Identifying Areas with Vitamin A Deficiency: The Validity of a Semiquantitative Food Frequency Method

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ABSTRACT

Objectives. The prevalence of vitamin A deficiency has traditionally been assessed through xerophthalmia or biochemical surveys. The cost and complexity of implementing these methods limits the ability of nonresearch organizations to identify vitamin A deficiency. This study examined the validity of a simple, inexpensive food frequency method to identify areas with a high prevalence of vitamin A deficiency.

Methods. The validity of the method was tested in 15 communities, 5 each from the Philippines, Guatemala, and Tanzania. Serum retinol concentrations of less than 20 μg/dL defined vitamin A deficiency.

Results. Weighted measures of vitamin A intake six or fewer times per week and unweighted measures of consumption of animal sources of vitamin A four or fewer times per week correctly classified seven of eight communities as having a high prevalence of vitamin A deficiency (i.e., 15% or more of preschool-aged children in the community had the deficiency) (sensitivity = 87.5%) and four of seven communities as having a low prevalence (specificity = 57.1%).

Conclusions. This method correctly classified the vitamin A deficiency status of 73.3% of the communities but demonstrated a high false-positive rate (42.9%). (*Am J Public Health.* 1997;87:186–191)

Introduction

Recent evidence of causal relationships between vitamin A status and child health and survival has stimulated nongovernmental, governmental, and private voluntary organizations to initiate programs to control vitamin A deficiency.[1–7] These nonresearch organizations need practical methods of identifying areas likely to have a high prevalence of vitamin A deficiency.

Traditional methods to assess the prevalence of vitamin A deficiency, including xerophthalmia surveys and biochemical analyses, pose serious financial, logistical, and technical constraints for these agencies.[8] Clinical surveys are costly and require large sample sizes. (A sample of 3090 is needed to identify a prevalence of 2% ± 0.5%.) Much smaller samples will suffice for biochemical surveys, but these surveys are expensive. They require technologists and equipment for proper collection and preparation of the samples, which also require special care in handling, transportation, and storage.

A semiquantitative food frequency method was developed by Helen Keller International under the auspices of the Vitamin A Technical Assistance Program. An earlier version of the method was used in a study that found measures of weekly consumption of vitamin A–rich foods for children aged 1 through 5 years to be strongly correlated with xerophthalmia.[9] The method was subsequently modified and is now based solely on a list that contains foods with at least 100 RE per 100 g vitamin A content. Subjects are asked on how many days and on average how many times per day the child ate these foods in the past week. The preliminary food frequency list is shown in Table 1. No information is collected on portion sizes, food preparation, or on which days of the week the items were consumed. The method was developed to provide nonresearch organizations and policymakers with a simple, inexpensive, user-friendly tool that can reasonably distinguish between areas (not individuals) with high and low risk of vitamin A deficiency in a variety of cultural settings. The food frequency method can replace the burdensome traditional population-based surveys used to generate prevalence estimates.

Methods

Subjects

The validity of the food frequency method was evaluated in three countries with different dietary patterns and levels of suspected vitamin A deficiency. Survey areas (districts or regions) in the Philippines, Guatemala, and Tanzania were selected to represent different magnitudes of suspected vitamin A deficiency (ranging from marginal to severe) between countries. In each area, five sites within 2 hours' driving distance from the study

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TABLE 1—Preliminary Food Frequency List

Questions
In the past week, on how many days did (child's name) eat (food item)?
On the average, how many times per day did (child's name) eat (food item)?
Food items
Staple food[a] (e.g., rice, bread, cassava)
Hot peppers[a]
Dark green leafy vegetables[a] (as a food group)
Whole milk[a]
Carrots[a]
Mango[a]
Pumpkin[a]
Spinach
Papaya[a]
Noodles
Eggs (with yolk)[a]
Small fish (liver intact)[a]
Yellow/orange sweet potato/yam[a]
Liver (any kind)[a]
Sweet potato leaves
Yellow/orange squash[a]
Butter
Beef/red meat[a]
Red palm oil/cod liver oil[a]
Foods cooked in oil[a]
Other locally identified vitamin A–rich foods (e.g., zapote)
Vitamin supplements

[a]These food items must remain on the instrument. The list can include 25 items or fewer.

TABLE 2—Sample Characteristics: Children in 15 Communities in the Philippines, Guatemala, and Tanzania Surveyed for Vitamin A Deficiency

	Philippines (n = 237)	Guatemala (n = 248)	Tanzania (n = 238)	Total Sample (n = 723)
Age, y, mean ± SD	3.0 ± 1.4	3.2 ± 1.4	2.7 ± 1.3*‡	3.0 ± 1.4
% male	51.9	50.4	57.1	53.0
Maternal education, y, mean ± SD	8.0 ± 3.1	1.1 ± 1.8***	4.5 ± 3.2‡	4.4 ± 4.0
No. children aged <6 y in home, mean ± SD	1.6 ± 0.7	1.9 ± 1.0***	1.8 ± 0.7**	1.9 ± 0.8
% with vaccination card	78.1	43.5***	63.9‡	61.0
% with home garden	73.4	23.4***	16.0***,†	37.3

*,†$P \leq .05$ compared with Philippine or Guatemalan sample, respectively.
**$P \leq .01$ compared with Philippine sample.
***,‡$P \leq .001$ compared with Philippine or Guatemalan sample, respectively.

laboratory were chosen at random. Villages with recent vitamin A capsule distribution and those considered politically unsafe were excluded from the sampling frame.

Sample size was calculated to identify a test efficiency (correct identification of 15% or more of the sample with serum retinol concentrations of less than 20 μg/dL) of 85% ± 10%, assuming an alpha error of 0.05, power = 80%, and a two-tailed test. Approximately 50 children were sampled in each site. When villages with less than 50 children were sampled, additional children were sampled in neighboring villages from households located closest to the original sample village. Although no formal household enumeration was conducted, community health workers indicated that a universal sample of households with children 1 through 5 years old was obtained in most locations. A total of 741 children in this age range participated in the surveys; results are presented for 723 children (97.6%) with known serum retinol status. To increase the likelihood of identifying vitamin A deficiency, the data collection was timed to occur before mango season and during periods of minimum food availability in the survey areas.

Participants were informed about the survey prior to data collection and were requested to bring all of their children aged 1 through 5 years old, with their birth certificates or vaccination cards, to a central data collection location. The survey team in each country consisted of an ophthalmologist, a pediatrician, two medical technicians, six interviewers, two supervisors, and local health workers.

These surveys were approved by the Medical Advisory Group of Helen Keller International and by the ethical advisory committees of each of the three local collaborating institutions (Davao Medical School Foundation in the Philippines; the Center for Studies of Sensory Impairment, Aging and Metabolism in Guatemala; and the Tanzanian Food and Nutrition Centre).

Interview and Dietary Assessment

To identify additional items to be integrated into the preliminary food list (Table 1), guided group discussions were held with the interviewers and local nutritionists and brief market surveys were conducted. The food list also included vitamin supplements. The questionnaire, food frequency instrument, and examination procedures were pretested in villages near the sample villages, after which minor modifications were made. Sociodemographic, health, and dietary data were collected in interviews by locally hired high school graduates who were given a 5-day training course, including a 1-day field test. The recent prevalence of diarrhea, cough, and fever (within 14 days prior to interview) and measles (within 1 month prior to interview) were reported by the childrens' caretakers and recorded by the interviewers without verification by diagnosis.

After receiving informed consent to conduct an eye examination and draw blood, an index child in each family was randomly selected (by means of numbered chits) by the interviewer. There were two (<1%) refusals to participate. All information, with the exception of maternal and household characteristics, referred to the index child. Questionnaires were translated into the local language and then duplicated. Table 2 presents sample characteristics.

Physical Examination

Interviewers were trained to measure children's mid-upper arm circumference, using Inser Arm Circumference Tapes donated by Ross Laboratories. The interviewer measured the arm circumference of each index child after conducting the interview. Age- and sex-specific data were used to categorize arm circumference as less than or equal to the 5th, 10th, and 25th percentiles in a standard population.[10]

Completed questionnaires were reviewed immediately by supervisors. Omissions or errors were corrected prior to the mother's departure. Previously undetected recording errors were corrected by interviewers, when possible, on final review of the questionnaires. Once en-

TABLE 3—Health and Nutritional Status of Sample Children

	Philippines (n = 237)	Guatemala (n = 248)	Tanzania (n = 238)	Total Sample (n = 723)
Mid-upper arm circumference[a]				
Mean cm ± SD	15.2 ± 1.2	15.1 ± 1.1	14.8 ± 1.0‡	15.1 ± 1.1
≤5th percentile, %	25.3	31.0	39.1***	31.8
≤10th percentile, %	40.9	46.8	52.9**	46.9
≤25th percentile, %	70.0	75.8	77.3	74.4
Serum retinol				
Mean µg/dL ± SD	24.9 ± 8.8	32.5 ± 7.4***	24.9 ± 7.7‡	27.5 ± 8.8
≤10 µg/dl, %	5.1	0.0***	1.3*	2.1
≤20 µg/dl, %	28.3	5.2***	26.9‡	17.8
Ocular indices, %				
Night blindness	2.1	0.8	0.4	1.1
Xerophthalmia	2.1	0.8	2.5	1.8
Abnormal CIC	30.3	26.7	32.9	29.9
Recent illness, %				
Diarrhea[b]	11.0	45.6***	22.7‡	26.7
Cough & fever[b]	23.6	45.6***	24.8‡	31.5
Measles[c]	1.3	4.0	7.1**	4.1

Note. CIC = conjunctival impression cytology.
[a]Percentiles are National Center for Health Statistics percentiles for the sample's mean age.
[b]Occurrence in the past 2 weeks.
[c]Occurrence in the past month.
*$P \leq .05$ compared with Philippine sample.
**$P \leq .01$ compared with Philippine sample.
***,‡$P \leq .001$ compared with Philippine or Guatemalan sample, respectively.

TABLE 4—Results of Dietary Survey: Children's Consumption of Vitamin A–Rich Foods

Predictive Variable	Philippines (n = 237)	Guatemala (n = 248)	Tanzania (n = 238)	Total Sample (n = 723)
Unweighted frequency[a]	15.0 ± 9.7	12.1 ± 7.4***	16.4 ± 8.1‡	14.5 ± 8.6
Servings[b]	19.9 ± 14.3	19.9 ± 14.1	31.3 ± 18.9‡	23.6 ± 16.7
Weighted frequency[c]	5.1 ± 3.6	5.5 ± 3.4	5.9 ± 3.5*	5.5 ± 3.5
No. vitamin A items[d]	6.8 ± 3.1	6.6 ± 3.3	6.4 ± 2.7	6.6 ± 3.0
Frequency of animal sources of vitamin A[a]	3.2 ± 3.0	4.2 ± 2.9***	3.8 ± 3.0*	3.7 ± 3.0
Vitamin A fruits[a]	1.8 ± 2.5	1.5 ± 1.9	2.5 ± 3.0**,‡	1.9 ± 2.5
Dark green leafy vegetables[a]	7.9 ± 6.3	3.9 ± 3.1***	7.4 ± 3.8‡	6.4 ± 4.9
Pumpkin/squash[a]	2.2 ± 2.1	1.8 ± 1.6*	2.6 ± 2.6‡	2.2 ± 2.2
Protein[a]	4.9 ± 4.0	11.6 ± 6.2***	8.1 ± 5.4‡	8.3 ± 5.9
Fats/oils[a]	4.0 ± 3.1	4.7 ± 3.5*	7.9 ± 5.1‡	4.6 ± 3.6
Usual diet, %[e]	100	95.6**	97.9	97.8
Vitamins, %[f]	18.1	5.6***	1.3***,†	8.3

Note. Numbers shown are mean ± SD unless otherwise indicated.
[a]Sum of days each vitamin A–rich item or food group was reported consumed in the past week.
[b]Number of servings consumed in the past week.
[c]Sum of (vitamin A–rich animal sources) + (vitamin A–rich plant sources divided by 6).
[d]Number of vitamin A–rich food items included on the food list.
[e]Percentage identifying past week's consumption as child's usual diet.
[f]Percentage providing supplemental vitamins to child in past week.
*,†$P \leq .05$ compared with Philippine or Guatemalan sample, respectively.
**$P \leq .01$ compared with Philippine sample.
***,‡$P \leq .001$ compared with Philippine or Guatemalan sample, respectively.

tered, data were reviewed for completeness and accuracy and consistency checks were performed.

Venous blood samples were drawn on 723 children aged 12 through 71 months. Approximately 4 to 5 mL of venous blood per child was collected in glass vacutainer tubes without anticoagulant. Within 30 minutes, the samples were placed in cooled ice chests containing packets of frozen blue ice. Styrofoam barriers were placed between the blood samples and blue ice packs to prevent freezing. Within 6 hours after the first blood samples were drawn, the samples were carefully transported by road to central rural laboratories where they were centrifuged. Serum was separated and extracted with pipettes into 2-mL Eppendorf tubes, relabeled, and frozen at −20°C or less. After a maximum of 1 week's frozen storage, serum samples were packed in cardboard boxes, aluminum foil, and 20 kg of dry ice and sent by express air cargo to Hoffman La Roche laboratories in Basel, Switzerland. All samples arrived in good condition and were kept frozen at −20°C or less until serum retinol assays were completed by high-performance liquid chromatography.[11]

The survey team ophthalmologist in each country examined all index children for clinical signs of xerophthalmia and conjunctivitis. After this examination, conjunctival impression cytology samples were taken by the Keenum disc applicator method. These samples were then stored in a fixative solution until staining at the Institute of Ophthalmology, Manila; at the Dr Rodolfo Robles Eye and Ear Hospital in Guatemala City; and at the Tanzanian Food and Nutrition Centre, Dar es Salaam. Slides were read by one reader in each country. The determination of conjunctival impression cytology status was based on suggested criteria.[12–13] All children with xerophthalmia or severe malnutrition (arm circumference less than the 5th percentile for age and sex) were given high-dose vitamin A capsules (200 000 IU vitamin A and 40 IU vitamin E) after blood extraction.

Statistical Analysis

The food frequency method was assessed as a screening tool to identify areas with vitamin A deficiency problems (i.e., 15% or more of preschool-aged children in the community with serum retinol concentrations of less than 20 µg/dL, as recommended by IVACG, International Vitamin A Consultative Group).[14] Analyses of the association between the food frequency measure and vitamin A status were thus conducted with the community and country used as the units of analyses. Bivariate analyses of the sample characteristics were conducted

TABLE 5—The Validity of a Semiquantitative Dietary Frequency Method for Identification of Vitamin A Deficiency in a Community

	Philippines (n = 5)	Guatemala (n = 5)	Tanzania (n = 5)	Total Sample (n = 15)
Sensitivity	4/4 = 100%	0/0	3/4 = 75%	7/8 = 87.5% (95% exact CI = 47%, 100%)
Specificity	0/1 = 0%	3/5 = 60%	1/1 = 100%	4/7 = 57.1% (95% exact CI = 18%, 90%)
Efficiency (TP + TN/n)	4/5 = 80%	3/5 = 60%	4/5 = 80%	11/15 = 73.3% (95% exact CI = 45%, 92%)
Positive predictive value	4/5 = 80%	0/2 = 0%	3/3 = 100%	7/10 = 70% (95% exact CI = 35%, 93%)
Negative predictive value	0/0	3/3 = 100%	1/2 = 50%	4/5 = 80% (95% exact CI = 28%, 99%)

Note. n = number of communities; CI = confidence interval; TP = true positive; TN = true negative. The method was equally valid for weighted intake of 6 or fewer times per week (weighted intake = sum of [days on which animal sources of vitamin A were consumed] + [days on which plant sources of vitamin A were consumed divided by 6]) and unweighted intake (sum of days on which animal sources of vitamin A were consumed) of 4 or fewer times per week.

(chi-square and Student's *t* tests were used for comparison of study site differences). Correlation analyses were also conducted to assess the association between other dietary indicators and serum retinol.

The food frequency method provides the following indices of dietary intake: (1) the sum of the reported number of days in the past week each vitamin A–rich food item was consumed ("unweighted frequency"); (2) the number of servings consumed in the past week; (3) the sum of the reported number of days on which vegetable and fruit sources were consumed divided by 6 (assuming 6 μg β-carotene = 1 μg retinol[15]) plus the number of days on which animal sources were consumed ("weighted frequency"); (4) the number of local vitamin A–rich food items included on the food frequency list; and (5) index 1 (above) categorized by food group (i.e., animal sources of preformed vitamin A, vitamin A–rich fruits, dark green leafy vegetables, and other vitamin A–rich vegetables). Animal sources of vitamin A include eggs (with yolk), small fish (with liver intact), and liver; milk was excluded because in the study areas it was unfortified and diluted by water. Other sources are dark green leafy vegetables, including spinach, sweet potato leaves, and local vegetables; carrots, pumpkins, yellow yams, yellow squash, and local yellow and orange vegetables; mango, papaya, and local fruits; and butter, red palm oil, and cod liver oil. The number of days in the past week on which common sources of protein (whole milk, eggs, small fish, liver, beef, red meat), fats and oils (butter, red palm and cod liver oil, other visible oils), and multivitamins were consumed was elicited to determine whether these were important limiting nutrients and whether vitamin supplements affected serum retinol concentrations. Distributions of these indices were reviewed and various cutoff points were defined to determine which were most predictive of vitamin A deficiency.

Results

The samples covered a variety of cultural settings. Minimal differences in age were observed among country samples (Table 2). The Tanzanian sample included slightly more male children than the other samples. The Philippine sample had the highest number of years of maternal education, the lowest number of preschoolers per family, and the highest percentages with vaccination cards and home gardens. The Guatemalan sample had the worst status on these indices except for home gardens.

The mid-upper arm circumference of the sample children (Table 3) was similar in the Philippines and Guatemala (15.2 ± 1.2 cm and 15.1 ± 1.1 cm, respectively) but lower in Tanzania (14.8 ± 1.0 cm). This difference is reflected in the proportion of children with low arm circumference percentiles. The recent prevalence of diarrhea, respiratory disease (defined as simultaneous cough and fever), and measles was lowest in the Philippine sample (Table 3). The highest rates of diarrhea and respiratory disease were observed in the Guatemalan sample.

As intended, the magnitude of vitamin A deficiency varied across countries (Table 3). The highest prevalence was found in the Philippines, with similar rates in Tanzania (mean serum retinol concentrations of 24.9 ± 8.8 μg/dL and 24.9 ± 7.7 μg/dL, respectively, slightly above the National Center for Health Statistics [NCHS] 10th percentile for the sample's mean age). The Guatemalan children had a mean serum retinol concentration of 32.5 ± 7.4 μg/dL (between the 25th and 50th percentiles of NCHS standards for the sample's mean age). The prevalence of night blindness in the Guatemalan sample was 0.8%, but this figure may be questionable as no local term for night blindness exists. The prevalence of night blindness, locally called *harap,* was 2.1% in the Philippines survey area. Although a local term exists, night blindness was rare in the Tanzanian sample (0.4%), but clinical signs of xerophthalmia, and particularly Bitot's spots, were commonly observed (2.5%). Conjunctival impression cytology results varied little between samples.

There were no consistent patterns of unweighted dietary indices (unweighted frequency, servings, food groups) across samples (Table 4). Guatemala had the highest (sum of days item was consumed = 4.2 ± 2.9), Tanzania intermediate (3.8 ± 3.0), and the Philippines the lowest (3.2 ± 3.0) consumption of animal sources of preformed vitamin A. The Guatemalan children also consumed protein-rich foods more frequently (sum of days item was consumed = 11.6 ± 6.2) than Tanzanian (8.1 ± 5.4) or Filipino (4.9 ± 4.0) children.

Lipid consumption was higher in the Tanzanian sample (sum of days item was consumed = 7.9 ± 5.1) and Filipino (4.0 ± 3.1) samples. Consumption of supplemental vitamins was highest in the Philippines (18.1%, vs 5.6% in Guatemala and 1.3% in Tanzania). Almost all the children's diets were reported to be "usual."

Only correlations between whether 15% or more of the 15 communities' children had serum retinol concentrations of less than 20 μg/dL and two of the dietary indices, weighted weekly frequency and frequency of consumption of animal sources of preformed vitamin A,

were in the expected direction (data not presented).

Table 5 presents the results of an assessment of the food frequency method as a screening tool to identify countries and communities with vitamin A deficiency. The community analysis indicates that the method correctly identified seven of eight (87.5%) communities where 15% or more of the children had serum retinol concentrations of less than 20 μg/dL by indices of weighted intake of 6 or fewer times per week or consumption of animal sources of vitamin A 4 or fewer times per week. Four of seven (57.1%) communities were correctly identified as not having a vitamin A deficiency problem by the same criteria ($P = .07$). These cutoff points were determined post hoc and were selected on the basis of the best results from analyses testing many threshold levels. They are similar to those found in a previous evaluation using an earlier version of the food frequency method.[9] The false-positive rate, however, indicates that three of seven (42.9%) communities were incorrectly identified as likely to have a vitamin A deficiency problem. In total, 73.3% of communities were correctly classified as having or not having a vitamin A deficiency problem of public health proportions. Positive and negative predictive values were 70% and 80%, respectively. Similarly, the sensitivity of the method analyzed by country was high (100% in the Philippines and Guatemala and 75% in Tanzania), but specificity was variable and resulted in lower test efficiency.

Conclusions

The multicountry sampling strategy provided the variability in cultural, serologic, and dietary status necessary to initially test the validity of the dietary frequency method. The extent of low serum retinol concentrations and xerophthalmia observed indicate that vitamin A deficiency is a problem in the sample sites in the Philippines and Tanzania, but not in Guatemala.

Indices of weighted intake 6 or fewer times per week and consumption of animal sources of preformed vitamin A 4 or fewer times per week correctly identified the vitamin A deficiency status of 73.3% of the communities sampled ($P = .07$). If we use a theoretical cutoff point of 60% (equivalent to 3 of 5) of communities sampled having vitamin A deficiency, the sample areas in the Philippines and Tanzania would be considered high priority and that in Guatemala low priority for vitamin A deficiency control programs. All other indices tested except the frequency of consumption of protein-rich foods were not predictive of a high community prevalence of low serum retinol concentrations.

The success of food frequency methods may be attributable to their simplicity, which reduces interviewer and recording errors and recall (memory) bias.[16–17] Initially, market surveys were included to ensure data completeness; however, the surveys' results demonstrated that attempts to achieve completeness and precision were not useful and reduced the reliability of the indices. Reporting of individual foods, particularly those eaten in small quantities, does not appear to be as reliable as reporting of food groups.[16] The sum of individual dark green leafy vegetable items on the list was poorly correlated ($r = .245$) to a single item added to the Tanzanian list (reported consumption of any and all dark green leafy vegetables, asked prior to eliciting consumption for each individual vegetable). The number of meals consumed daily probably varies little by culture and more by season (pre- or postharvest). Serving sizes probably vary by age, as do serum retinol concentrations. Therefore these indices were not discriminating. Including foods with a substantial content of the nutrient of interest consumed reasonably often by the population of interest and in portion sizes large enough to aid in the discrimination of those with and without deficiency is key to the method's success.

Interestingly, the strongest correlations were found between the frequency of protein consumption and community serum retinol concentrations of less than 20 μg/dL ($r = -0.776, P = .007, n = 15$). This correlation may reflect the importance of protein and zinc for the utilization of available liver stores of vitamin A or it may indicate greater reliability, as is always found for macronutrients compared with micronutrients. Alternatively, protein-rich foods are usually expensive and may be associated with better serum retinol concentrations for other than dietary reasons (fewer infections, better access to health care, etc.).

Food group analyses (animal sources of preformed vitamin A and protein) were the best indicators of vitamin A deficiency. This could suggest that eliciting dietary information solely by food group may be more reliable and better predict deficiency than obtaining dietary data on individual items. The rationale behind using individual items in this dietary frequency method, however, was to provide a simple, inexpensive instrument that nonresearch organizations could use for multiple purposes, that is, to identify areas at risk of vitamin A deficiency, to identify locally acceptable vitamin A–rich foods to promote, and to act as a baseline for nutrition programs against which to evaluate the increased consumption of those vitamin A–rich foods in childrens' diets. The sole recommended modification to the food frequency method presented here is the deletion of the second question, which elicited the number of times per day each item was consumed.

It is unlikely that our results represent an ecologic fallacy. Prediction of a physiologic response, using the relative dose–response test, has been recommended to identify individual cases of vitamin A deficiency, but this method was not logistically feasible for inclusion in this study.[18] Prediction of disease is difficult, as xerophthalmia is a rare condition. Sommer and Tarwotjo have demonstrated the relationship between serum retinol concentration, frequencies of food group consumption, and xerophthalmia in Indonesian children in a large community-based study.[19–20] This validation study found that children whose weighted weekly vitamin A intake frequency was 6 or less had mean serum retinol concentrations of 26.7 ± 8.3 μg/dL, compared with 29.0 ± 9.3 μg/dL in those with higher intake ($P = .001$). Almost identical results were observed for those who consumed animal sources of vitamin A 4 or fewer times per week (26.6 ± 8.3 μg/dL compared with 29.5 ± 9.4 μg/dL, $P = .000$). The mean serum retinol concentration for those with xerophthalmia was 24.6 ± 11.4 μg/dL, compared with 27.6 ± 8.7 μg/dL in those without xerophthalmia ($P = .37$); this difference is not statistically significant, but few cases of xerophthalmia were encountered ($n = 13$).

The food frequency method is an inexpensive, simple, sensitive indicator to identify areas of vitamin A deficiency and is one of the few simple methods tested for validity. The method holds much promise, yet it incorrectly classified 42.9% of communities as likely to have a vitamin A deficiency problem. Although the method works well in areas where vitamin A deficiency is prevalent, the small number of communities and countries included in this study is inadequate to accurately estimate the specificity of the

method. Further efforts—including validation in two or more additional countries where vitamin A deficiency is suspected to be a *marginal* problem (such as Brazil, Pakistan, or Senegal); and in at least 10 communities per country to obtain more precise estimates of sensitivity, specificity, and predictive value; and in communities of varying size—are necessary to determine the accuracy and limitations of the food frequency method. □

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