diversity Score (DDS): number of food groups eaten (1–8): staples, vegetables, milk, meat, fish, egg, fruits and green leaves.

Seventy-five different food items in total were eaten by the children during the registration period, corresponding to a theoretical maximum of the Food Variety Score (FVS) of 75. The mean FVS was 20.5 (Table 1), the minimum registration of FVS was 13 and the maximum 29. Mean value of Dietary Diversity Score (DDS) was 5.8. For DDS the theoretical range was 1 to 8, while in the sample it varied from 3 to 8. There was no difference in FVS and DDS between girls and boys.

Table 2 Food groups and food items used at least once during a 3-day weighed recorded survey in Koutiala town in April–August 1995 ($n=76$ children aged 13–58 months). These food groups were the basis for calculation of Dietary Diversity Score

Food groups[a]	*Frequency*	*Food items*[b]
Staples	100%	> 80%: Groundnuts (*Arachis hypogaea*) > 70%: Rice (*Oryza sativa*), sorghum (*Sorghum* spp.) > 60%: Millet (*Eleusine* spp.) > 40%: Wheat bread, macaroni > 30%: Maize (*Zea mays*) > 20%: Beans (*Vigna uncuiculata*) > 10%: Potato (*Solanum tuberosum*), yam (*Dioscorea* spp.), bambara groundnuts (*Voandezia subterranea*)
Vegetables	99%	> 90%: Onion (*Allium cepa*), 'soumbala' (*Parkia biglobosa*) > 80%: Peppers (*Capsicum pubescens*), ladies-fingers (*Hibiscus esculentus*) > 70%: Tomato (*Lycopersicon esculentum*) > 20%: Eggplant, native (*Solanum macrocarpon*), shea butterseed (*Butyrospermum parkii*), garlic (*Allium sativum*) > 10%: Eggplant (*Solanum melongena*)
Fruit	77%	> 40%: Mango (*Mangifera indica*) > 20%: Lemon (*Citrus limon*) > 10%: Gumvine (*Saba senegalensis*), banana (*Musa sapientum*), coconut (*Cocos nucifera*)
Meat	69%	> 50%: Beef > 20%: Mutton
Milk	66%	> 40%: Cow milk (fermented) > 20%: Milk powder, cow milk (fresh)
Fish	83%	> 80%: Dry fish
Egg	7%	–
Green leaves	74%	> 40%: Baobab (*Adansonia* spp.) > 30%: Red sorrel leaves (*Hibiscus sabdariffa*) > 10%: Amaranth (*Amaranthus* spp.), bean leaves (*Vigna uncuiculata*)
Other	100%	> 90%: Beef cube, oil, tomato puree, sugar > 10%: Sweets, cake

[a]Food groups: in Dietary Diversity Score (DDS) all groups except 'other' were included. [b]Food items eaten by more than 10% of the children; in addition ~40 items were eaten by less than 10% of the children. In the Food Variety Score (FVS) all the food items were included.

Table 3 Intake of nutrients together with recommended or safe level of intake and prevalence of inadequate intake of the nutrient among children in Koutiala town ($n = 76$, aged 13–58 months)[a]

	Intake/person/day					
	Median	Q_{25}	Q_{75}	*Recommended/safe level of intake (RDA)*[b]	*Median NAR*[c]	*Proportion of children with intake below RDA*
Energy (MJ/d)	5.5	4.6	7.1	4.8–7.1[d]	1.18	58%
Protein (g/kg/d)	2.2	1.6	2.5	1.1–1.3[e]	1.58	9%
Fat (% of energy)	22	16	26	30[f]	0.73	93%
Vitamin A[g] (μg/d)	132	68	323	400	0.33	83%
Vitamin C (mg/d)	24	16	43	45	0.53	78%
Thiamin (mg/10 MJ)	1.6	1.5	1.8	1.2	1.36	0%
Riboflavin (mg/10 MJ)	0.8	0.7	1.1	1.4	0.59	90%
Niacin (mg/10 MJ)	18.9	16.1	22.5	15.7	1.19	22%
Folic acid (g/kg/d)	5.2	3.0	7.5	3.4	1.53	30%
Iron (mg/d)	22	16	31	10	2.16	4%
Calcium (mg/d)	383	216	645	800	0.48	84%

[a]Mean intake over 3 days for 67 children, over 2 days for 9 children. [b]Recommendation for daily intake for children from National Research Council (1989) is used except where otherwise indicated. [c]NAR (Nutrient Adequacy Ratio) = actual intake/recommended intake. [d]FAO/WHO/UNU average daily energy requirements on the basis of age and sex (WHO, 1985). [e]FAO/WHO/UNU safe level of daily protein intake on the basis of age (WHO, 1985). [f]Energy distribution recommended in the Nordic recommendations is used (Sandstrom *et al*, 1996). [g]Includes μg retinol $+\frac{1}{6}$ β-carotene $+\frac{1}{12}$ other carotenoids.

Nutrient adequacy

The proportion of children with a nutrient intake below the recommendations varied between the nutrients. All the children had a sufficient intake of thiamin with a Nutrient Adequacy Ratio (NAR) above 1. Even though folic acid had a higher median NAR than thiamin, 30% had an intake of folic acid below the recommendations. Vitamin A had the lowest median NAR (only 0.33) and 83% of the children had an intake below the RDA. Even though the median NAR for the fat energy percentage was 0.73, as many as 93% had an intake below the requirements (Table 3).

Table 4 shows the correlation between the two different scores and the nutrient adequacy expressed as NAR for different nutrients. Neither FVS nor DDS correlated significantly with other nutrients than vitamin C, vitamin A and the fat energy percentage. Nevertheless, both of them correlated strongly with Mean Adequacy Ratio (MAR), as an overall score for the nutritional adequacy of the diet. The correlation coefficient between MAR and DDS was 0.39 (Table 4).

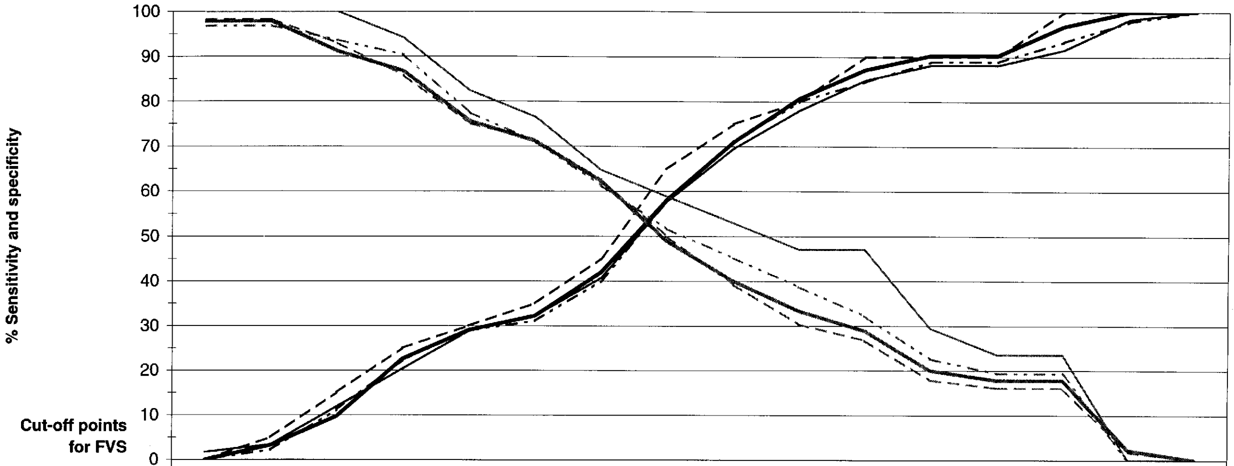
Table 4 Pearson's correlation coefficient between Nutrient Adequacy Ratio (NAR) of some nutrients and Food Variety Score (FVS) or Dietary Diversity Score (DDS) ($n = 76$ children aged 13–58 months in Koutiala town, 1995).

	FVS[a]	*DDS*[b]
NAR energy (MJ/d)	0.01	−0.02
NAR fat energy percentage	0.29*	0.30**
NAR protein (g/kg/d)	0.01	0.08
NAR iron (mg/d)	−0.15	−0.02
NAR riboflavin (mg/10 MJ)	0.12	0.22
NAR niacin (mg/10 MJ)	−0.07	−0.13
NAR vitamin C (mg/d)	0.38**	0.29*
NAR calcium (mg/d)	0.01	0.17
NAR folic acid (g/kg/d)	0.13	0.03
NAR vitamin A (g/d)	0.27*	0.30**
Mean Adequacy Ratio (MAR)	0.33**	0.39**

[a]Number of all food items used in the study period
[b]Number of food groups eaten (1–8): staples, vegetables, milk, meat, fish, egg, fruits and green leaves.
*Correlation is significant at the 0.05 level.
**Correlation is significant at the 0.01 level.

Overall, the mean MAR was 0.77 (Table 1). The ideal cut-off for nutrient adequacy should be 1, which would mean that all nutrients were covered. In this survey none of the children reached this level. Seventy-five per cent had MAR greater than or equal to 0.70; 60% of the children had MAR greater than or equal to 0.75; and only 5% had MAR greater than or equal to 0.85. In Figure 1 different cut-off points of FVS were tested for sensitivity and specificity against different definitions of a nutritionally adequate diet ranging from MAR = 0.70 to MAR = 0.85. This was done in order to find an optimal cut-off point for FVS that can identify as many inadequate diets as possible as inadequate (high sensitivity), without losing too much ability to identify those with a nutritionally adequate diet (specificity). The figure shows that the sensitivity and the specificity were very little influenced by changing the cut-off points of MAR. In the following we will therefore use MAR = 0.75 as cut-off point for a nutritionally adequate diet. To get sensitivity of FVS higher than 85%, the cut-off for FVS must be 23 or higher, while to get a specificity of at least 20%, the cut-off for FVS needs to be 24 or lower. With a cut-off for FVS on 23, the sensitivity will be 87% and the specificity 29%. If the cut-off for FVS had been increased by one, the sensitivity would have been somewhat increased, to 90%, but the specificity would decrease to 20%. On the other hand, if the cut-off had decreased by one, the sensitivity would have dropped to 81%, and the specificity would have increased to 33%.

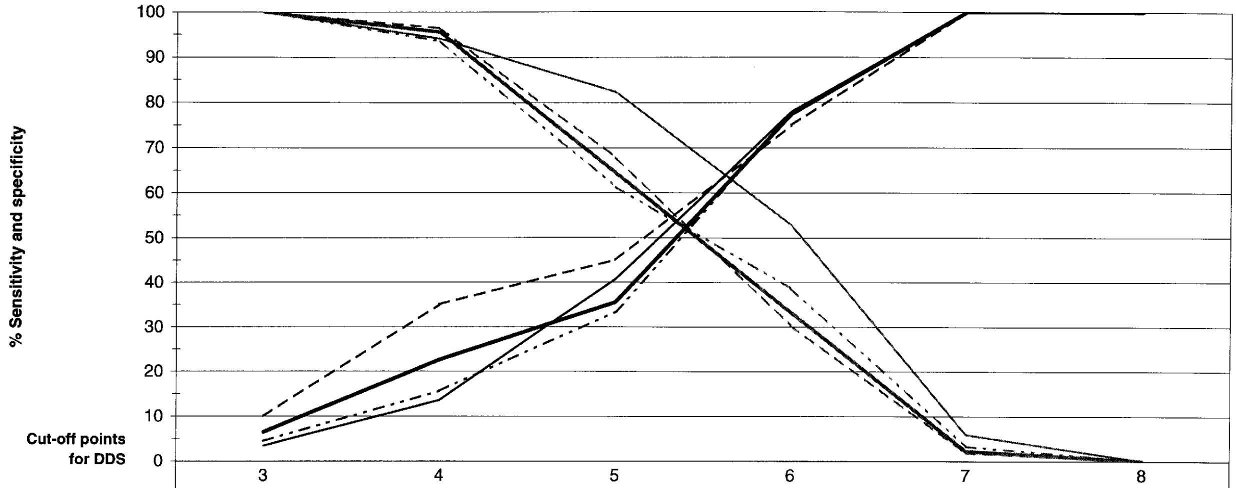
The same kind of exercise was undertaken to decide the cut-off point for DDS. As shown in Figure 2, a cut-off point for DDS equal to 6 gave a sensitivity of 77% and a specificity of 33%. If the cut-off point had been increased to 7, the sensitivity would have been 100% and the specificity only 2%. Decreasing the cut-off point to 5 would have decreased the sensitivity to 35%, while the specificity would be 64%. Thus a cut-off point for DDS of 6 is, in this study, the only one that gives both a sensitivity higher than 75% and a specificity higher than 30%.



Cut-off points for FVS	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	29
Sensitivity – – MAR 0.70	0	5	15	25	30	35	45	65	75	80	90	90	90	100	100	100
Sensitivity ▬ MAR 0.75	0	3	10	23	29	32	42	58	71	81	87	90	90	97	100	100
Sensitivity · · – MAR 0.80	0	2	11	22	29	31	40	58	71	80	84	89	89	93	98	100
Sensitivity —— MAR 0.85	2	3	12	20	29	32	41	58	69	78	85	88	88	92	98	100
Specificity – – MAR 0.70	98	98	93	86	75	71	63	50	39	30	27	18	16	16	2	0
Specificity ▬ MAR 0.75	98	98	91	87	76	71	62	49	40	33	29	20	18	18	2	0
Specificity · · – MAR 0.80	97	97	94	90	77	71	61	52	45	39	32	23	19	19	0	0
Specificity —— MAR 0.85	100	100	100	94	82	76	65	59	53	47	47	29	24	24	0	0

Sensitivity and specificity (%) for different cut-off points of Food Variety Score

Figure 1 Sensitivity and specificity of different cut-off points for FVS with cut-off points of MAR changing from 0.70 to 0.85 *Sensitivity MAR 0.70–0.85* = Sensitivity for a given cut-off point of FVS with a cut-off point for MAR varying from 0.70 to 0.85. *Specificity MAR 0.70–0.85* = Sensitivity for a given cut-off point of FVS with a cut-off point for MAR varying from 0.70 to 0.85. Sensitivity = identify nutritionally inadequate diets as inadequate; specificity = identify nutritionally adequate diets as adequate.



Cut-off points for DDS	3	4	5	6	7	8
Sensitivity – – – MAR 0.70	10	35	45	75	100	100
Sensitivity ▬ MAR 0.75	6	23	35	77	100	100
Sensitivity · · · – MAR 0.80	4	16	33	78	100	100
Sensitivity —— MAR 0.85	3	14	41	78	100	100
Specificity – – – MAR 0.70	100	96	68	30	2	0
Specificity ▬ MAR 0.75	100	96	64	33	2	0
Specificity · · · – MAR 0.80	100	94	61	39	3	0
Specificity —— MAR 0.85	100	94	82	53	6	0

Sensitivity and specificity (%) for different cut-off points of Dietary Diversity Score

Figure 2 Sensitivity and specificity of different cut-off points for DDS with cut-off points of MAR changing from 0.70 to 0.85. *Sensitivity MAR 0.70–0.85* = Sensitivity for a given cut-off point of DDS with a cut-off point for MAR varying from 0.70 to 0.85. *Specificity MAR 0.70–0.85* = Sensitivity for a given cut-off point of DDS with a cut-off point for MAR varying from 0.70 to 0.85. Sensitivity = identify nutritionally inadequate diets as inadequate; specificity = identify nutritionally adequate diets as adequate.

To what extent do FVS and DDS determine the MAR? Our data show an increasing MAR with increasing DDS and FVS (Table 5). It seems, however, that the FVS needs to be at least 15 in order to give a MAR above 0.75. Similarly, it seems that DDS needs to be at least 5 in order to give a satisfactory MAR. This seems to be confirmed by the theoretically estimated MAR, using the results from a linear regression model (Table 6). Here in order to achieve a MAR greater than 0.75 with a DDS of 4 one will need FVS of at least 30. With a DDS of 7, the FVS can be as low as 10 (Table 6). It seems easier to achieve a satisfactory level of MAR by an increased DDS rather than an increased FVS. A DDS of 7 gives a MAR above 0.75 already at FVS as low as 10.

The results from the regression model (see Table 6, footnote) show that it is only DDS that contributes significantly to the fit of the model. Controlling for age, number of household members, illnesses during the two previous weeks and nutritional status (weight for height and height for age) did not change the conclusions, and therefore is not shown here.

Table 5 Mean MAR scores for different levels of Food Variety Score (FVS) and Dietary Diversity Score (DDS) ($n=76$ children aged 13–58 months in Koutiala town, 1995)

Dietary Diversity Score (DDS)	*Food Variety Score (FVS)*			
	11–15	*16–20*	*21–25*	*26–30*
3	–	0.60 ($n=2$)	–	–
4	0.65 ($n=4$)	0.77 ($n=2$)	0.67 ($n=1$)	–
5	0.78 ($n=3$)	0.77 ($n=12$)	0.81 ($n=3$)	–
6	–	0.75 ($n=14$)	0.76 ($n=10$)	0.82 ($n=3$)
7	–	0.81 ($n=4$)	0.80 ($n=10$)	0.83 ($n=7$)
8	–	–	–	0.96 ($n=1$)

Table 6 Estimated MAR scores for different levels of Food Variety Score (FVS) and Dietary Diversity Score (DDS) from a linear regression model ($n=76$ children aged 13–58 months in Koutiala town, 1995)

Dietary Diversity Score (DDS)	*Food Variety Score (FVS)*					
	5	*10*	*15*	*20*	*25*	*30*
1	0.57	0.59	0.61	0.62	0.64	0.66
2	0.60	0.62	0.64	0.65	0.67	0.69
3	0.63	0.65	0.67	0.68	0.70	0.72
4	0.66	0.68	0.70	0.71	0.73	0.75
5	0.69	0.71	0.73	0.75	0.76	0.78
6	n.a.	0.74	0.76	0.78	0.79	0.81
7	n.a.	0.77	0.79	0.81	0.82	0.84
8	n.a.	0.80	0.82	0.84	0.85	0.87

$MAR = 0.522 + 0.0302*DDS + 0.0036*FVS$

Linear regression model: Dependent variable: MAR
Predictors: DDS and FVS

R^2	*Adjusted* R^2	*SE of estimate*	*Significance*
0.165	0.142	0.097	0.001

Unstandardized coefficients

	β	*SE*	*T*	*Significance*
Constant	0.522	0.068	7.74	< 0.001
FVS	0.0036	0.004	0.93	0.357
DDS	0.0302	0.014	2.19	0.032

Discussion

This survey has shown that it is possible to predict the nutritional adequacy of the diet by counting food groups in a Dietary Diversity Score (DDS), and that this score is a better predictor than a simple food count (FVS). Such scores can provide simple indicators to be used in large-scale demographic and nutritional surveys, which often tend to avoid food consumption indicators. It can also be used as an indicator in monitoring of projects.

Our results are similar to earlier studies on food group scores and dietary nutritional adequacy (Guthrie & Scheer, 1981; Ries & Daehler, 1986; Schuette *et al*, 1996). The use of food groups in those studies was based on the assumption that diets with foods from all food groups will give an adequate dietary intake.

It is difficult to compare our results for the FVS with former studies as each study has its own definition of what a food item is. But even with those limitations, our results are similar to those from most studies, showing a positive correlation between number of foods eaten and nutritional adequacy (Randall *et al*, 1985; Krebs-Smith *et al*, 1987). Only one survey has found a negative correlation between food variety and nutrient adequacy (Drewnowski *et al*, 1996), but in that study French eating habits were compared with the US dietary recommendations. The discrepancy in results may therefore be due to methodological weaknesses.

The results from our study show that food and dietary scores can identify fairly well the children with an inadequate nutrient intake. With cut-off points for FVS at 23 and for DDS at 6, the indices have high ability to identify those with an inadequate diet, but lower ability to identify those with a nutritionally adequate diet. This has also been shown by Schuette *et al* (1996). They point out that as sensitivity and specificity are inversely related, an increase in one typically relates to a decrease in the other, as shown in Figures 1 and 2. For nutrition promotion and prevention of malnutrition, a high sensitivity is desirable to identify accurately most subjects at nutritional risk (Habicht *et al*, 1982), as long as false positives do not cause other risks. False positives do not pose any risk in this case.

In an assessment of how to select optimal cut-off points for FVS and DDS for an adequate diet, one might think that the choice of cut-off point for MAR would have a strong influence. Figures 1 and 2, however, show that changing the cut-off point for MAR from 0.70 to 0.85 did not have any vital importance for the conclusions. However, we recommended 0.75 as the cut-off point for MAR, the same as used by Schuette *et al* (1996). This is supported by the results in Tables 5 and 6, where it is quite clear that to reach a MAR of 0.75, one needs DDS of at least 5 and FVS higher than 20.

FVS counts all the food items consumed, even condiments used in sauces. Used alone it can therefore give a falsely favourable impression of the quality of the diet. A high DDS, however, will reflect a consumption of foods from several of the food groups, and such a diet may therefore also have a higher nutritional quality. It is interesting to note here that in the regression model with MAR as the dependent variable, only DDS contributed significantly to the fit, indicating that FVS is a poorer predictor for MAR than DDS, at least in a linear model. These findings are important because a fairly accurate estimation of DDS is easier to get than of FVS. It also makes sense in nutritional terms, since a high DDS corresponds to dietary recommendations in several countries (National Research Council, 1989; Sandstrom *et al*, 1996), while this is not necessarily the case for FVS.

In constructing a DDS one can take into account both nutritional aspects and the local food culture. By creating different food groups, critical issues can be given greater importance in a locally adapted DDS. In our construction we have emphasised high-status foods by dividing them into four different animal food groups: meat, fish, egg and milk. As all the children have eaten either fish or meat, they are thereby given different values in the DDS if they have eaten both or only one of the groups. As in previous studies (Kant *et al*, 1993, 1995; Drewnowski *et al*, 1996) fat sources and sugar were excluded from the DDS. We ran analyses with cooking oil and sugar included, and it made no difference to the results (data not shown). One may encounter situations, however, where inclusion of cooking oil and sugar give important information both on the quality of the diet and on the socioeconomic situation. Therefore, in an African setting one should always consider including a separate energy-dense food group.

In our study we used 2–3 days' weighed records to construct the MAR that is used as the external reference against which FVS and DDS have been compared. The limitations of the weighed records is said to be under-reporting, under-representation of 'usual diet' over an insufficient number of days and distortion of food habits due to the recording process (Nelson, 1997). We consider the reliability of the MAR to be relatively good here. The project supervisor closely followed the data collection, and methodological issues were regularly discussed throughout the study. The fact that the children were served in separate bowls, instead of eating from the common family plate, may have influenced the results, but it was not observed that the children's diet varied from that of the rest of the family. The only way it might have influenced the results is on the quantity, not on the quality. This will not have influenced the FVS and DDS, but might have increased the MAR in some extent. The effects of a weak reliability would probably have weakened the associations and not established new ones.

The most serious threat to findings in dietary studies is weak validity, in particular with regard to differential misclassification. The children included in the study were chosen randomly, and there was no indication that some caregivers systematically influenced the quantity and quality of foods and dishes given to the children because of our presence. The construction of the DDS was done after the data collection, which should exclude a frequent systematic misclassification due to the way questions are posed and the respondent's answer. Thus we cannot see that there should be a systematic bias influencing the results. It is therefore doubtful whether any of the findings are due to biases in the results.

One might question the external validity of the study. The study was carried out in an urban area, with a relatively high availability of food. The conclusions here may therefore only be valid for similar urban settings, but the methods and approaches are equally valid for rural areas. Development of simple analytic tools for collecting information on predictors for nutritional adequacy is a stepwise process. In this article we have focused on the association between Food Variety Scores/Dietary Diversity Scores constructed from a food intake study and the nutritional adequacy of the diet of children. This study indicates that these scores are useful tools. It remains, however, to show whether simple methodology for assessing food intake (such as 24 h or 48 h dietary recall) can yield similar results. Further validation studies are therefore needed.

Although the DDS and the FVS cannot give a full picture of the adequacy of the nutrient intake, the results from this study show that such food scores can give a fairly good indication of the nutritional adequacy of the diet, in particular when they are combined. Such indicators are important for identifying vulnerable groups in areas where people normally eat from shared bowls, which makes detailed dietary intake studies difficult, time consuming and expensive.

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