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Food variety and dietary diversity scores in children: are they good indicators of dietary adequacy?

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Abstract

Objective: To assess whether a food variety score (FVS) and/or a dietary diversity score (DDS) are good indicators of nutrient adequacy of the diet of South African children.

Methods: Secondary data analyses were undertaken with nationally representative data of 1–8-year-old children ($n = 2200$) studied in the National Food Consumption Study in 1999. An average FVS (mean number of different food items consumed from all possible items eaten) and DDS (mean number of food groups out of nine possible groups) were calculated. A nutrient adequacy ratio (NAR) is the ratio of a subject's nutrient intake to the estimated average requirement calculated using the Food and Agriculture Organization/World Health Organization (2002) recommended nutrient intakes for children. The mean adequacy ratio (MAR) was calculated as the sum of NARs for all evaluated nutrients divided by the number of nutrients evaluated, expressed as a percentage. MAR was used as a composite indicator for micronutrient adequacy. Pearson correlation coefficients between FVS, DDS and MAR were calculated and also evaluated for sensitivity and specificity, with MAR taken as the ideal standard of adequate intake. The relationships between MAR and DDS and between anthropometric *Z*-scores and DDS were also evaluated.

Results: The children had a mean FVS of 5.5 (standard deviation (SD) 2.5) and a mean DDS of 3.6 (SD 1.4). The mean MAR (ideal = 100%) was 50%, and was lowest (45%) in the 7–8-year-old group. The items with the highest frequency of consumption were from the cereal, roots and tuber group (99.6%), followed by the 'other group' (87.6%) comprising items such as tea, sugar, jam and sweets. The dairy group was consumed by 55.8%, meat group by 54.1%, fats by 38.9%, other vegetables by 30.8%, vitamin-A-rich by 23.8%, other fruit by 22%, legumes and nuts by 19.7% and eggs by 13.3%. There was a high correlation between MAR and both FVS ($r = 0.726$; $P < 0.0001$) and DDS ($r = 0.657$; $P < 0.0001$), indicating that either FVS or DDS can be used as an indicator of the micronutrient adequacy of the diet. Furthermore, MAR, DDS and FVS showed significant correlations with height-for-age and weight-for-age *Z*-scores, indicating a strong relationship between dietary diversity and indicators of child growth. A DDS of 4 and an FVS of 6 were shown to be the best indicators of MAR less than 50%, since they provided the best sensitivity and specificity.

Conclusion: Either FVS or DDS can be used as a simple and quick indicator of the micronutrient adequacy of the diet.

Keywords
Dietary diversity
Food variety
Mean adequacy ratio
Dietary diversity score
Food variety score

Micronutrient malnutrition remains one of the largest nutritional problems worldwide, affecting people in both developed and developing countries[1]. Children are particularly vulnerable to micronutrient deficiency owing to their high nutrient requirements for growth and susceptibility to infectious diseases such as diarrhoea and respiratory infections, which can inhibit nutrient absorption as well as decrease appetite[2]. The nutrient density of the diet given to young children is often insufficient to meet their nutrient requirements, and increasing the diversity of foods provided to young children, particularly meat, poultry, fish, eggs, fruits and vegetables, is recommended to improve micronutrient intakes[3].

Despite the intuitive link between increasing diversity of the diet and increased nutrient intake, the relationship between dietary diversity and adequate micronutrient intake has not yet been sufficiently validated across different cultural settings and in different age groups.

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Progress towards developing an indicator of dietary diversity for use in pubic health settings has been slow due to a lack of consistent methodology and differences in the correlations of interest, which range from the relationship with energy intake to food security, child anthropometry and micronutrient adequacy. The few studies which have focused on the relationship between dietary diversity and micronutrient intake from the diet have mainly shown positive correlations[4–9].

In a summary of seven studies reviewed by Ruel, five found a positive association between dietary diversity score and nutrient adequacy[10]. Of the studies focusing on young children, a positive correlation was found between dietary diversity score and nutrient adequacy in Mali[4], Kenya[6] and Niger[7], while inconsistent results or no correlation were found in Guatemala[11], Ghana[12] and Malawi[12]. Greater dietary diversity was associated with improved nutrient adequacy in children 4–8 years of age in Kenya[13]. Analysis of children aged 6–13.9 months from four developing countries concluded that there was promising evidence for the utility of dietary diversity as an indicator of inadequate nutrient intake[14].

Designing a simple and easy-to-use indicator reflective of the nutrient adequacy of the diet has become a priority for many working in the field of public health nutrition. Much of the preliminary work on this subject, including developing a validation protocol and conducting the first validation studies using the protocol, was conducted by the World Health Organization (WHO), the International Food Policy Institute (IFPRI) and the University of California at Davis. To further efforts towards development of an indicator of micronutrient adequacy of the diet, the Food and Agricultural Organization of the United Nations (FAO), WHO and IFPRI convened a workshop in October 2004 to refine and disseminate a methodology for validating indicators of dietary diversity for different age groups. The analysis in the present paper is based on the protocol refined during the workshop.

Materials and methods

Subjects

Secondary data analyses were undertaken of the National Food Consumption Survey (NFCS), which took place in 1999. The NFCS population comprised children aged 1 to 8.9 years (12–108 months) in South Africa and was a nationally representative sample ($n = 2200$, weighted for provincial representativeness), which was randomly selected. A detailed description of this process is given elsewhere[15,16].

Dietary intake

The NFCS collected data by 24-hour recall, a method which has been used by numerous other researchers[6,8,17]. A 24-hour recall was conducted with the caregiver of each child by trained interviewers who visited the homes of the participants. Dietary aids comprising household utensils and wax food models were used to determine portion sizes. Relative validity was determined by comparison with data obtained from the same participants using a food-frequency questionnaire. Furthermore, three 24-hour recalls were repeated in 10% of the sample. The dietary results are available elsewhere[18].

Anthropometry

Height and weight of each participant were determined according to recommended techniques. Anthropometric results have been published elsewhere[18].

Diet diversity and food variety scores

The evaluation of dietary adequacy used in the present analysis is based on the method described by Hatloy *et al.*[4] in Mali. The dietary diversity score (DDS) is defined as the number of food groups consumed over a period of 24 h. The diet was classified according to nine food groups as recommended by FAO, which included: (1) cereals, roots and tubers; (2) vitamin-A-rich fruits and vegetables; (3) other fruit; (4) other vegetables; (5) legumes and nuts; (6) meat, poultry and fish; (7) fats and oils; (8) dairy; and (9) eggs. Other remaining items such as tea, sugar and sweets were not used in DDS and food variety score (FVS) calculations. The FVS is defined as the number of food items consumed over a 24 h period, from a possible total of 45 items[4]. The possible total ($n = 45$) reflects all the different types of food items eaten by this sample of children.

In order to determine the nutrient adequacy of the diet, the nutrient adequacy ratio (NAR,%) was calculated for each of 11 micronutrients (vitamins A, B_6, B_{12} and C, niacin, thiamin, riboflavin, folate, calcium, iron and zinc) and energy and protein. NAR was calculated as the intake of a nutrient divided by the recommended intake for that nutrient (RNI), using WHO/FAO recommended intakes[19] which are set at two standard deviations above the average requirements. In the case of iron and zinc, the category for moderate bioavailability was used. The mean adequacy ratio (MAR, %) was calculated as a measure of the adequacy of the overall diet, where MAR is the sum of each NAR (truncated at 100%) divided by the number of nutrients (excluding energy and protein)[4]. For both NAR and MAR a value of 100% is the ideal since it means that the intake is the same as the requirement.

Pearson correlation tests were done between DDS (and NARs) and MAR and between FVS and MAR to test for a significant relationship, while controlling for energy. Finally, the DDS and FVS cut-off points optimising sensitivity, specificity and positive predictive values for MAR were determined.

Results

The anthropometric characteristics of the sample are summarised in Table 1. The high negative *Z*-scores for

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Table 1 Summary of South African children's anthropometric characteristics determined in the National Food Consumption Survey, 1999

Variable	1–3 years ($n = 795$)	4–6 years ($n = 861$)	7–8 years ($n = 544$)	Total group ($n = 2200$)
Age (months)	29.9 (8.5)	65.2 (9.7)	95.9 (8.4)	60.0 (25.3)
Weight (kg)	12.6 (2.1)	18.3 (3.3)	23.9 (5.8)	17.6 (5.3)
Height (m)	0.87 (0.07)	1.08 (0.08)	1.23 (0.09)	1.04 (0.15)
HAZ	−0.95 (1.33)	−0.85 (1.34)	−0.71 (1.41)	−0.85 (1.35)
WAZ	−0.50 (1.09)	−0.44 (1.16)	−0.50 (1.29)	−0.48 (1.15)
WHZ	0.16 (1.05)	0.12 (1.23)	0.01 (1.47)	0.11 (1.19)

HAZ – height-for-age *Z*-score; WAZ – weight-for-age *Z*-score; WHZ – weight-for-height *Z*-score.
Values are expressed as mean (standard deviation).

height and weight show that the values are skewed to the left, i.e. there is a large degree of stunting and underweight prevalent in the group.

Table 2 shows the MAR and the NARs of individual nutrients in the children's diet. MAR was lowest (57.3%) in the 7–8-year-old children and averaged 63.3% for the group as a whole. FVS and DDS were similar in all age groups, being 5.5 and 3.6, respectively, for the whole group. Nutrients which had an average NAR of at least 100% were protein, zinc, vitamin B_{12}, vitamin C, riboflavin and thiamin. Those with an average NAR greater than or equal to 90% were energy, iron, vitamin A and vitamin B_6. The average NARs for calcium and folate were too low, being less than 56% for calcium and less than 65% for folate.

Pearson correlation coefficients between adequacy ratios and different micronutrients revealed that all correlations were significant ($P < 0.05$) with the exception of DDS with vitamin C in the group as a whole (Table 3). MAR showed a strong positive correlation (all $r > 0.6$) with both DDS and FVS in all age groups.

Pearson correlation coefficients were also determined between anthropometric values and NARs, MAR, DDS and FVS (Table 4). The most striking finding was the significant positive correlations between anthropometric *Z*-scores and FVS, DDS and MAR for the group as a whole and all age groups, with the exception of weight-for-height *Z*-score in the 1–3-year-old group. Nutrients which showed little or no correlation with mean *Z*-scores were vitamin A, vitamin C and vitamin B_{12}.

Figure 1 shows the relationship between DDS and NARs of energy, protein and minerals. For all nutrients there was an increase in NAR as DDS increased. For energy, NAR reached 100% at a DDS of 4.5, while NAR reached 100% at a DDS of 2 for protein. NAR increased above 100% at a DDS of 4 for zinc and at a DDS of 5 for iron. Calcium remained below 100% of NAR (Fig. 1). All NARs for vitamins increased as DDS increased (Fig. 2). NAR reached 100% at a DDS of 6 for folate; at a DDS of 4 for vitamins A, C and B_6; and at a DDS of 3 for riboflavin. Figure 3 presents the relationship between DDS and *Z*-scores. The *Z*-score rose above zero at a DDS of 4, 7.5 and 8 for weight-for-height, weight-for-age and height-for-age, respectively.

Mean MAR values for different levels of DDS and FVS are presented in Table 5. If one evaluates levels having an MAR of at least 70%, FVS is above 11 with a DDS of at least 4. Another alternative is to have a DDS of at least 8 with an FVS of 6–10. No child had MAR of 100%. Those having a DDS of less than 4 and an FVS of less than 5 had MAR of less than 50%.

Figures 4 and 5 indicate the sensitivity and specificity of the receiver–operator characteristic curves for MAR

Table 2 Mean adequacy ratio (MAR), nutrient adequacy ratios (NARs), food variety score (FVS) and dietary diversity score (DDS) of South African children in the National Food Consumption Survey, 1999

Variable	1–3 years ($n = 795$)	4–6 years ($n = 861$)	7–8 years ($n = 544$)	Total group ($n = 2200$)
MAR (%)	64.7 (17.0)	65.8 (18.8)	57.3 (25.2)	63.3 (19.4)
FVS	5.37 (2.23)	5.58 (2.56)	5.67 (3.24)	5.52 (2.54)
DDS	3.51 (1.18)	3.60 (1.41)	3.64 (1.74)	3.58 (1.37)
NAR (%) vitamin A	92.4 (146.9)	96.9 (243.3)	90.4 (277.3)	93.7 (210.7)
NAR (%) vitamin B_6	100.1 (60.2)	108.2 (75.3)	68.6 (58.4)	95.5 (67.6)
NAR (%) vitamin B_{12}	238.4 (610.7)	243.0 (888.3)	167.4 (753.4)	222.6 (750.1)
NAR (%) vitamin C	104.2 (194.4)	108.9 (207.1)	157.1 (960.4)	119.1 (417.4)
NAR (%) calcium	66.4 (51.8)	52.0 (40.7)	46.1 (44.5)	55.7 (47.3)
NAR (%) folate	60.9 (41.4)	72.8 (51.7)	54.5 (51.8)	63.9 (47.7)
NAR (%) iron	81.4 (48.8)	107.8 (65.3)	77.5 (66.3)	90.8 (59.6)
NAR (%) niacin	94.1 (56.7)	96.4 (61.8)	70.8 (58.2)	89.3 (59.6)
NAR (%) riboflavin	139.2 (118.5)	128.6 (135.6)	89.4 (121.6)	122.8 (126.9)
NAR (%) thiamin	118.4 (51.4)	120.6 (55.1)	86.8 (50.6)	111.5 (54.1)
NAR (%) zinc	103.6 (49.2)	104.0 (54.9)	103.2 (75.1)	103.7 (56.0)
NAR (%) energy	96.2 (33.7)	91.4 (35.3)	81.8 (37.9)	90.7 (35.3)
NAR (%) protein	133.6 (58.0)	137.7 (62.9)	127.1 (74.3)	133.6 (62.7)

Values are expressed as mean (standard deviation).

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Table 3 Pearson correlation coefficients between nutrient adequacy ratio (NAR) of certain nutrients and food variety score (FVS) and dietary diversity score (DDS) of South African children in the National Food Consumption Survey, 1999

	All subjects ($n = 2200$)		1–3 years ($n = 795$)		4–6 years ($n = 861$)		7–8 years ($n = 544$)	
Nutrient	FVS	DDS	FVS	DDS	FVS	DDS	FVS	DDS
NAR (%) vitamin A	0.188	0.199	0.229	0.253	0.157	0.174	0.205	0.195
NAR (%) vitamin B_6	0.584	0.479	0.610	0.514	0.619	0.506	0.598	0.459
NAR (%) vitamin B_{12}	0.110	0.125	0.131	0.160	0.097 ($P = 0.001$)	0.112 ($P = 0.0002$)	0.118 ($P = 0.014$)	0.105 ($P = 0.029$)
NAR (%) vitamin C	0.183	0.150	0.357	0.318	0.339	0.311	0.108 ($P = 0.025$)	0.063 ($P = 0.192$)
NAR (%) calcium	0.293	0.251	0.234	0.191	0.393	0.347	0.353	0.300
NAR (%) folate	0.344	0.295	0.325	0.281	0.395	0.342	0.297	0.236
NAR (%) iron	0.287	0.256	0.260	0.239	0.331	0.292	0.266	0.231
NAR (%) niacin	0.561	0.491	0.544	0.487	0.594	0.516	0.611	0.516
NAR (%) riboflavin	0.416	0.359	0.421	0.362	0.443	0.396	0.415	0.325
NAR (%) thiamin	0.265	0.220	0.229	0.193	0.327	0.276	0.296	0.222
NAR (%) zinc	0.451	0.403	0.443	0.401	0.470	0.418	0.436	0.386
NAR (%) energy	0.465	0.378	0.436	0.355	0.515	0.438	0.483	0.352
NAR (%) protein	0.490	0.447	0.451	0.417	0.535	0.488	0.489	0.435
MAR (%)	0.669	0.633	0.649	0.617	0.695	0.661	0.713	0.659

All correlations significant at $P < 0.0001$, unless otherwise indicated.

using DDS and FVS. If one selects <50% MAR as a cut-off for sensitivity and >50% MAR for specificity, then a DDS of 4 is most appropriate. It gives a sensitivity of 75% and a specificity of 70%. Using the same cut-off points for FVS makes an FVS of 6 the most appropriate since the sensitivity is 82% and the specificity is 65%.

Discussion

Since 1990 researchers in the USA have been promulgating a variety of foods in the diet[20], the underlying principle being that variety will ensure an adequate intake of essential nutrients and hence promote good health[7,21,22]. But there has been much speculation about what dietary variety encompasses and how it should be measured. In South Africa there is a food-based dietary guideline[23] which advocates: 'Enjoy a variety of foods'. However, this has not been quantified to date and health workers might not be sure how to interpret it.

Overall, the diet of South African children as measured in the NFCS in 1999 was found to have low mean FVS and DDS – of 5.5 and 3.6, respectively – compared with some other developing countries. Although this might be due in part to the different dietary methods used, it should be recognised that dietary variety is very limited in the majority of children's diets in South Africa[18].

Table 4 Pearson correlation coefficients between nutrient adequacy ratio (NAR) of certain nutrients with height-for-age *Z*-score (HAZ), weight-for-age *Z*-score (WAZ) and weight-for-height *Z*-score (WHZ) of South African children in the National Food Consumption Survey, 1999

	All subjects ($n = 2200$)			1–3 years ($n = 795$)			4–6 years ($n = 861$)			7–8 years ($n = 544$)		
Nutrient	HAZ	WAZ	WHZ	HAZ	WAZ	WHZ	HAZ	WAZ	WHZ	HAZ	WAZ	WHZ
NAR (%) vitamin A	0.04	0.04	0.01	0.02	0.01	−0.01	0.05	0.06	0.02	0.04	0.04	−0.01
NAR (%) vitamin B_6	0.15*	0.18*	0.09*	0.16*	0.13*	0.04	0.18*	0.21*	0.10†	0.18†	0.25*	0.14†
NAR (%) vitamin B_{12}	0.02	0.01	0.00	−0.01	−0.03	−0.02	0.04	0.04	0.01	0.03	0.02	−0.01
NAR (%) vitamin C	0.02	0.03	0.02	0.06	0.05	0.01	0.138	0.11†	0.01	−0.04	−0.00	0.03
NAR (%) calcium	0.08*	0.12*	0.07†	0.05	0.09†	0.07	0.16*	0.16*	0.04	0.08	0.17†	0.13
NAR (%) folate	0.11*	0.13*	0.05†	0.08†	0.10†	0.06	0.15*	0.15*	0.05	0.13†	0.13	0.03
NAR (%) iron	0.10*	0.08*	−0.00	0.10†	0.07	−0.01	0.09†	0.06	−0.03	0.12	0.15†	0.05
NAR (%) niacin	0.15*	0.15*	0.05	0.15*	0.09†	−0.01	0.16*	0.17*	0.06	0.18†	0.25*	0.13
NAR (%) riboflavin	0.09*	0.12*	0.07†	0.08†	0.08†	0.03	0.12†	0.12†	0.05	0.13	0.24*	0.18†
NAR (%) thiamine	0.08*	0.09*	0.04	0.03	0.07	0.06	0.14*	0.10†	−0.00	0.15†	0.15†	0.03
NAR (%) zinc	0.13*	0.13*	0.04	0.10†	0.09†	0.02	0.13*	0.11†	0.01	0.18†	0.22*	0.10
NAR (%) energy	0.15*	0.16*	0.06†	0.08†	0.11*	0.08†	0.23*	0.18*	0.01	0.19†	0.22*	0.09
NAR (%) protein	0.14*	0.15*	0.05†	0.10†	0.09†	0.03	0.17*	0.16*	0.04	0.19†	0.23*	0.10
FVS	0.21*	0.23*	0.10*	0.21*	0.14*	0.01	0.23*	0.26*	0.11†	0.20*	0.35*	0.25*
DDS	0.19*	0.21*	0.10*	0.15*	0.10†	−0.01	0.23*	0.25*	0.10†	0.17†	0.32*	0.25*
MAR (%)	0.17*	0.19*	0.08*	0.13*	0.11*	0.03	0.21*	0.20*	0.05	0.25*	0.33*	0.17†

* $P < 0.0001$.
† $P < 0.01$.

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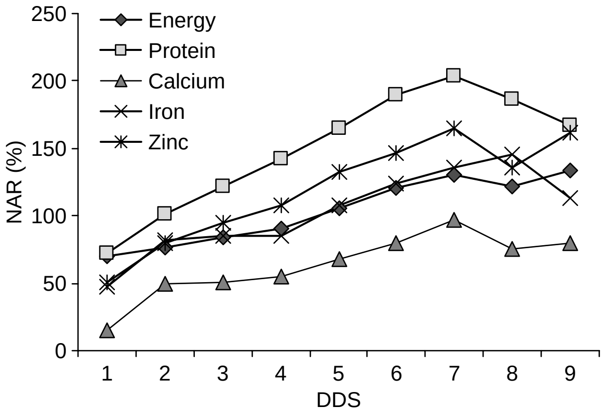

Fig. 1 Mean nutrient adequacy ratio (NAR, expressed as %) of energy and nutrients at different levels of dietary diversity score (DDS)

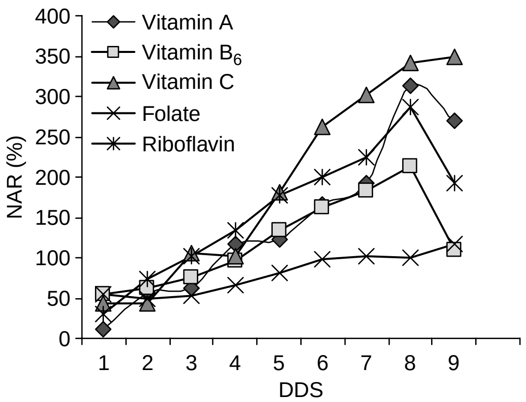

Fig. 2 Mean nutrient adequacy ratio (NAR, expressed as %) of vitamins at different levels of dietary diversity score (DDS)

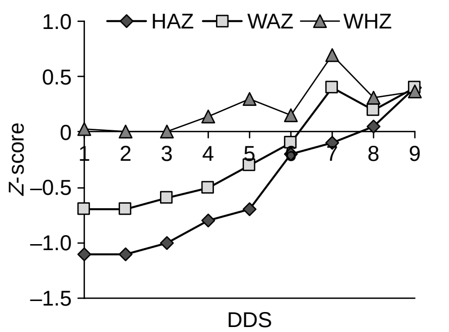

Fig. 3 Mean anthropometric *Z*-scores (WAZ – weight-for-age; HAZ – height-for-age; WHZ – weight-for-height) at different levels of dietary diversity score (DDS)

In Guatemala, Brown *et al.*[11] measured an FVS of 10 in 9–11-month-old children. In four African countries, Kenya[6], Niger[7], Ghana and Malawi[12], DDS was found to be 6, 4.8, 7.1 and 8, respectively. In Mali[4] MAR was found to be 0.77 for pre-school children, while in South Africa it was only 0.63. Thus it appears that South African children have a diet with little dietary variety. Furthermore, it was found that certain micronutrients were particularly deficient in the diet, these being calcium and folate. Although iron and zinc intakes appeared to be reasonable, bioavailability was based on the RNI for a moderate intake. Not all studies have taken this into consideration when calculating variety indicators.

It is difficult to compare countries on the basis of DDS and FVS because of the different ways in which these indicators have been defined and calculated in different countries[4]. Some have counted food groups, some food codes or even food ingredients. Thus, in an attempt to overcome this, some researchers have developed other ways of classifying dietary quality such as the Healthy Eating Index and Dietary Quality Index[24–27]. The disadvantages of these indices, however, are that the methods become more complex and time-consuming and hence can deflect from the very purpose for which they were designed.

Individual dietary diversity scores have promise as a rapid and efficient means to estimate nutrient adequacy of the diet. For example, health professionals can do a quick 24-hour recall with a caregiver to ascertain a child's DDS over the previous 24 h. Children who have a DDS value less than 6 will most probably have weight-for-age and weight-for-height *Z*-scores less than zero and should be regarded as being at risk of undernutrition. This measure can also be useful as an indicator to assess improvement in diets over time. Recent applications of such measures include, for example, the use of DDS as an indicator in the Knowledge, Practice and Coverage Surveys used to monitor progress in child survival projects[28] and as part of Demographic and Health Surveys.

Health workers require simple, quick and reasonably accurate indicators to evaluate the dietary intake of children. In the fast-paced primary health-care setting, it is not feasible to use lengthy dietary intake methods to establish whether the diet is adequate in terms of micronutrient quality; they want something fast which can assist them in classifying children according to the quality of their diet. This would be one specific use of the DDS and/or FVS, particularly since it has been shown to correlate significantly with MAR[14] and with weight-for-age, height-for-age and weight-for-height *Z*-scores in the present study. Furthermore, in eight studies in children, six showed significant associations between an indicator of dietary variety and nutritional status[10].

Hence, health-care workers in the South African context can simply question the caregivers of children regarding the number of food groups they usually give to their children on an average day. A DDS of less than or equal to 7 may result in weight-for-age and/or weight-for-height *Z*-sore of less than zero, while a DDS of less than 3 is associated with height-for-age *Z*-score of a less than zero.

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Table 5 Mean adequacy ratio (MAR) (%) for different levels of food variety score (FVS) and dietary diversity score (DDS) of South African children in the National Food Consumption Survey, 1999

	FVS				
DDS	0–5	6–10	11–15	16–20	≥21
0	1.4 ($n = 1$)				
1	26.4 ($n = 114$)				
2	38.0 ($n = 494$)	53.1 ($n = 6$)			
3	44.9 ($n = 469$)	56.8 ($n = 73$)			
4	50.4 ($n = 194$)	55.3 ($n = 279$)	**73.4 ($n = 2$)**		
5	45.4 ($n = 8$)	62.3 ($n = 269$)	**74.0 ($n = 24$)**		
6		67.2 ($n = 115$)	**75.9 ($n = 51$)**	**79.9 ($n = 2$)**	
7		66.7 ($n = 26$)	**77.6 ($n = 36$)**	**85.8 ($n = 5$)**	
8		**75.5 ($n = 3$)**	**75.0 ($n = 23$)**	**81.7 ($n = 2$)**	**86.9 ($n = 1$)**
9		69.9 ($n = 1$)	**83.0 ($n = 1$)**		

MAR of at least 70% indicated in bold.

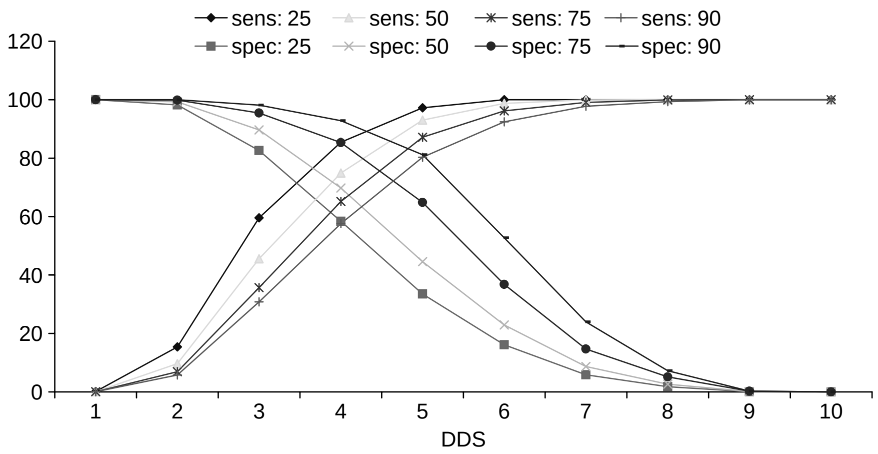

Fig. 4 Sensitivity (sens) and specificity (spec) (%) for different cut-off points of diet diversity score (DDS).

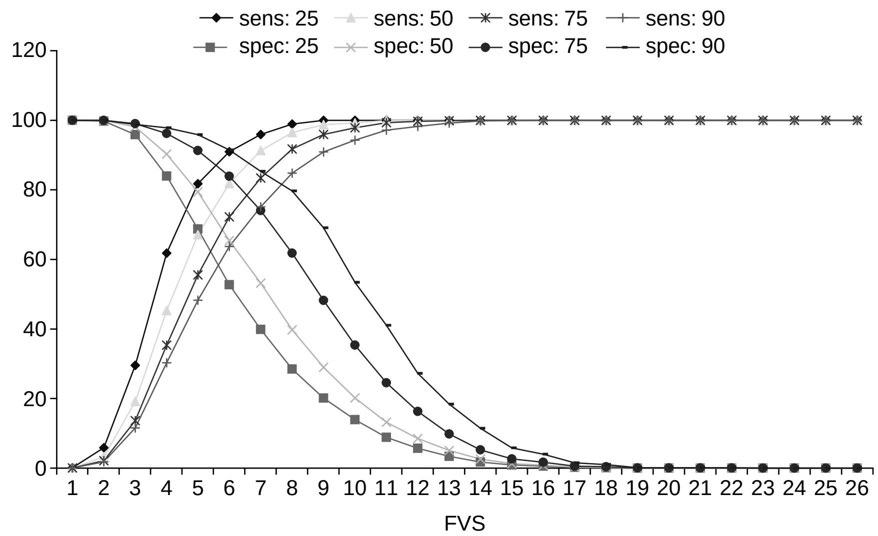

Fig. 5 Sensitivity (sens) and specificity (spec) (%) for different cut-off points of food variety score (FVS).

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Furthermore, a DDS of 4 and an FVS of 6 were shown to be the best indicators of MAR less than 50%, since they provided the best sensitivity and specificity.

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