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Which dietary diversity indicator is best to assess micronutrient adequacy in children 1 to 9 y?

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ABSTRACT

Objectives: The aim of this study was to determine the best dietary diversity indicator to measure dietary diversity and micronutrient adequacy in children.

Methods: A national representative cross-sectional survey of children ages 1 to 9 y (N = 2,200) was undertaken in all ethnic groups in South Africa. A 24-h recall was done with the mother or caregiver of each child. A dietary diversity score (DDS), the number of food groups consumed at least once in a period of 24 h, was calculated for each child in accordance with 6-, 9-, 13-, and 21-food group (G) indicators and compared with a mean adequacy ratio (MAR). The nutrient adequacy ratio (NAR) was calculated for 11 micronutrients by comparing the distributions of estimated intakes with the Estimated Average Requirements for that micronutrient. The MAR was the average of all NARs. Correlations were done between MAR and DDS and sensitivity and specificity calculated for each group indicator.

Results: Pearson's correlations between food group indicators and MAR indicate that *r* values were all highly significant ($P < 0.0001$). There were no consistent or large differences found between the different group indicators although G13 and G21 appeared to be marginally better. Sensitivity and specificity values in the current study lay between DDS of 3 and 5, suggesting one of these as the best indication of (low) micronutrient adequacy.

Conclusions: Overall results seem to indicate that any of the four G indicators can be used in dietary assessment studies on children, with G13 and G21 being marginally better. A cut-off DDS of 4 and 5, respectively, appear best.

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Introduction

The dietary diversity score (DDS), as measured by a quantitative number of food groups, has become a widely used method of determining variety in the diet, and by proxy, nutrient adequacy [1–5]. A low DDS also has been associated with low weight and stunted growth [6,7], cardiovascular risk [8,9], dyslipidemia [10], and higher probability of metabolic syndrome [11]. Numerous classification systems have evolved in determining dietary diversity adequacy with the number of food group indicators ranging from 6 to 21 groups (Table 1). Although the outcomes from using various food group indicators have been tested in adults [12], to our knowledge, this has not been the case in children.

One study [12] evaluated four different indicators in an attempt to establish the best indicator of micronutrient adequacy in adult women. All four food group indicators (G6, G9, G13, G21) tested were positively correlated with the mean probability of adequacy of micronutrients, even when controlling for energy intake [12]. However, their predictive strength differed among the five sites tested. In South Africa, one study evaluated the effectiveness of using a G9 diversity indicator in preschool children [7]; the resulting DDS of 4 was shown to be the best cut-off of mean adequacy ratio (MAR) of 11 micronutrients because it provided the best sensitivity and specificity [7].

NPS was the main writer and was involved in all aspects of the study. JN conducted all statistical analyses and interpretation thereof. DL was the principal investigator of the original study. EM was a co-principal investigator of the original study and contributed to the writing. HSK contributed to the writing.

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Table 1
Percent of children having food consumed from specific food groups

6 food groups (%)	9 food groups (%)	13 food groups (%)	21 food groups (%)
All starch staples (99.6)	All starch staples (99.6)	All starch staples (99.6)	All starch staples (99.6)
All dairy (56.2)	All dairy (56.2)	All dairy (56.2)	Milk/yogurt (55.8) Cheese (3.7)
All animal foods excluding dairy (57.8)	Organ meat (5.5) Eggs (13.3) Flesh foods (50)	Organ meat (5.5) Eggs (13.3) Flesh foods (46.8) Small fish eaten whole (4.2)	Organ meat (5.5) Eggs (13.3) Red meat (26.7) Chicken/birds (23.4) Insects, grubs small animals (0) Large whole fish/seafood (4) Small fish (4.2)
All legumes & nuts (19.5)	All legumes & nuts (19.7)	All legumes & nuts (19.7)	Cooked dry beans and peas (9.5) Nuts and seeds (8.9) Soybeans & products (2.6)
Vitamin A-rich fruit & vegetables (23.4)	Vitamin A-rich dark green leafy vegetables (12.2) Other vitamin A-rich vegetables & fruit (12.1)	Vitamin A-rich dark-green leafy vegetables (12.2) Vitamin A-rich deep yellow/ orange/red vegetables (11.5)	Vitamin A-rich dark-green leafy vegetables (12.2) Vitamin A-rich deep yellow/orange/ red vegetables (11.5)
Other fruits & vegetables (53.9)	Other fruits & vegetables (53.9)	Vitamin A-rich fruits (0.7) Vitamin C-rich vegetables (20.8) Vitamin C-rich fruits (9.5) All other fruits & vegetables (40.5)	Vitamin A-rich fruits (0.7) Vitamin C-rich vegetables (20.8) Vitamin C rich fruits (9.5) All other fruits (16.9) All other vegetables (30.8)

However, it is unknown whether other group diversity indicators would work as well (or better) than the G9 used in children. Hence, the primary objective of this study was to test the use of different food group indicators, namely G6, G9, G13, and G21, on the micronutrient adequacy of children, in order to identify the best indicator to use in future dietary studies. To our knowledge, this is the first study to do this in children. There might be multiple benefits since the results from a single unquantified 24-h recall can be used to calculate DDS and the indicator that attains the best sensitivity and specificity with regard to the identification of micronutrient deficiencies can be used to identify children at risk when undertaking dietary analyses in future studies.

Methods

Source of nutrient data

The dietary database used in the current study was that of the National Food Consumption Survey (NFCS) [13], which took place in 1999. The NFCS population comprised children ages 1 to 8.9 y (12–108 mo) in South Africa and was a nationally representative sample (N = 2200, weighted for provincial representativeness). A detailed description of this process is given elsewhere [14,15]. The NFCS collected data by means of a 24-h recall, and a dietary frequency; however, only the 24-h results were used in this study. A 24-h recall was conducted with the caregiver of each child by trained interviewers who visited the participants' homes. Dietary aids in the form of food models were used to increase the accuracy of portion size estimations.

Dietary diversity

The DDS is defined as the number of food groups consumed at least once in a period of 24 h. As done in a previous [12], we also selected eight food group diversity indicators that were based on groups not individual items; varied in level of aggregation of groups; included a minimum amount of consumption for the group to count (15 g); and were based on the recall of a single day. The dietary data of the children in the study were classified according to G6, G9, G13, and G21 food group indicators described in Table 1. A score of 1 was given for each different group consumed providing that a minimum of 15 g had been consumed from that group. A group was not counted more than once.

Nutrient adequacy ratio

The nutrient adequacy ratio (NAR) was used to determine adequacy of 11 nutrients, namely vitamins A, B_6, B_{12}, C, thiamin, riboflavin, niacin, folate, and calcium, iron, and zinc. These were based on Recommended Nutrient Intakes (RNIs) using Food and Agriculture Organization of the United Nations/World Health Organization-recommended intakes [16], which are set at two SD above average requirements. For iron and zinc, the moderate bioavailability category was selected. NAR was calculated for each nutrient by dividing the person's intake of each nutrient with the RNI for that micronutrient and calculating a percent. The MAR was calculated as the sum of NARs for all evaluated nutrients divided by the number of nutrients evaluated, expressed as a percentage. Values above 100% were truncated at 100%. MAR has a range from 0 to 100% with 100% being ideal.

Data analyses

Data was analyzed in SAS 9.3. For age groups and urban/rural differences χ^2, Student's *t* test, and Bonferroni post hoc test were used to test for comparisons between groups. Pearson's correlations were used to measure associations between MAR and food group indicators. Receiver operating characteristic (ROC) curve was used to determine sensitivity and specificity of different food group indicators measuring MAR. Accuracy of the ROC test is measured by the area under the ROC curve. An area of 1 represents a perfect test, 0.90 to 1 an excellent test, and 0.80 to 9.0 a good test [17].

Ethical approval

Ethical approval was obtained before the study commenced from Stellenbosch University Ethics Committee. Signed informed consent was obtained from the caregivers of the children who were participants in the study.

Results

In this sample, 8.6% (95% confidence interval [CI], 7.4%–9.9%) of children had a weight for age < -2 SD of the median of the National Centre for Health Statistics (NCHS); a 19.4% (95% CI,17.5%–21.2%) had a height of age < -2 SD NCHS, and 3.3% (95% CI, 2.5%–4.1%) weight for height < -2 SD NCHS standards indicating that overall stunting was highly prevalent in this population. Prevalence for all three nutritional status parameters were significantly higher in rural than in urban areas, indicating higher levels of under nutrition ($P < 0.001$).

Table 1 illustrates that in general, the majority of the group had staple foods, followed by dairy products (milk and yogurt) and all animal foods excluding dairy, followed by other fruits and vegetables. Table 1 also shows how the food groups used in this study to calculate DDS become progressively more disaggregated as food group size increased. In the vitamin A and C groups, for example, there are more options available and it is easier to

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