The Journal of Nutrition
Community and International Nutrition

Dietary Diversity Score Is a Useful Indicator of Micronutrient Intake in Non-Breast-Feeding Filipino Children[1,2]

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Abstract

Micronutrient malnutrition remains a problem of public health concern in most developing countries, partly due to monotonous, cereal-based diets that lack diversity. The study objective was to assess whether dietary diversity score (DDS) based on a simple count of food groups consumed and DDS using a 10-g minimum intake for each food group (DDS 10g) are good indicators of adequate micronutrient intake in 24–71-mo-old non-breast-feeding Filipino children. Pearson's correlation and linear regression were used to assess the utility of DDS and DDS 10g as indicators of micronutrient intake. Sensitivity and specificity analysis were used to determine the most appropriate cut-off point for using DDS to categorize children with high probability of adequate micronutrient intake. The average diet of the sample population consisted of 4–5 food groups. The mean probability of adequate nutrient intake (MPA) of 11 micronutrients was 33%. The Pearson's correlation coefficient between MPA and DDS was 0.36 ($P < 0.001$) and for DDS 10g it increased to 0.44 ($P < 0.001$). Intake of individual micronutrients was correlated to DDS for most nutrients. When maximizing sensitivity and specificity, the best cut-off points for achieving 50 and 75% probability of adequate micronutrient intake were 5 and 6 food groups, respectively. DDS and DDS 10g were both significant predictors of adequate micronutrient intake. This study demonstrates the utility of indicators of dietary diversity to predict adequate intake of micronutrients in the diets of young non-breast-feeding children. J. Nutr. 137: 472–477, 2007.

Introduction

Micronutrient malnutrition remains a serious nutritional concern in developing countries. In the Philippines, 40% of children 6 mo–5 y of age have low or deficient serum retinol levels and 29% of children 1–5 y of age are anemic (1). The prevalence of low serum retinol and anemia in Filipino children has increased over the past decade. The increase in low serum retinol has occurred despite Department of Health biannual vitamin A capsule supplementation program for young children, most probably as a result of low coverage and poor compliance with biannual doses. The continuing high prevalence of anemia is attributed to low birth weight, low dietary iron intake, and helminth infections (1).

Evidence from dietary intake research in the Philippines shows that the diets of a large percentage of young children are deficient in iron, vitamin A, and calcium. Intakes of vitamin C, niacin, riboflavin, and thiamin were found to be adequate. Average energy intake of preschool age children was also below recommended levels (2). Moving from a monotonous diet to one containing a more diverse range of foods has been shown to increase intake of energy as well as micronutrients in developing countries (3–7). Intake of a diverse variety of foods has been a recommendation for achieving adequate nutrient intake and the recommendation appears in the dietary guidelines of many countries. The nutritional guidelines for the Philippines include a number of recommendations on dietary diversity; 2 recommendations specify daily intake; *1*) eat a variety of foods every day and *2*) consume milk, milk products, and other calcium rich foods such as small fish and dark green leafy vegetables every day (8). Other recommendations encourage greater consumption of certain food groups but do not specify how often these should be consumed (fish, lean meat, poultry, dried beans, vegetables, fruits, and root crops). The precise number of foods or food groups that one should strive to consume over any given period is not commonly mentioned in most dietary guidelines. Japan advises consumption of 30 different food items per day (9) and the US advocates consumption of a variety of nutrient-dense foods and beverages within and among 5 basic food groups, with an item from each food group consumed daily [the 5 USDA food groups are: cereals, vegetables, fruit, dairy, and protein source foods (meat, fish, poultry, eggs, nuts, beans)] (10).

Despite many national nutritional guidelines recommending consumption of a variety of foods to meet nutritional needs,

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[1] Supported by the FAO of the United Nations. There are no known conflicts of interest.

[2] Supplemental Tables 1 and 2 are available with the online posting of this paper at jn.nutrition.org.

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Manuscript received 6 May 2006. Initial review completed 19 June 2006. Revision accepted 20 November 2006.

including those in the Philippines, the question remains how to operationalize this message for use as an indicator in the public health setting. The use of dietary diversity as an indicator of adequate nutrient intake remains under evaluation, particularly in developing countries. In those settings where the importance of dietary diversity to adequate nutrient intake has been assessed, researchers have used different food group classification systems, as well as diverse reference periods, cut-off points, and age groups (11). There is need for a set of comparable validation studies using the same methodology for creating a dietary diversity score (DDS)[7] to predict adequate micronutrient intake.

The purpose of this study is to validate dietary diversity as an indicator of micronutrient adequacy in the diet of Filipino children 24–71 mo of age and to quantify the appropriate DDS cut-off point for use as an indicator of inadequate micronutrient intake. The results of this study will aid in the development and promotion of rapid assessment tools for measuring diversity of the diet and further understanding of the utility of a measure of dietary diversity as part of a set of indicators used to monitor food and nutrition security.

Materials and Methods

Data were from non-breast-fed children 24–71 mo of age in the Philippines 1993 National Nutrition Survey. The survey used a stratified 2-stage sampling design including a total of 4050 households and 3164 children 24–71 mo of age. All surveyed households provided informed consent prior to participation. Ethical consent for the study was obtained from the Philippines Food and Nutrition Research Institute. Detailed information on the 1993 survey methodology has been published elsewhere (12).

The food intake data of the preschool children were collected by individual 24-h food recall. The mother or caregiver was the respondent. The interviews included a detailed description of the foods eaten, the cooking method, and brand names (e.g. for milk consumed or other processed snack foods). The amount consumed by the child was estimated by the respondent, expressed in terms of cups, spoons, matchbox pieces, and other common household utensils. The respondents were shown visual aids to assist them in accurately reporting food intake. For mixed recipes, the respondent was asked how the food was prepared and how much of the visible components (e.g. pieces of meat, vegetables, etc.) were eaten by the child.

To compute nutrient values, the cooked weight was converted to raw weight using the Filipino Food and Nutrition Research Institute's Individual Dietary Evaluation Software. The software also contains a library of food composition values in their raw form. Nutrient values for energy, protein, fat, calcium, iron, vitamin A, vitamin C, thiamin, riboflavin, and niacin are from the 1997 food composition tables of the Philippines (13) and from food labels, particularly for iron and vitamin A, for fortified foods. For this study, nutrient values for vitamin B-6, vitamin B-12, folate, zinc, and phytate were obtained from the World Food Dietary Assessment System, version 2.0 (14). Nutrient retention values, from the USDA Table of Nutrient Retention Factors, Release 5 (2003), were added to account for nutrient losses during cooking process (15).

The data were cleaned for the purposes of this study. The average per capita daily energy requirement (kcal/d) for children 12–47 mo of age in the Philippines was calculated using the Population Energy Requirements software (16). The average per capita energy requirement was estimated at 4707 kJ/d (1125 kcal/d). The 5th and 95th percentiles, corresponding to intakes below 1607 kJ/d (384 kcal/d) and above 6632 kJ/d (1585 kcal/d) were discarded, leaving a total of 2805 records used in the analysis.

For the analysis using anthropometric data, only records with complete information on age, gender, weight, and height were included. WHO fixed exclusion ranges were used as criteria for cleaning outlying anthropometric Z scores (17).

DDS. DDS were calculated for each child using a set of 10 food groups (cereals and tubers; meat, poultry and fish; dairy; eggs; pulses and nuts; vitamin A-rich fruits and vegetables; other fruit; other vegetables; oils and fats; and other). The choice of the 10 food groups was based on the outcome of discussions held during a workshop on validation methods for dietary diversity held in Rome, Italy in October 2004. The decision was based on previous experience and testing of the usefulness of different food groupings (5) and is reflected in a set of basic guidelines for validating DDS in non-breast-feeding children 24–83 mo of age (18) and also in validation guidelines for children 0–24 mo of age (19). The food group "other," consisting of sugar, non-juice or dairy beverages, and condiments and spices, was used in descriptive statistics but was not used for tests of correlation, because this group does not contribute substantially to micronutrient intake. The majority of the analysis presented is based on the 9 food groups, excluding the "other" category.

DDS were calculated by summing the number of unique food groups consumed by the child in the 24-h period. An all inclusive DDS was calculated without a minimum intake for the food group. A second DDS was calculated applying a 10-g minimum intake for all food groups (DDS 10g) except fats and oils.

Nutrient bioavailability. Bioavailability adjustments were made for calcium, iron, and zinc. The purpose of making the bioavailability adjustments was to derive estimates of absorbed calcium, absorbed iron, and absorbed zinc to more accurately reflect concurrence between dietary intake and requirements. Bioavailability factors for calcium were 25% for roots, tubers, and legumes; 45% for fruits and vegetables; 5% for high oxalate vegetables (amaranth, cassava root and leaves, and spinach); and 32% for all other foods, based on Weaver et al. (20).

Bioavailability factors for iron were estimated at 6% for plant foods and 11% for animal source foods, based on a synthesis of sources, including FAO/WHO and Tseng et al. (21,22).

Bioavailability factors for zinc were calculated based on the phytate to zinc molar ratio. A ratio of ≤ 18 was considered to have 30% bioavailability, whereas for a phytate to zinc ratio >18, a bioavailability factor of 22% was used based on calculations derived from Hotz and Brown (23).

Estimated average nutrient requirements and probability of adequate intake. The estimated average requirements (EAR) were used to assess the probability of adequate nutrient intake (PA). The EAR approach has been recommended as an improvement over using recommended nutrient intakes (RNI) for nutrient assessment of groups (24) as it allows for calculation of the probability that the individual's intake is adequate given the requirement distribution. The assumptions of the probability approach are that: *1*) the requirement and intakes are independent; *2*) the mean and variance of the requirement is known; and *3*) the shape of the requirements distribution is known or can be assumed (25). The Institute of Medicine (IOM) report on applications of dietary reference intakes indicates that for all nutrients except energy, intakes and requirements are independent (24). The mean, variance, and distribution of requirements are known or calculated and assumed normal for all nutrients, with the exception noted in the IOM document of iron, where the distribution of requirements is skewed (24).

PA was calculated by the equation PA = PROBNORM [(estimated child intake – EAR)/SD], where PROBNORM is the statistical function that calculates the probability that a child's intake is above the EAR. The mean probability of adequate micronutrient intake (MPA) for each child is the average of the PA for the 11 micronutrients in the analysis. The mean PA and mean MPA were then calculated for the entire sample. The probability approach to assess adequacy of intake has been used in recent studies with a similar aim (5,26) and is also now part of the World Food

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[7] Abbreviations used: DDS, dietary diversity score; DDS 10g, dietary diversity score with 10-g minimum consumption; EAR, estimated average requirement; IOM, Institute of Medicine; MAR, mean adequacy ratio; MPA, mean probability of adequate micronutrient intake; PA, probability of adequate micronutrient intake; RNI, recommended nutrient intake.

Dietary Assessment System, version 2.0 (14). More information about the application of the probability approach can be found in the IOM report on applications in dietary assessment (24).

EAR for micronutrients. To derive EAR based on international requirements set by the United Nations, the EAR was back calculated from FAO/WHO RNI (**Table 1**). The RNI is defined as EAR+2SD_{EAR} (21). The CV used to perform the calculations was based on IOM recommendations, set at 10% for all nutrients except 15% for niacin, 20% for vitamin A, and 25% for zinc (27–29).

Due to the fact that bioavailability adjustments were made to calcium, iron, and zinc, the requirement was adjusted to reflect the amount of absorbed nutrient required. An EAR for absorbed calcium was calculated from the recommended dietary allowance used in the Dietary Reference values for the United Kingdom using a CV of 10% (30). An EAR for absorbed zinc requirement was based on FAO/WHO using a CV of 25% (21).

Because iron requirements are not normally distributed, calculation for iron requirement and probability of adequate intake were derived from IOM iron requirements (29). Table 1-5 in that document was used as the basis for constructing a matrix for probability of adequate iron intake for children in age ranges 12–47 mo and 48–107 mo. We converted data in that table from 18% bioavailability to 10% bioavailability, which is more realistic of a high phytate, primarily vegetable-based diet (21) as typically consumed by children in the Philippines (**Supplemental Table 1**).

Statistical analysis. Statistical analysis was performed using SPSS version 11.5. PA and MPA were calculated separately for children 12–47 and 48–71 mo using respective EAR. Pearson's correlations were run by age group to verify the linear association for MPA and individual PA for each micronutrient. Linear regression models have been estimated separately for DDS and DDS 10g. DDS was evaluated for sensitivity and specificity using MPA as the gold standard. Sensitivity and specificity analysis were performed to quantify the accuracy of DDS to correctly classify children with high MPA values and then to determine the DDS cut-off point that maximized sensitivity and specificity. Two MPA cut-off values (0.50 and 0.75) were used in the analysis to categorize the children with low or high nutrient intakes.

TABLE 1 EAR and SD used for calculating PA for non-breast-feeding Filipino children 24–71 mo of age[1]

Nutrient	Children 12–47 mo		Children 48–83 mo	
	EAR	SD	EAR	SD
Vitamin A,[2] *μg RE*	200.0	40.0	200.0	40.0
Vitamin C, *mg*	25.0	2.5	25.0	2.5
Thiamin, *mg*	0.4	0.04	0.5	0.05
Riboflavin, *mg*	0.4	0.04	0.5	0.05
Niacin, *mg*	4.6	0.69	6.2	0.92
Vitamin B-6, *mg*	0.4	0.04	0.5	0.05
Vitamin B-12, *μg*	0.8	0.08	1.0	0.1
Folate, *μg*	133.0	13.33	167.0	16.7
Absorbed calcium, *mg*	220.0	22.0	220.0	22.0
Absorbed Zinc, *mg*	0.83	0.083	0.97	0.097

[1] Data for absorbed iron are in Supplemental Table 1. Probability of adequate absorbed iron intake back calculated by multiplying the values in Table 1-5 on p. 701 (29). These values are higher than the FAO/WHO 2002 values and thus may lead to overestimation of inadequate intake.

[2] The Philippines Food Composition Table (FCT) calculates the retinol equivalent (RE) as 1 RE = 1 μg retinol or 6 μg β-carotene. This is compatible with FAO/WHO calculations for RE. The EAR for vitamin A was not back calculated from the RNI value but was interpreted as the mean requirement μg RE/d reported in FAO/WHO 2002 (21). The mean requirement is described as "the minimum daily intake of vitamin A as presented in μg retinol equivalents to prevent xerophthalmia in the absence of clinical or sub-clinical infection. The required level of intake is set to prevent clinical signs of deficiency, allow for normal growth and reduce the risk of vitamin A-related severe morbidity and mortality on a population basis." p. 97.

TABLE 2 Descriptive statistics of non-breast-feeding Filipino children 24–71 mo of age[1]

Child age, *mo*	46.5 ± 13.7
Gender, *% male*	50.9
HAZ	−1.59 ± 1.17
WAZ	−1.51 ± 0.91
WHZ	−0.67 ± 0.81
Stunting, *%*	37.5
Underweight, *%*	32.2
Wasting, *%*	4.2
DDS	4.91 ± 1.57
DDS 10g	4.05 ± 1.54

[1] Values are means ± SEM or %, $n = 2805$.

[2] Abbreviations used only in table: HAZ, height-for-age Z score; WAZ, weight-for-age Z score; WHZ, weight-for height Z score.

Results

The mean age of the children was just under 4 y. One-half of the children in the study were male and one-half were female. Over one-third of the children in the sample suffered from undernutrition. The mean DDS was close to 5 and decreased to 4 when a 10-g minimum was applied (**Table 2**).

Nearly all children consumed a cereal/tuber; meat, fish, or poultry; and an item from the food group "other" (**Table 3**). Median energy intake was 3736 kJ (893 kcal). Cereals/tubers represented 68% of total energy intake. Meat, fish, and poultry accounted for 10% and fruits and vegetables accounted for another 8% of total energy intake. Energy intake from the "other" category accounted for 7% of total intake. Additional food intake data are presented in **Supplemental Table 2.**

As DDS increased, a larger percentage of children consumed items from 1 or more of the 3 fruit and vegetable groups or fats/oils. Only at a DDS of 7 or more were more >50% of children consuming a food from the dairy, egg or legumes, and pulses and nuts food group (**Table 4**).

In general, median micronutrient intake was lower than the EAR (**Table 5**) and did not increase with increasing age of the

TABLE 3 Summary of food group intakes by non-breast-feeding Filipino children 24–71 mo of age[1]

Food group	Children consuming, *%*	Food intake, *g*	Energy intake,[2] *kcal*
Cereals/tubers	99.9	182 (133:239)	593 (439:767)
Meat, poultry, fish	95.8	46 (23:76)	61 (30:116)
Other	87.1	12 (4:42)	40 (12:88)
Other fruit	51.9	8 (0:53)	5 (0:75)
Vitamin A-rich fruits and vegetables	47.6	0 (0:6)	0 (0:5)
Other vegetables	47.2	0 (0:5)	0 (0:5)
Oils and fats	47.1	0 (0:3)	0 (0:22)
Dairy	38.3	0 (0:8)	0 (0:32)
Eggs	35.0	0 (0:9)	0 (0:15)
Pulses/nuts	28.4	0 (0:4)	0 (0:9)
Total		351 (266:459)	893 (687:1116)

[1] Values are medians (25th, 75th percentiles), $n = 2805$.

[2] Multiply by 4.184 to convert kcal to kJ.

TABLE 4 Percent consumption of different food groups by DDS (0 g minimum) for non-breast-feeding Filipino children 24–71 mo of age ($n = 2805$)

DDS	Cereal/tuber	Meat, poultry, fish	Other fruit	Vitamin A-rich fruits and vegetables	Other vegetable	Oils and fats	Dairy	Eggs	Legumes, pulses, and nuts
				%					
1	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	100.0	89.2	0.6	4.5	1.3	1.3	2.5	0.6	0.0
3	100.0	90.7	26.1	19.5	16.0	19.7	14.7	7.2	6.1
4	100.0	94.5	45.0	36.6	35.6	31.1	21.1	19.8	16.1
5	99.9	97.1	52.6	50.6	52.2	50.2	38.0	33.6	25.7
6	100.0	98.4	64.7	63.7	64.3	64.9	54.2	49.4	40.3
7	100.0	99.7	82.1	72.1	72.4	80.0	70.0	69.3	54.5
8	100.0	100.0	88.4	87.0	86.2	87.0	86.2	87.7	77.5
9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

child (data not shown). The mean MPA was 0.33. Only 1 nutrient, niacin, had an average probability of adequate intake above 50%. The next highest intakes were for vitamin B-6, iron, and vitamin A. Intakes of absorbed calcium, absorbed zinc, and folate had the lowest probability of adequacy. Pearson's correlation coefficient for DDS and mean PA and mean MPA were significant for all nutrients except calcium and vitamin B-12. Results of correlations using the 10-g cut-off point were similar to the no-gram minimum. Mean MPA increased with DDS and DDS 10g (**Fig. 1**).

DDS and child age in months were significant determinants of MPA in all 4 models tested (**Table 6**). In particular, higher values of DDS correspond to higher values of MPA, whereas age was negatively associated with MPA. When not controlling for energy, higher child weight values also increased the MPA. Energy intake was significantly and positively associated with MPA. Finally, the 2 models including energy seemed to perform better than the other 2 models, resulting in higher adjusted r^2 coefficients.

Sensitivity and specificity curves. Sensitivity indicates the percentage of children truly at risk (low MPA) who are correctly classified by low DDS. Specificity maximizes the percentage of children not at risk of nutrient inadequacy (high MPA) and who are correctly classified by high DDS. Using an MPA of 0.50, the best DDS cut-off point (where the sensitivity and specificity curves meet) is 5 food groups. Increasing the MPA to 0.75 increased the DDS cut-off point to 6 food groups (**Fig. 2**).

TABLE 5 Median micronutrient intake, MPA, and correlation between mean PA and mean DDS for non-breast-feeding Filipino children 24–71 mo of age

	Intake[1]	PA[2]	Correlations[3]	
			DDS	DDS 10g
Vitamin A, μg RE	142 (77:235)	0.34 ± 0.41	0.37*	0.43*
Vitamin C, *mg*	13 (3.6:31.2)	0.31 ± 0.45	0.25*	0.29*
Thiamin, *mg*	0.3 (0.2:0.5)	0.29 ± 0.41	0.25*	0.31*
Riboflavin, *mg*	0.3 (0.2:0.4)	0.25 ± 0.39	0.33*	0.40*
Niacin, *mg*	7.9 (5.7:10.6)	0.80 ± 0.33	0.19*	0.23*
Vitamin B-6, *mg*	0.4 (0.29:.56)	0.44 ± 0.45	0.10*	0.13*
Vitamin B-12, *μg*	0.5 (0.2:1.0)	0.30 ± 0.44	0.02	0.06*
Folate, *μg*	90 (61:1305)	0.19 ± 0.35	0.30*	0.35*
Absorbed zinc, *mg*	0.6 (0.4:0.8)	0.21 ± 0.37	0.08*	0.11*
Absorbed calcium, *mg*	61 (38:105)	0.13 ± 0.33	0.001	0.02
Absorbed iron, *mg*	0.3 (0.2:0.5)	0.37 ± 0.28	0.11*	0.15*
Mean MPA		0.33 ± 0.19	0.36*	0.44*

[1] Values are medians (25th, 75th percentiles), $n = 2805$.

[2] Values are means ± SEM, $n = 2805$.

[3] $*P < 0.05$.

Discussion

Overall, the diet of the Filipino children is based on differing combinations of rice, meat or fish, oil, vegetables, and fruit. Using 9 food groups, children had a mean DDS of nearly 5 (4.9) and a mean MPA of 33%. Using the DDS10g indicator, children consumed a mean of 4 (4.05) food groups. Both the DDS and DDS10g were significantly correlated with MPA, illustrating the potential of simple scores of dietary diversity for use as indicators of micronutrient adequacy of the diet. These findings are similar to those of other studies testing the utility of dietary diversity as an indicator of nutrient adequacy in the diet of preschool and school age children (4–7).

In a study of school-aged children in Kenya, the mean DDS was 5.18 (based on 7 food groups) and mean MPA was 70% (5). In Kenya, the highest probability of inadequate intake for individual nutrients was zinc, vitamin B-12, calcium, vitamin E, and vitamin A. The results from our study were similar, with calcium, folate, and zinc having the lowest PA.

There are 2 similar validation studies on children of roughly the same age group in developing countries, 1 from South Africa and another from Mali. These studies used recommended dietary allowance instead of EAR to validate adequate intake of micronutrients and calculated nutrient adequacy ratios and a mean nutrient adequacy ratio (MAR) for each child. The study in South Africa found a mean DDS of 3.58 (based on the same 9 food groups used in this study) with a mean MAR of 50% (6).

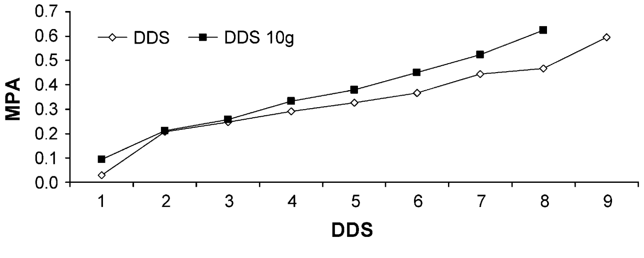

Figure 1 PA by DDS in non-breast-feeding Filipino children 24–71 mo of age. Values are MPA, $n = 2805$.

TABLE 6 Linear regression of determinants of MPA in non-breast-feeding Filipino children 24–71 mo of age

	Unadjusted[1]				Adjusted for energy			
Variable	DDS				DDS 10g			
DDS/DDS 10g	0.0451*	0.0022	0.0618*	0.0024	0.0219*	0.0019	0.0333*	0.0021
Male	0.0107	0.0069	0.0102	0.0067	−0.0023	0.0056	−0.0019	0.0054
Age, *mo*	−0.0026*	0.0005	−0.0025*	0.0004	−0.0030*	0.0004	−0.0029*	0.0004
Weight, *kg*	0.0104*	0.0032	0.0093*	0.0031	−0.0000	0.0026	−0.0000	0.0025
Height, *m*	0.0008	0.0010	0.0007	0.0010	0.0011	0.0008	0.0010	0.0008
Energy, *kcal*					0.0004*	0.0000	0.0004*	0.0000
Constant	0.0084	0.0585	−0.0022	0.0565	−0.1195	0.0469	−0.1219	0.0460
Adj. R^2	0.150		0.205		0.460		0.475	

[1] *$P < 0.05$.

The nutrients with the lowest adequacy ratios were iron, calcium, and zinc. In Mali, the mean DDS was 5.8 (based on 8 food groups), with a mean MAR of 0.77 (4). The nutrients with the lowest nutrient adequacy ratio were riboflavin, calcium, vitamin A, and vitamin C.

The low intake of thiamin and riboflavin in this study was somewhat surprising, because these nutrients are present in most staple foods. Low PA of these nutrients in this study also differed from the results in Kenya (5). Rice has the lowest amount of thiamin and riboflavin per 100 g compared with wheat and maize, with maize being the staple food in Kenya, whereas the Filipino diet is based on rice. The practice of milling rice into highly polished white kernels removes an additional large percentage of thiamin. Highly milled polished rice contains roughly 0.06 mg thiamin/100 g, or only 12% of the EAR for a young child. Another explanation for the low intakes of thiamin and riboflavin in Filipino children comes from low milk consumption, particularly in children over the age of 1 y (1).

Our Pearson's correlation (0.36) between DDS and MPA was significant. The studies in Kenya, South Africa, and Mali also found significant correlations between DDS and nutrient intake: 0.39 (Mali), 0.32 (Kenya), and 0.64 (South Africa). In this study, using DDS 10g improved the correlation with MPA to 0.44, indicating that the performance of dietary diversity as an indicator of adequate micronutrient intake is improved when a minimum intake for each food group can be assessed. This finding has important implications for field use of the indicator, as collecting information on quantities of food consumed is more time consuming than simply recording the number of food groups consumed.

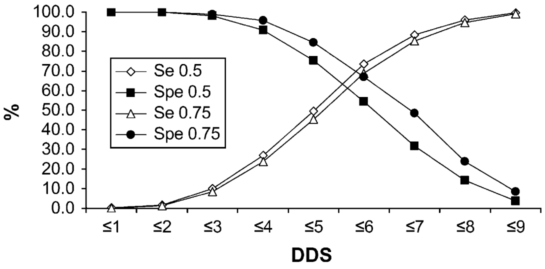

Figure 2 Sensitivity and specificity of DDS for 2 different cut-off points of MPA for non-breast-feeding Filipino children 24–71 mo of age. Se = Sensitivity, Spe = specificity. Sensitivity indicates the percentage of children truly at risk of inadequate micronutrient intake identified as at risk. Specificity identifies the percentage of children correctly identified as not at risk of inadequate micronutrient intake.

In our study, 2 nutrients, calcium and vitamin B-12, were not significantly correlated with DDS. Vitamin B-12 is found only in animal source foods, particularly liver, dairy products, and eggs. The best sources of calcium are dairy products, some legumes, green leafy vegetables, and small fish species, particularly if the bones are consumed. Dairy, eggs, and legumes were the least consumed food groups in the study population and lack of these groups could explain the poor correlation with DDS. Green leaves and fish were more commonly consumed, although the portion size consumed tended to be small. The lack of consumption of any foods from the dairy, egg, or legume group is the more likely explanation of poor correlation, as small portion sizes were common for most food groups except cereals/tubers.

A final aim of the study was to determine cut-off points for DDS, which can be used to classify children who are at greater risk of inadequate micronutrient intake. Similar to the Kenya study and using the 50th percentile of MPA, our results (not shown) found the best cut-off point to maximize sensitivity and specificity is a DDS of 5. However, the 50th percentile of our population corresponded to a mean MPA of 0.31, which may not be considered a sufficiently high enough cut-off to achieve an adequate improvement in population micronutrient intake. The results in Figure 2 test the sensitivity and specificity cut-off points using MPA of 0.50 and 0.75, a methodology previously applied by Hatloy et al. using MAR (4). Using MPA of 0.50 and 0.75, the best cut-off point for maximizing both sensitivity and specificity is between DDS of 5 and 6. Determining a fixed cut-off point where children can be defined as having greater or less risk of inadequate micronutrient intake has potential application in both immediate population nutritional assessment and continued monitoring of improvement in micronutrient intake. The ultimate decision as to which is the most appropriate MPA to use to define the DDS cut-off point, as well as whether it is more desirable to maximize sensitivity or specificity or find the point that optimizes both, will depend on the desired use of the DDS indicator. For example, if the goal of the indicator is to maximize identification of at-risk children, one would aim to maximize sensitivity; however, this would reduce specificity, thereby including more children who are not truly at risk in the target group. One potential use of the DDS is as an international indicator of risk of inadequate micronutrient intake. To realize this objective, additional validation studies using the same methodology for datasets from different geographic and cultural settings should be replicated.

One limitation of the study is that only 1 24-h recall was available per child; therefore, it was not possible to correct for within-person variation of intake. Not accounting for this variation could affect the MPA as well as perhaps the DDS cut-off point. Future studies should test the use of the indicator after adjusting for within-person variation in intake.

The aim of this study was to determine how well a simple score of food groups can be used to predict adequate micronutrient intake. The results have shown that DDS is correlated with MPA and also that DDS is a significant determinant of MPA. Using the more rigorous measure of DDS 10g did improve the correlation and regression model. Additionally, energy intake had a strong influence on MPA.

Current methods used to assess micronutrient deficiencies primarily rely on biochemical diagnostic tests of blood or urine, which, although considered the gold standard, are often difficult, time consuming, and expensive to collect and analyze, and are thus not generally widely used in community settings for monitoring and evaluation of nutrition improvement programs. There is a need to develop convenient, cost efficient indicators that can measure changes in the micronutrient status of vulnerable populations. This paper demonstrates that a simple count of food groups can be used to predict the probability of adequate micronutrient intake in young non-breast-feeding Filipino children. Indices that include additional information such as quantities of food consumed or total energy intake should enhance the performance of the indicator. The decision about the level of detail to incorporate into a survey will depend on the time available for data collection, overall study budget, and purpose or objective for which the indicator will be used.

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