Prevalence of vitamin A deficiency in children aged 6–9 years in Wukro, northern Ethiopia

Tarik Kassaye,[1] Olivier Receveur,[2] Timothy Johns,[3] & Margaret R. Becklake[4]

Objective To determine the prevalence of vitamin A deficiency in children aged 6–9 years in northern Ethiopia.
Methods A cross-sectional study was carried out and the data were analysed for 824 (61.5%) of 1339 eligible children for whom there was complete information on biochemical vitamin A status, dietary vitamin A intake, ocular examination for xerophthalmia, and anthropometry.
Findings The prevalence of xerophthalmia was 5.8%; serum retinol levels were below 0.35 µmol/l and between 0.35 and 0.70 µmol/l in 8.4% and 51.1% of the children respectively. The liver vitamin A reserve (modified relative dose response ratio $\geqslant$ 0.06) was low in 41.0% of the children.
Conclusion The high prevalence of severe vitamin A deficiency in children aged 6–9 years indicates the need to re-evaluate the practice of targeting vitamin A supplementation programmes on children under 6 years of age in areas where vitamin A deficiency is endemic.

Keywords Vitamin A deficiency/epidemiology; Vitamin A/administration and dosage/blood; Xerophthalmia/etiology; Child; Cross-sectional studies; Ethiopia (*source: MeSH*).

Mots clés Rétinol, Carence/épidémiologie; Vitamine A/administration et posologie/sang; Xérophtalmie/étiologie; Enfant; Etude section efficace; Ethiopie (*source: INSERM*).

Palabras clave Deficiencia de vitamina A/epidemiología; Vitamina A/administración y dosificación/sangre; Xeroftalmía/etiología; Niño; Estudios transversales; Etiopía (*fuente: BIREME*).

Bulletin of the World Health Organization, 2001, **79**: 415–422.

Voir page 421 le résumé en français. En la página 421 figura un resumen en español.

Introduction

Some 250 million preschool children are at risk of vitamin A deficiency, mainly in developing countries (*1*). The largest number of countries affected is in Africa, whereas the largest number of children with this deficiency is in south-east Asia (*2*) because of insufficiently varied diets, poor maternal education and inadequate hygiene (*3*, *4*). In Ethiopia, vitamin A deficiency of public health significance was identified in 1958 (*5*, *6*). Subsequent surveys revealed low dietary vitamin A intake except in the southern region (*7–9*). Specific evidence of vitamin A deficiency in children and pregnant and lactating women (*10–15*) underscored the gravity of the problem.

In 1989 the Ethiopian Nutrition Institute adopted a national intervention programme with the aim of reducing the prevalence of vitamin A deficiency to a level that would not be of significance from the public health standpoint by 2000. The programme involves screening vulnerable children and the treatment of xerophthalmic children by trained personnel. Capsules containing high doses of vitamin A are distributed in high-risk areas. Nutritional education and the development of horticulture are promoted (*16*). The distribution of high-dose vitamin A capsules through the Expanded Programme on Immunization began in 1996 (*17*).

In all of these interventions the targeted groups are usually infants, who receive capsules containing 100 000 IU vitamin A, and lactating mothers and children below 6 years of age, who are given 200 000 IU. In addition the Bureau of Health, supported by UNICEF, distributes capsules containing 50 000 IU vitamin A to pregnant mothers in the rural areas of Tigray (*18*). The targeting of vulnerable groups is necessary in countries where resources are limited. However, the evaluation of vitamin A deficiency in other segments of the population also deserves attention. Some studies on the magnitude of vitamin A deficiency have included schoolchildren with children under 6 years of age but the gravity of the problem has not been clearly established in older age groups. There is evidence from Ethiopia (*12*, *13*, *19*) and South Africa (*20*) that the prevalence of

[1] Former PhD candidate, School of Dietetics and Human Nutrition, McGill University, 21,111 Lakeshore Road, Ste Anne de Bellevue, PQ, H9X 3V9, Canada. Correspondence should be addressed to Dr Kassaye.

[2] Assistant Professor, School of Dietetics and Human Nutrition, McGill University.

[3] Associate Professor, School of Dietetics and Human Nutrition, McGill University.

[4] Professor, Respiratory Epidemiology Unit, Department of Epidemiology and Biostatistics, McGill University, 1110 Pine Avenue West, H3A 1A3, Montreal, Canada.

Ref. No. **99-0186**

vitamin A deficiency in children increases with age. This contrasts with a World Bank report of zero prevalence of vitamin A deficiency in children aged 5–14 years in developing countries (*21*).

The objective of the present study was to determine the prevalence of vitamin A deficiency in children aged 6–9 years in northern Ethiopia, in advance of a prospective, randomized, placebo-controlled, community-based trial that would evaluate the effect of vitamin A supplementation on the status of lung function.

Materials and methods

Study area and subjects

A cross-sectional study was undertaken in Wukro *wereda,*[a] Tigray administrative region, northern Ethiopia, from April to July 1997. The eastern zone[a] of this region is densely populated and impoverished, and the socioeconomic and ecological conditions do not differ markedly between its main *weredas*. Wukro was selected because of its proximity to Mekelle, the capital of the administrative region. Within Wukro, five study sites (*tabias*[a]) (Mesanu, Genfel, Abreha-Atsbeha, Negash and Gemad) were selected because they were rural or semirural and had an all-weather road and a health facility such as a health station, clinic, health centre or hospital. Their altitudes ranged from 1900 metres to 2330 metres above sea level.

A list of all households in the study sites was drawn up and those with eligible children, i.e. aged 6–9 years, were identified. A random sample was taken at each site, based on the estimated sample size of 1339 required for the five sites and weighted so that each site contributed in proportion to its population. The sample size estimates were based on the outcome variable, namely forced expiratory volume in one second (FEV_1) for the intervention trial referred to above, to allow a detection of a change of 0.16 litres in FEV_1, with a power of 80% and a 5% probability level. One child per household was included in the study. If there were two or more eligible children in a household the oldest was included in order to minimize the likelihood of including children who might recently have received supplementation under the national intervention programme.

During home visits, eligible households were informed of the objectives of the study and asked if they would consent to participate.

The study protocol was approved by the Ethiopian Science and Technology Commission, the Ethics Committee of the Department of Paediatrics and Child Health, Addis Ababa University, and the Ethical Review Committee of Macdonald Campus, McGill University, Canada.

[a] Zone (1st level), *wereda* (2nd level), *tabia* (3rd level) and *kushet* (4th level) are subdivisions within the Tigray administrative region.

Data collection

Questionnaire

A pretested questionnaire, translated into Tigrigna, the local language, was administered by trained interviewers at home to mothers or female care-givers, in order to collect demographic and health information on the children studied and on socio-economic and environmental factors of relevance to the households. A local events calendar was prepared for each site to assist in determining the age of each child.

The children' dietary vitamin A intake was assessed with the help of a semiquantitative food frequency questionnaire. A measuring cup and teaspoon were used to estimate the usual portion sizes of 19 locally available food items containing vitamin A. The mothers or female caregivers were asked if the children had consumed each food item during the preceding post-harvest season, i.e. from October to January. If the response was positive, the usual portion size and the frequency of consumption were recorded. For each serving of the 19 items, the vitamin A content in retinol equivalents (RE) was calculated with the help of food composition tables (*22–24*). Two weeks after the completion of the baseline questionnaire, anthropometric measurements, ocular examinations and vitamin A status determinations based on the modified relative dose response (MRDR) method (*25*, *26*) were initiated on children whose parents consented to send them to the health facility.

Anthropometry

Height and weight were measured without footwear. Height was measured to the nearest 0.1 cm (*27*) by means of a wooden board with a scale and a sliding headpiece (Shorr Corporation, USA). The weights of children wearing light clothing were measured with an electronic load cell scale (Seca 770, Germany) to the nearest 0.1 kg (*27*). Data on height, weight, age and sex were used to calculate standardized nutritional indices (Z-scores), using the EpiInfo Program (Version 6.02, Centers for Disease Control and Prevention, USA, and WHO). Children were classified as underweight, stunted and wasted if the calculated weight-for-age, height-for-age and weight-for-height Z-scores respectively were below –2.0 standard deviations, using data from the United States National Center for Health Statistics as the reference.

Vitamin A assessment

Ocular examinations were conducted by an ophthalmic assistant who had been trained by a leading ophthalmologist in accordance with WHO guidelines (*28*). Children with any clinical signs of xerophthalmia were treated immediately with 200 000 IU vitamin A on days 1, 2 and 7 after ocular examination and were not included in the prospective study, which lasted six months. They were, however, included in the calculation of the prevalence of xerophthalmia in the study population. The various stages of xerophthlamia were not identified nor was information on night blindness collected. Corneal scarring was not included in the diagnosis of xerophthalmia.

The MRDR method developed by the Vitamin A Research Group at Iowa State University was used to assess the vitamin A liver reserve (*25*, *26*); retinol was assessed as part of this assay.

At the health facilities all the children in the study were given a single dose of 225 μl 3,4-didehydroretinyl acetate, synthesized by the Vitamin A Research Group, in corn oil by means of a 250 μl Gilson positive displacement pipette (Rainin Instruments, Woburn, Massachusetts, USA). After dosing, each child was given a snack of *beso/tihni* and tea. *Beso* was prepared from ground roasted barley, salt, water and oil; its fat content was estimated to be approximately 15 g per serving. A blood sample was obtained from each child by antecubital venipuncture within 4–6 hours after dosing. The blood samples were protected from light, stored in cool boxes and centrifuged for 10 minutes at 1000 g within 2–3 hours after collection. The serum was transferred to amber-coloured micropipettes and transported at low temperature to Mekelle Hospital, where they were stored at –70 °C to await shipment in dry ice to Canada.

The MRDR method (*26*) was adopted with the following changes. Instead of hexane, petroleum ether was used for the extraction of retinol and didehydroretinol from the serum samples. After the petroleum ether extract was dried by means of nitrogen the lipid residue was reconstituted using an 80:20 mixture of methanol:acetonitrile instead of a 3:1 (v/v) methanol:methylene dichloride mixture, and 100% methanol was used as the mobile phase instead of the suggested 90:10 methanol:water mixture. Most of these changes were made because of differences in the HPLC system used.

Data analysis

Data were entered using the EpiInfo Program and were managed and analysed by means of the SAS system for Windows (version 6.11; SAS Institute, Cary, North Carolina, USA). *P* values below 0.05 were considered statistically significant. Student's t-test and chi-square tests were used to test differences between continuous and categorical variables respectively. Means and standard deviations were calculated for continuous variables. The overall prevalence of vitamin A indicators was adjusted as a weighted average of site-specific prevalences. Table 1 shows the distribution of eligible study children for whom there were complete data (*n* = 824) and those for whom the data were incomplete (*n* = 515) by study site. Table 2 shows the characteristics of children in the study by sites. The overall prevalence of vitamin A indicators was adjusted as a weighted average of site specific prevalences (Table 3).

Criteria used to define vitamin A deficiency

The main study outcome, vitamin A deficiency, was defined as:

(i) **xerophthalmia** if any clinical signs of vitamin A deficiency were exhibited in one eye or both eyes;
(ii) **severe hyporetinolaemia** if the serum retinol concentration was < 0.35 μmol/l;
(iii) **mild to moderate hyporetinolaemia** if the serum retinol level was between 0.35 and 0.70 μmol/l;
(iv) **low vitamin A reserve** if the modifed relative dose response ratio was ⩾0.06.

Dietary vitamin A intake was expressed in RE and based on the dietary vitamin A intake, classified as being:

(i) below the basal requirement (< 250 RE/day);
(ii) between the basal and normative requirements (250–400 RE/day);
(iii) equal to or above the normative requirement (⩾400 RE/day) (*29*, *30*).

The corresponding risks of vitamin A deficiency were high, moderate and low respectively.

Results

A questionnaire was completed for one child in each of the 1339 eligible households; 1198 (89.5%) of the children came to the health facility and anthropometric measurements were made on them; 1121 (83.4%) gave blood samples. Among these samples, 162 (14.4%) were of inadequate volume or were haemolysed, and for 94 (8.3%) there were problems associated with the MRDR procedure. Complete information on biochemical vitamin A status, dietary vitamin A intake, ocular examination and anthropometry was available for 824 of the remaining 865 samples (62%). Table 1 lists the study variables for which there were significant differences at the 0.20 probability level between children with complete records (*n* = 824) and children with incomplete records (*n* = 515). Other variables that did not differ between groups at this probability level are indicated in Table 1 (footnote). The characteristics of the children for which there were complete data (*n* = 824) at each site are shown in Table 2. There were significant differences between sites for school attendance, stunting, dietary vitamin A intake, vaccination status, measles status, mean age of measles occurrence, malaria status and illness status during the month before interview. Because of the high variability of the data on dietary vitamin A intake,Table 2 includes logarithmic transformations.

Prevalence of vitamin A deficiency

Table 3 shows vitamin A status as assessed by ocular examination, serum retinol level and the MRDR assay. Of the 824 children, 48 had clinical signs of xerophthalmia. Most of them exhibited Bitot's spots

Table 1. **Characteristics of eligible study children with complete and incomplete records[a]**

Characteristics	Whole sample ($n = 1339$)	Complete records ($n = 824$)	Incomplete records ($n = 515$)	P-value[b]
Height (sd[c]) in cm[d]	115.7 (7.9)	115.9 (7.6)	115.2 (8.5)	0.20
Age child had measles (sd) in years[e]	3.9 (1.9)	4.0 (1.8)	3.7 (2.0)	0.12
Distribution by study site (%)				
Abreha-Atsbeha	12.7	13.6	1.3	0.001
Mesanu	14.6	17.8	9.5	
Negash	23.7	21.5	27.4	
Genfel	15.5	17.0	13.0	
Gemad	33.5	30.1	38.8	
Radio ownership (%)	12.9	13.8	11.5	0.20
Fields cultivated (%)				
Fewer than 3 fields cultivated	73.5	71.4	76.9	0.03
3 or more fields cultivated	31.7	28.6	23.1	
Type of toilet (%)				
Field used as toilet	92.8	93.6	91.4	0.07
Pit latrine used as toilet	7.2	6.3	8.5	–

[a] Variables listed are for differences with $P \leqslant 0.20$. Variables which were examined and not listed had $P > 0.20$; these related to sex, age, weight, breastfeeding status during infancy, number of months breastfed, vaccination status, measles status, malaria status, illness during the month before interview, religion, head of household, questionnaire respondent, distance to nearest health facility, source of drinking-water, availability of soap in house at time of interview, plough ownership, number of fields cultivated and number of bags of crops harvested.

[b] Significant at $P < 0.05$, t-test for continuous variables and χ^2 test for categorical variables.

[c] Standard deviation.

[d] For height, $n = 1198$ (whole sample), $n = 824$ (complete records), and $n = 374$ (incomplete records).

[e] For age in years at which child had measles, $n = 706$ (whole sample), $n = 438$ (complete records), and $n = 268$ (incomplete records).

Table 2. **Characteristics of study children by sites**

Characteristics	Whole sample ($n = 824$)	Study sites in Wukro *wereda*					
		Mesanu ($n = 147$)	Genfel ($n = 140$)	Abreha-Atsbeha ($n = 248$)	Negash ($n = 112$)	Gemad ($n = 177$)	P-value[a]
Personal							
% girls	51.1	49.7	49.3	55.4	50.8	51.2	0.89
% school attendance – ever	6.4	3.4	13.6	7.1	7.3	3.2	0.001
% school attendance – current	5.3	2.0	11.4	6.3	6.2	2.8	0.001
% breastfed during infancy	98.2	97.9	99.3	100.0	99.4	99.6	0.57
Mean number of months of breastfeeding during infancy (sd[b])	27.7 (7.6)	27.2 (7.2)	27.4 (7.4)	27.0 (8.3)	27.1 (7.4)	28.8 (7.7)	0.10
Anthropometry							
Mean age in years (sd)	7.8 (0.9)	7.8 (0.9)	7.8 (1.0)	7.6 (0.9)	7.8 (0.9)	7.8 (0.9)	0.50
Mean height in cm (sd)	115.9 (7.7)	116.5 (7.5)	116.9 (8.1)	115.5 (7.1)	115.4 (7.9)	115.7 (7.5)	0.33
Mean weight in kg (sd)	18.7 (2.7)	19.0 (2.7)	18.9 (2.9)	18.4 (2.7)	18.5 (2.6)	18.6 (2.6)	0.34
% underweight	44.3	37.4	42.9	45.5	48.6	45.6	0.34
% stunted	39.9	32.0	32.9	39.3	43.5	46.4	0.02
% wasted	10.4	8.8	10.0	13.4	9.6	10.9	0.80
Dietary vitamin A							
% dietary vitamin A intake <250 RE/day – high risk	85.2	82.3	90.0	83.9	80.8	87.9	0.10
Dietary vitamin A intake (sd) RE/day	135.9 (185.8)	152.6 (145.2)	115.4 (108.4)	169.6 (242.0)	151.0 (257.2)	111.4 (144.3)	0.01
Log dietary vitamin A intake (sd)	4.1 (1.6)	4.5 (1.3)	4.3 (1.4)	4.3 (1.5)	3.4 (2.4)	4.1 (1.2)	
Health-related							
% vaccinated at least once	28.6	33.3	50.0	19.6	20.9	23.4	0.001
% children who had had measles	53.5	49.7	32.1	53.6	58.8	64.1	0.001
Mean age in years when child had measles (sd)	4.0 (1.8)	5.5 (1.7)	3.8 (1.9)	4.3 (1.8)	3.6 (1.8)	3.4 (1.6)	0.0001
% children who had had malaria	17.8	14.0	27.1	55.7	1.7	10.1	0.001
% children who had had an illness during month before interview	28.6	31.3	31.4	44.6	22.6	22.6	0.001

[a] Significant at $P < 0.05$, ANOVA for continuous variables and χ^2 test for categorical variables for differences across study sites.

[b] Standard deviation.

Table 3. **Indicators[a] of vitamin A status by study sites**

Vitamin A assessment	Indicator/cut-off	Whole sample ($n = 824$)	Study sites in Wukro *wereda* (within Eastern zone of Tigray)[b] Mesanu ($n = 147$)	Genfel ($n = 140$)	Abreha-Atsbeha ($n = 112$)	Negash ($n = 177$)	Gemad ($n = 248$)	*P*-value[c]
	% prevalence (95% confidence interval)	Adjusted[d]	Unadjusted					
Ocular examination	% xerophthalmia	5.8 (4.2, 7.4)	8.2	2.1	8.0	5.1	6.1	0.19
Serum retinol	% <0.35 µmol/L	8.4 (6.6, 10.2)	10.9	5.0	2.7	11.3	8.9	0.04
Serum retinol	% 0.35–0.7 µmol/L	51.1 (47.7, 54.5)	53.7	57.1	47.3	40.6	56.0	0.01
MRDR ratio	% ⩾0.06 MRDR	41.0 (37.6, 44.4)	49.7	45.7	41.1	37.9	37.1	0.09
Mean (sd[e]) retinol (µmol/l)		0.69 (0.31)	0.62 (0.24)	0.66 (0.29)	0.77 (0.3)	0.79 (0.42)	0.63 (0.25)	0.0001
Range		0.1–2.49	0.19–1.53	0.10–2.49	0.11–1.89	0.11–2.45	0.13–1.50	
Mean (sd) MRDR ratio		0.05 (0.06)	0.06 (0.07)	0.05 (0.05)	0.05 (0.07)	0.05 (0.07)	0.04 (0.05)	0.11
Range		0–0.47	0–0.47	0–0.20	0–0.47	0–0.47	0–0.27	

[a] % prevalence for xerophthalmia, deficient, mild-to-moderate serum retinol level and low vitamin A reserve with cut-offs; mean (standard deviation, range) for serum retinol and MRDR ratio (continuous variables).

[b] Based on adjusted estimates of the vitamin A deficiency indicators obtained from sample of 824, the number of children affected by vitamin A deficiency, can be estimated for Wukro *wereda* and Eastern zone of Tigray administrative region (see text for description of study area). For example, in Wukro *wereda*, 591 children would be affected by xerophthalmia (adjusted estimate, 5.8%, multiplied by population of eligible children in Wukro, 10 186). Similarly, in the Eastern zone, 31 266 children would have low vitamin A reserve (adjusted estimate, 41.0%, multiplied by the number of eligible children in Eastern zone, 76 258). The population figures were obtained from the 1994 national census (*35*) for children aged 5–9 years. Category available in census was based on age group 5–9 years.

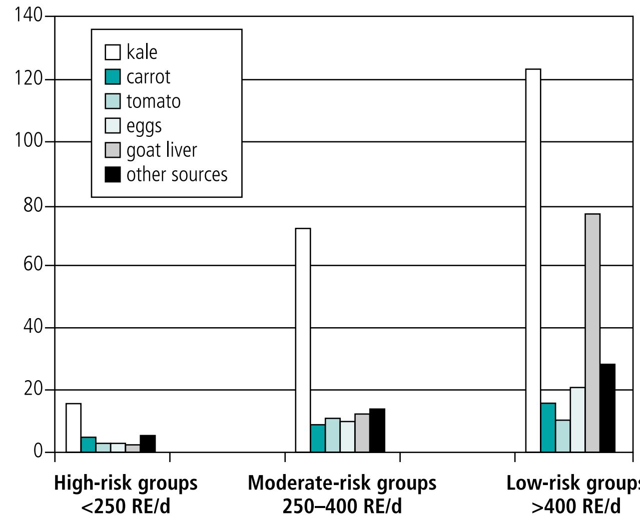
[c] Significant at $P < 0.05$, ANOVA (continuous variables) and χ-square test (categorical variables) for differences across study sites.

[d] Obtained as a weighted average of site-specific prevalence given in columns 4–8 above, with weights given by site-specific distribution in Table 2.

[e] Standard deviation.

(X1B) and a few had conjunctival xerosis (X1A), corneal xerosis (X2) and corneal lesions (X3A); none had corneal scars (XS). After adjustment for differences in the distribution of study sites, the prevalence of xerophthalmia was 5.8% and that of MRDR ratio ⩾ 0.06 was 41.0%. The serum retinol concentration was deficient (<0.35 µmol/l), low (0.35–0.70 µmol/l inclusive) and normal (>0.7 µmol/l) in 8.4%, 51.1% and 40.5% of the children respectively. There were significant differences between sites for serum retinol by both cut-offs, i.e. 0.35 µmol/l and 0.35–0.70 µmol/l (Table 3), but not for xerophthalmia and MRDR ratio. A significant difference between sexes was noted only for low vitamin A reserve (⩾ 0.06 MRDR). Girls had significantly lower liver vitamin A reserves than boys ($p < 0.04$) (Table 4). There was no significant difference between age groups, although there was a tendency for the younger age group to have a higher prevalence of vitamin A deficiency by both serum retinol cut-offs and ⩾0.06 MRDR ratio (Table 4).

Fig. 1. **Percentage of daily vitamin A intake from main sources as basal requirement of vitamin A (250 RE/day)**



Dietary vitamin A intake

Variables related to dietary vitamin A intake

The data on the19 food sources containing vitamin A indicated that 85.2% of the children were at high risk of vitamin A deficiency (daily intake below basal requirement), 9.2% were at moderate risk (intake between basal and normative requirement), and only 5.6% were at low risk (above and equal to normative requirement). Fig. 1 shows dietary vitamin A intake from the main sources expressed as percentages of the basal requirement (250 RE/day) (*31*) and categorized by risk of vitamin A deficiency. The mean dietary vitamin A intake (RE) and frequency of children in each risk category are also indicated. The basal requirement was used to express the vitamin A intake because, according to a theoretical calculation, it is the minimum amount required to prevent clinical signs of vitamin A deficiency in children of this age group. Kale (*Brassica acephala*) was the most important source of dietary vitamin A intake for all the children

Table 4. **Indicators[a] of vitamin A status by sex and age group**

Demographic characteristics	% prevalence			
	% xerophthalmia	Serum retinol		% ⩾0.06 MRDR
		% <0.35 µmol/l	% 0.35–0.7 µmol/l	
Sex (*n*)	6.7	8.1	53.8	44.9
Female (421)	5.0	8.4	58.3	38.0
Male (403)	0.30	0.85	0.21	0.04
P				
Age group (*n*)				
6–7 years (180)	4.4	12.2	62.7	43.3
7–8 years (308)	5.5	7.1	54.2	43.2
>8 years (336)	6.9	7.1	54.2	39.0
P	0.52	0.09	0.16	0.48

[a]% prevalence for xerophthalmia, deficient, mild-to-moderate serum retinol level and low vitamin A reserve.

in the study. However, the daily vitamin A intakes from kale and goat liver were 8 and 41 times higher respectively in the low-risk group than in the high-risk group. Vitamin A intake from these two sources contributed to 73.0% of the children's daily intake.

Discussion

In Ethiopia in 1980–81 a national survey revealed that 59.6% of children under 6 years of age had subclinical vitamin A deficiency as indicated by the serum retinol level (⩾ 0.70 µmol/l), the mean value of which was 0.62 µmol/l (*12*, *31*). Using the same criteria, the present study on children aged 6–9 years gives remarkably similar results, with subclinical vitamin A deficiency in 59.4% of the children and a mean serum level of 0.69 µmol/l (standard deviation 0.31). Furthermore, the estimated prevalences of xerophthalmia in the earlier survey and the present study were 6% and 5.8% respectively.

No previous study reported vitamin A status in Ethiopian children on the basis of the MRDR assay. The overall prevalence of children having an MRDR ratio equal to or higher than 0.06 was 41.5% (Table 3) and was virtually unchanged (41.0%) when adjusted to account for the differences in distribution at the study sites. A prevalence exceeding 5% serum retinol levels below 0.35 µmol/l in a population is a strongly corroborative clinical criterion of public health concern. Similarly, a prevalence of 20% or above for subclinical serum retinol (⩾ 0.7 µmol/l) and a prevalence of 30% or more for the MRDR ratio (⩾ 0.06) are indicative of severe vitamin A deficiency of public health importance (*1*, *32*). These WHO criteria are based on surveys of children aged 6–71 months. If the above criteria are also applicable to children aged 6–9 months, severe vitamin A deficiency of public health priority is indicated by the prevalences of 51.1% for serum retinol level between 0.35 and 0.70 µmol/l and 41.0% with an MRDR ratio of ⩾ 0.06. In South Africa a prevalence of 39.1% subclinical vitamin A deficiency, as indicated by serum retinol, was reported in children aged 6–11 years (*20*), whereas for children under 6 years of age the corresponding figure was 33.1% (*33*). These results and the present findings underline the magnitude and severity of vitamin A deficiency in an age group that policy-makers do not usually consider to be at risk in this respect.

Although the prevalence of vitamin A deficiency was high at all the sites studied, there were significant differences between sites in serum retinol data with cut-offs of <0.35 µmol/l and 0.35–0.7 µmol/l. The highest prevalence of vitamin A deficiency based on ocular examination and low vitamin A reserve was noted in Mesanu. Although this site had irrigation and dark leafy vegetables and carrots were grown, the produce was usually sold in the nearest town and generally not consumed locally. Girls had significantly lower vitamin A reserves than boys (Table 4), a difference explained by the size difference between boys and girls. When BMI and height variables, which were not correlated (r = –0.06), were included in logistic regression to adjust for size, the significant sex difference disappeared (odds ratio =1.19; 95% confidence interval = 0.9–1.6).

Our findings may be generalized to the 10 186 children in Wukro *wereda* and the 76 258 children in the larger, Eastern zone of Tigray administrative region where the socioeconomic and ecological environments are similar to those of the sites studied (*34*). On the basis of the estimates obtained from our data (Table 3), therefore, the numbers of children in the Eastern zone of Tigray administrative region affected by vitamin A deficiency would be as follows, with the 95% confidence intervals in parentheses:

(i) 4423 (3203–5643) with xerophthalmia;
(ii) 6406 (5033–7778) with serum retinol below 0.35 µmol/l;
(iii) 38 968 (36 376–41 561) with serum retinol between 0.35 and 0.7 µmol/l;
(iv) 31 266 (28 673–33 859) with lo999w vitamin A reserve (⩾ 0.06 MRDR).

The prevalence of severe vitamin A deficiency is widespread in children aged 6–9 years in rural areas of Tigray. Efforts to reduce vitamin A deficiency in younger children to a level not considered to be of public health significance are encouraging but a challenging task remains in countries where the number of children affected is larger than previously expected. As school enrolment in rural Ethiopia is very low, alternative channels of providing children with vitamin A supplements should be explored. Organizations committed to eliminating vitamin A deficiency need to re-evaluate policies for reducing vitamin A deficiency in populations similar to those covered by the present study. ■

Acknowledgements

This work was carried out with the aid of a core grant (95-1052/02746) from the International Development Research Centre, Ottawa, and with partial funding from the Rockefeller Foundation (African Dissertation Internship Award to TK). Dr Mesfin Minas, Head, Bureau of Health, Mekelle, Tigray, kindly provided invaluable logistic and moral support. The Relief Society of Tigray is gratefully thanked for supporting the project. Dr Hagos Beyene, former Head, Department of Paediatrics and Child Health, Addis Ababa University, gave advice during the data collection phase, and Dr Fitsum trained personnel to perform ocular examinations for xerophthalmia. HPLC analysis of the serum samples was conducted by Dr V. Barthet at the Centre for Indigenous Peoples' Nutrition and Environment, McGill University, Canada. Dr Sherry A. Tanumihardjo, Vitamin A Research Group, Iowa State University, synthesized the 3,4-didehydroretinyl acetate given to the children in the study, and provided valuable advice on the MRDR assay. Finally, the statistical advice given by Professor James A. Hanley, Department of Biostatistics and Epidemiology, McGill University, is greatly appreciated.

Conflicts of interest: none declared.

Résumé

Prévalence de la carence en vitamine A chez les enfants de 6 à 9 ans à Wukro (nord de l'Ethiopie)

Objectif Déterminer la prévalence de la carence en vitamine A (avitaminose A) chez les enfants de 6 à 9 ans dans le nord de l'Ethiopie.

Méthodes On a réalisé une étude transversale et analysé les résultats de 824 enfants (61,5 %) sur les 1339 qui répondaient aux critères d'inclusion dans l'étude et pour lesquels on disposait de données complètes sur le bilan vitaminique A (défini par les analyses biochimiques), l'apport alimentaire en vitamine A, l'examen ophtalmologique à la recherche d'une xérophtalmie, et les données anthropométriques.

Résultats La prévalence de la xérophtalmie était de 5,8 % ; les taux sériques de rétinol étaient inférieurs à 0,35 µmol/l chez 8,4 % et à 0,70 µmol/l chez 51,1 % des enfants. Les réserves hépatiques en vitamine A (RDR modifié $\geqslant$ 0,06) étaient faibles chez 41,0 % des enfants.

Conclusion La forte prévalence de la carence grave en vitamine A chez les enfants de 6 à 9 ans indique la nécessité de réévaluer la politique consistant à axer les programmes de supplémentation en vitamine A sur les enfants de moins de 6 ans dans les régions où la carence en vitamine A est endémique.

Resumen

Prevalencia del déficit de vitamina A entre niños de 6 a 9 años en Wukro (norte de Etiopía)

Objetivo Determinar la prevalencia del déficit de vitamina A entre niños de 6 a 9 años en el norte de Etiopía.

Métodos Se llevó a cabo un estudio transversal partiendo de 1339 niños que reunían las condiciones requeridas para participar en él. Se analizaron los resultados correspondientes a 824 (61,5%) de ellos, para los que se obtuvieron datos completos en lo relativo a sus reservas de vitamina A, el aporte alimentario de vitamina A, los signos oculares de xeroftalmía y las variables antropométricas.

Resultados La prevalencia de xeroftalmía fue del 5,8%; el retinol sérico se situaba por debajo de 0,35 µmol/l y entre 0,35 y 0,70 µmol/l en el 8,4% y el 51,1% de los niños, respectivamente. Las reservas hepáticas de vitamina A (razón modificada de respuesta relativa a la dosis $\geqslant$ 0,06) eran bajas en un 41,0% de los niños.

Conclusión La alta prevalencia de déficit grave de vitamina A entre los niños de 6 a 9 años indica que es necesario reevaluar la práctica de focalizar los programas de administración de suplementos de vitamina A en los menores de seis años en las zonas donde tal déficit es endémico.

References

1. **Underwood BA, Arthur P.** The contribution of vitamin A to public health. *Federation of American Societies of Experimental Biology Journal*, 1996,**10**: 1040–1048.
2. **Underwood BA.** Vitamin A in human nutrition: public health considerations. In: Sporn M, Roberts AB, Goodman PS, eds. *The retinoids: biology, chemistry and medicine.* New York, Raven Press, 1994.
3. **Brink EW, Perera WDA, Broske SP.** Vitamin A status of children in Sri Lanka. *American Journal of Clinical Nutrition*, 1979, **32**: 84–91.
4. **Oomen HAPC.** Xerophthalmia in nutrition. In: Beaton GH, Begoa JM, eds. *Preventive medicine.* Geneva, World Health Organization, 1976 (Monograph Series, No. 62).
5. *Ethiopia nutrition survey.* Washington DC, Interdepartmental Committee on Nutrition for National Defense, 1959.
6. **Postmus S.** *Report on nutritional needs of children in Ethiopia.* Rome, Food and Agriculture Organization of the United Nations, 1958.
7. **Selinus R et al.** Dietary studies in Ethiopia. I. Dietary pattern among the Rift Valley Arsi Galla. *American Journal of Clinical Nutrition*, 1971, **24**: 365–377.
8. **Selinus R et al.** Dietary studies in Ethiopia. II. Dietary pattern in two rural communities in Ethiopia. *Acta Societatis Medicorum Upsaliensis (Uppsala)*, 1971, **76**: 17–38.
9. **Selinus R, Gobezie A, Vahlquist B.** Dietary studies in Ethiopia. III. Dietary pattern among the Sidamo ethnic group. A study of villages in the ensete mono-culture area in southern Ethiopia with special attention to the situation in young children. *Acta Societatis Medicorum Upsaliensis (Uppsala)*, 1971, **76**: 158–178.
10. **De Sole G, Belay Y, Zegeye B.** Vitamin A deficiency in southern Ethiopia. *American Journal of Clinical Nutrition*,1987, **45**: 780–784.
11. **Demeke T, Gebre H.** Xerophthalmia: a review of hospital out-patient records. *Ethiopian Medical Journal*, 1982, **20**: 15–20.
12. **Wolde-Gebriel Z, DemekeT, West CE.** Xerophthalmia in Ethiopia: a nationwide ophthalmological, biochemical, anthropometric survey. *European Journal of Clinical Nutrition*, 1991, **45**: 469–478.
13. **Wolde-Gebriel Z et al.** Severe vitamin A deficiency in a rural village in Hararge region of Ethiopia. *European Journal of Clinical Nutrition*, 1993, **47**: 104–114.
14. **Gebre-Medhin M, Vahlquist A, Hofyander Y.** Breast milk composition in Ethiopian and Swedish mothers. *American Journal of Clinical Nutrition*, 1976, **29**: 441–451.
15. **Thein M.** Study on milk vitamin A. Serum vitamin A and serum protein levels of lactating mothers of Bochassa village, rural Ethiopia. *East African Medical Journal*, 1979, **56** (11): 542–547.
16. **Taffesse Y, Fisseha T.** *Vitamin A deficiency control program in Ethiopia (1989–1993) — Two decades of progress: linking knowledge to action.* Abstract of XVI IVACG Meeting; Chaing Rai, Thailand; 1994.
17. **Haile-Giorgis et al.** *Preliminary report on pre-intervention assessment for the evaluation of the different strategies of vitamin A deficiency control program in three different administrative regions of Ethiopia.* Ethiopia Health and Nutrition Research Institute and the Nutrition and Food Science Department, 1996.
18. **Gobezie A.** Personal communication, 1996.
19. **Tafesse Y et al.** Vitamin A deficiency : a serious threat in Dodota district in central Ethiopia. *East African Medical Journal*, 1996, **73**: 303–307.
20. **Van Stuijvenberg ME et al.** Effect of iron-, iodine-, and ß-carotene-fortified biscuits on the micronutrient status of primary school children: a randomized controlled trial. *American Journal of Clinical Nutrition*,1999, **69**: 497–503.
21. **World Bank.** *World development report 1993: investing in health.* New York, Oxford University Press,1993.
22. *Food composition table for use in Africa.* Rome, Food and Agriculture Organization of the United Nations; Bethesda, United States Department of Health, Education and Welfare, 1968.
23. **West CE, Poortvliet EJ.** *The carotenoid content of foods with special reference to developing countries.* Wageningen, Department of Human Nutrition, 1993.
24. *Ethiopian traditional recipes.* Addis Ababa, Ministry of Health. 1980.
25. **Furr HC, Tanumihardjo SA, Olson JA.** *Training manual for assessing vitamin A status by use of the modified relative dose response and the relative dose response assays.* Iowa State University, 1992.
26. **Tanumihardjo SA et al.** Application of the modified relative dose response test to pregnant Indonesian women for assessing vitamin A status. *European Journal of Clinical Nutrition*, 1995, **49**: 897–903.
27. *How to weigh and measure children. Assessing the nutritional status of young children in household surveys.* New York, United Nations, 1976.
28. *Control of vitamin A deficiency and xerophthalmia.* Geneva, World Health Organization, 1982 (WHO Technical Report Series, No. 672).
29. **Hadi H et al.** Vitamin A supplementation selectively improves the linear growth of Indonesian pre-school children: results from a randomized controlled trial. *American Journal of Clinical Nutrition*, 2000, **71** (2): 507–513.
30. *Requirements of vitamin A, iron, folate and vitamin B_{12}.* Rome, Food and Agriculture Organization of the United Nations, 1988 (report of a joint FAO/WHO expert committee; FAO Food and Nutrition Series No. 23).
31. *Global prevalence of vitamin A deficiency.* Geneva, World Health Organization, 1995 (Micronutrient Deficiency Information System, Working Paper No. 2).
32. *Indicators for assessing vitamin A deficiency and their application in monitoring and evaluating intervention programmes.* Geneva, World Health Organization, 1994 (unpublished document WHO/NUT/94.1).
33. **Ramaligaswami V.** Challenges and opportunities – one vitamin, two minerals. *World Health Forum*, 1992, **13**: 222–231.
34. *The 1994 population and housing census of Ethiopia: results for Tigray region. Volume 1. Statistical report.* Addis Ababa, Central Statistical Authority, 1995.