Original Research

Prevalence of Undernutrition and Vitamin A Deficiency in the Dogon Region, Mali

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Objectives: A representative sample of 1510 preschool children living in the Bandiagra circle (Mopti Region, Mali) was examined between March and April 1997 to determine the level of vitamin A deficiency.

Methods: Using a randomized two level cluster sampling, 20 clusters of 75 children aged six months to six years were selected for evaluating xerophthalmia (XN night blindness and/or X1B Bitot spot). Concurrently stature and weight were determined. A semiquantitative seven-day dietary questionnaire was applied to the mothers of 484 infants to assess consumption of vitamin A rich foodstuffs. The prevalence of biochemical deficiency was attested using the Modified Relative Dose Response test (MRDR) on a sub-sample of 192.

Results: Of the studied children, 4.3% (95% Confidence interval [CI]: 3.2–5.3) reported night blindness and 2% (95% CI: 1.3–2.7) had Bitot spots. Prevalence of xerophthalmia attested by at least one of these signs was 5.4% (95% CI: 4.2–6.5). The prevalence reached 10.5% at three years of age. The MRDR test proved abnormal in 77.1% of the subjects (95% CI: 70.3–82.7). Serum retinol was lower than 0.35 μmol/L in 43.8% (95.6% CI: 36.9–51.3) and less than 0.70 μmol/L in 92.7% of the children (95% CI: 87.8–95.8). Weekly consumption of vitamin A rich food was rare: 75.8% had not eaten any animal vitamin A rich food, and 22.1% had consumed less than seven times a vitamin A rich food of either vegetable or animal origin.

Conclusions: These data define vitamin A deficiency as a severe public health problem in the Bandiagara area of Mali.

INTRODUCTION

Vitamin A deficiency has been underestimated for a long time in Africa. The problem is particularly severe in Sahelian countries such as Mali, as attested by several surveys [1–5].

The GTZ Primary Health Care project in Sévaré, which planned to add a vitamin A supplement program during the National Immunization Days (NIDs), solicited the support of the African Institute of Tropical Ophthalmology (IOTA) to evaluate vitamin A deficiency in the Bandiagara district among preschool children.

METHODS

Study Area

The Bandiagara circle (212 300 inhabitants) is situated in the center of Mali. This largely agrarian population mostly consists of Dogons living on the plateau and cliffs.

Sampling Methods

The study was conducted from March 26 to April 20, 1997. The sample was recruited using a randomized two-level cluster sampling method, following procedures recommended by the World Health Organization (WHO) blindness prevention program method [6].

The 1987 national census list of villages served as the sampling frame for the area [7]. No urban or rural stratification was retained for the selection procedure. A required sample of 1465 children six months to six years of age was estimated, based on an expected prevalence of 4%, an alpha error of 5% and a desired absolute precision of 1%. Twenty villages (clusters), were randomly selected, each of 75 children to provide a total of 1500 individuals. If a cluster was too small for recruiting 75 children, the most proximate village should have been chosen for completing the cluster. No design effect was considered in determining sample size.

Two sub-samples were drawn randomly: one child out of

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every three for food intake inquiries and health status assessment (planned n = 500) and from this later group one out of every two individuals for biochemical status assessment (planned n = 250).

Measurements

Ophthalmologic Examination. A history of night blindness (XN stage) was obtained by questioning children's mothers. Three questions were sequentially asked to ascertain if the child was able to see during daytime, during the night and, finally, if night blindness was present using a vernacular term (in Dogon "gire nama", in Peul, "pinku" and in Bambara "surofinye"). Children who also had daytime vision problems were excluded.

All children received an ophthalmologic examination by the same ophthalmologist using a X2.5 magnification with a lamp. Clinical signs of xerophthalmia, Bitot spots (X1B) and active or non-active corneal lesions were noted. A categorical variable for xerophthalmia was derived corresponding to the presence of night blindness and/or Bitot spots.

Vitamin A treatment (one capsule of 200 000 IU × 3) was given to children showing clinical signs of vitamin A deficiency and tetracycline ointment was applied in case of ocular infection.

Anthropometry. Stature (cm) and body weight (kg) were measured by one of the two trained nurses. Infants under two years of age were weighed using a 25 kg Salter hanging scales (CMS Weighing equipment, High Holborn, London, United Kingdom). Children over two years were weighed on scales calibrated before each session. Body weight was measured on children fully dressed (with light clothing) but without shoes.

Infants under two years were measured lying down using a conventional wooden height board. Individuals over two years were measured standing up.

Whenever possible, age was verified on presentation of a birth certificate. Otherwise, it was estimated using a local calendar and history of past events.

These measurements allowed calculation of three standard normal deviate (Z) scores based on reference values from the National Center for Health Statistics (NCHS) published by WHO [8]:

- the weight for age (W:A), reflecting weight insufficiency (underweight)
- the height for age (H:A), reflecting stunted growth or chronic malnutrition,
- the weight for height (W:H), reflecting wasting malnutrition.

Z-scores under the threshold of −2 were considered as moderate and those less than −3 as severe nutritional deficiency.

Food Survey. Information about breastfeeding and age for weaning was recorded by questioning the mothers. A seven-day food frequency questionnaire was administered to them to estimate the number of occurrences on which food sources of vitamin A and carotenoid were consumed during the previous week. Trained local health practitioners compiled a list of 21 available foods, six from animal origin rich in retinol and 15 of vegetable origin rich in beta-carotene. Sauces containing vegetables rich in beta-carotene, such as baobab or gombo leaves, which are ingested in very small amounts, were given a weight considered to one fifth of a serving in the intake analysis.

Morbidity. Two weeks' history of morbidity symptoms was recorded: episodes of coughing, fever, diarrhea as well as oral intake of rehydration salts. A six-week history of measles and measles immunization and use of vitamin A capsules for the preceding three months were noted.

Biochemical Markers. Vitamin A status was assessed by measuring serum retinol concentration and the Modified Relative Dose Response test (MRDR), an individual indicator of liver retinal stores [10,11].

Briefly, 200 μg of acetate of 3,4-dehydroretinol (DR) was orally administered. Five hours later, 0.5 mL of capillary blood was extracted by pricking the child's finger with a vaccination scratch blade and was collected in a "Microtainer Benson Dickson" tube. The tubes were set in a vacuum flask filled with ice and kept dark. Within three hours the tubes were centrifuged at room temperature (1300 × g, 10 min). The serum was fractionated off, aliquots placed on ice for no more than five hours, frozen to −20°C in a deep-freeze at the nearest health center before being taken to Bamako and then shipped on dry ice for laboratory analysis to Grenoble (France). Freezer tubes were thawed slowly to room temperature just before assay. A high performance liquid chromatography assay (HPLC), made up of an isocratic system using silica gel (adsorption) as the stationary phase, was used for dehydroretinol and retinol determination, and 0.5 mL aliquots of serum were extracted. Briefly, proteins were precipitated with absolute ethanol, and the fat-soluble vitamin A was extracted subsequently into an n-hexane phase, and analyzed by automated high-performance liquid chromatography with a Lichrosorb Si 60.5 column. Retinol peak was detected spectrophotometrically at 313 nm. The peaks were integrated by means of Perkin Elmer Chromatography Data Station Sigma 10B system. Cumulative quality-control data for each analysis were provided during the analysis period. Briefly, the coefficients of variation for the estimation of retinol and dehydro-retinol were 3.3% and 3.0%, respectively.

The ratio of DR to retinol was calculated. The performance and reproducibility of this ratio of has been evaluated in different groups with normal and abnormal vitamin A classified status [11,12]. A deficiency is defined as a ratio greater than or equal to 0.06. A prevalence of abnormal tests greater than 20% defines a public health problem. The situation is considered to be severe when the prevalence is over 30% [12]. Serum retinol thresholds used were 0.7 μmol/L and 0.35 μmol/L, reflecting low status and severe deficiency, respectively.

Statistical Analysis

Statistical comparisons were carried out using the chi-square for categorical variables. Continuous data across groups was compared by variance analysis.

Data analysis was carried out using the EPI INFO program, version 6.03.

The protocol was approved by the IOTA's ethical committee and a consent form written in French language and translated either in Dogon, Peul or Bambara language was signed by the infant mothers prior to the examinations.

RESULTS

The ophthalmic examination was conducted on 1510 children. Dietary intake and health status assessment were evaluated in 484 children. Sub-sample with biochemical evaluation was limited to 192 children due to insufficient blood collected or loss to follow-up.

Age distribution by age of the survey population was comparable to that observed in Mali as a whole (Table 1). Boys and girls were equally represented (49.6% to 50.4%).

Anthropometrical Findings

Three hundred and fifteen children (20.9%) were stunted (H:A < -2 Z score) and 113 (7.5%) were severely stunted (H:A < -3 Z score). A total of 340 (22.5%) were underweight (W:A < -2 Z score) and 94 (6.2%) were severely underweight (W:A < -3 Z score).

Wasting was less frequent; 193 children (12.8%) were moderately wasted (W:H < -2 Z score), and 52 (3.4%) severely (W:H < -3 Z score).

Boys tended to be more underweight ($p = 0.01$) and stunted than girls ($p = 0.004$). The gender difference was not significant for wasting (Table 2).

Table 1. Comparison of the Sample and the Population of Children under Seven Years of Age in Mali as a Whole by Age

Age	Studied Sample		Children under Seven Years of Age in Mali*
	Number	Percentage (%)	Percentage (%)
6–11 months	116	7.7	8.3
1 year	222	14.7	16.0
2 years	281	18.5	15.8
3 years	305	20.5	15.5
4 years	271	17.7	15.2
5 years	189	12.6	15.0
6 years	126	8.3	14.2
Total	1510	100.0	100.0

* Source [7].

Table 2. Malnutrition Prevalence by Gender (Percentage under −2 Z Score Threshold)

Gender	H:A < -2	W:H < -2	W:A < -2
Male	23.8%	13.1%	25.1%
Female	17.9%	12.4%	19.9%
All individuals	20.9%	12.8%	22.5%
p value*	0.004	0.67	0.01

H:A = height for age, W:H = weight for height, W:A = weight for age.
* Test used: Chi squared.

Vitamin A Status

Clinical Markers. A history of night blindness was available on 1474 children, the mothers of 36 of the children being unable to provide information. Sixty-three children, 4.3% (95% CI: 3.2–5.3), were presently night blind. The ophthalmologic examination was conducted on 1509 children, 30 of whom, 2% (95% CI: 1.28–2.69) had Bitot spots. Eighty-one, 5.4% (95% CI: 4.22–6.50) had either night blindness or Bitot spots. Twelve, 0.8% (95% CI: 0.43–1.43) had night blindness and Bitot spots.

There was no active case of corneal involvement. Only four children had an old corneal opacity that could not be evidently related to a history of xerophthalmia or measles episode.

The prevalence of xerophthalmia varied with age (Fig. 1). No case was found under one year of age. At the age of three, prevalence of night blindness and Bitot spots peaked at 8.5% and 3.3% respectively.

Night blindness was more common among boys (5%) than girls (3.6%), but this difference was not statistically significant ($p = 0.17$). The prevalence of Bitot spots was significantly higher in boys than in girls, 2.9% *vs.* 1.1% ($p = 0.01$). Therefore respective prevalence for xerophthalmia was significantly higher in boys than in girls, 6.6% *vs.* 4.1%, $p = 0.03$ (Fig. 2).

The distribution of xerophthalmia depended widely on the geographic area and ranged from 1.8% to 10.7%. The central district demonstrated the lowest level of xerophthalmia (1.8%), while the highest level (10.7%) was observed in the Kani-Gogouna district.

Biochemical Markers. From the 250 sample dedicated to biochemical evaluation, 192 have been able to be analyzed: 77.1% (95% CI: 70.3–82.7) of the children were tested abnormal for the MRDR assay; 92.7% (95% CI: 87.8–95.8) had a serum retinol level lower than 0.7 μmol/L and 43.8% (95% CI: 36.9–51.3) lower than 0.35 μmol/L, with the highest prevalence of abnormal MRDR and serum retinol <0.35 μmol/L found among one year old children (Table 3).

Dietary Habits Related to Vitamin A Intake

Breast-Feeding. During the first year of life, breast milk was the only major source of vitamin A. Between 10 and 12 months, 59% of the children were still being breast-fed, 42% between 12 and 18 months and 29% between 18 to 24 months.

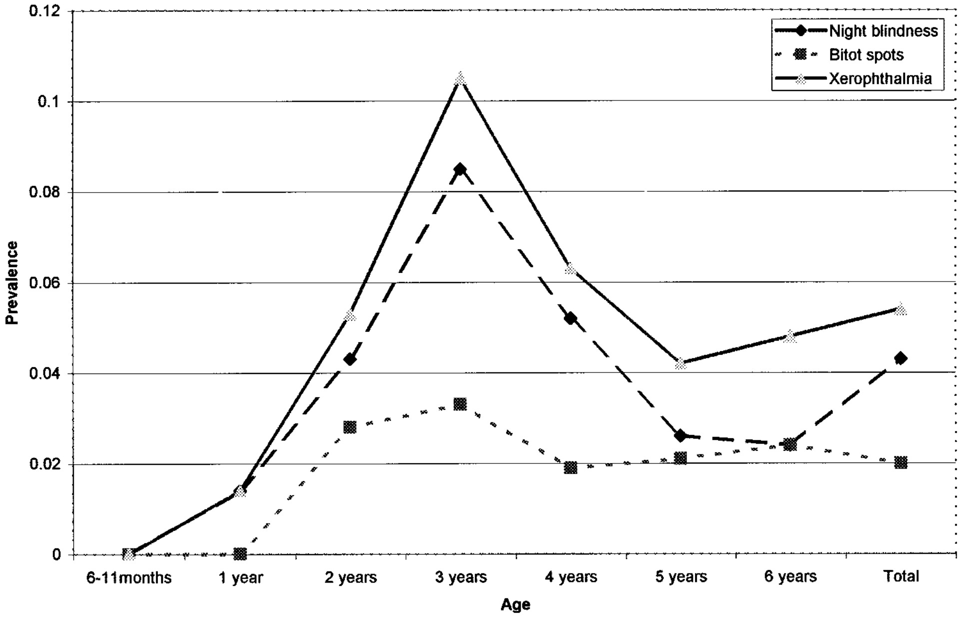

Fig. 1. Distribution of xerophthalmia as a function of age.

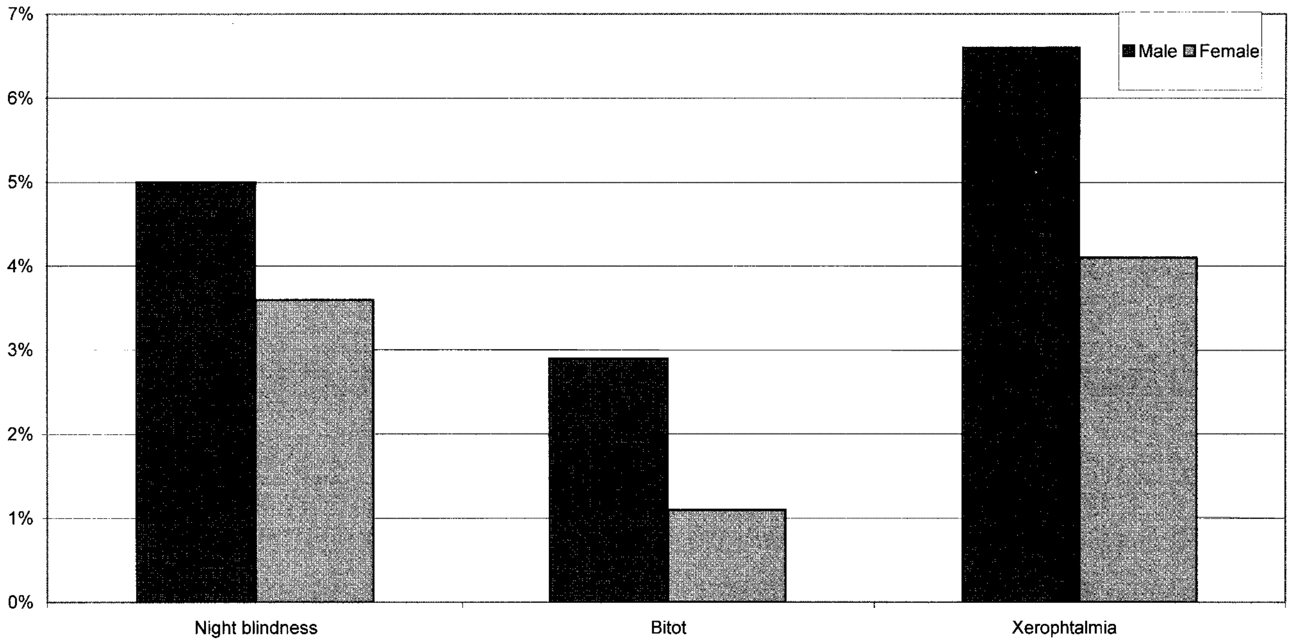

Fig. 2. Distribution of night blindness and Bitot spots by gender.

Children appeared weaned late as only 5.3% had been completely weaned in the course of the second year. The average age at which breast-feeding stopped was 23.8 months.

Vitamin A Intake. Weekly intake of vitamin A rich foods was estimated for 430 children, as 54 children still being exclusively breast-fed, have been subsequently excluded from the analysis (Table 4).

The mean number of times animal foods rich in vitamin A was consumed in the previous week was 0.75. These occurrences were rare since 75.8% had not consumed any animal-based foods rich in vitamin A during the week.

The average vegetable vitamin A eating occurrences were 20.56.

Twenty-two percent of children had consumed fewer than seven times during this week foods rich in vitamin A, whether animal or vegetable-based.

Table 3. Vitamin A Deficiency (%) by the MRDR Test and Serum Retinol Concentration according to Age

Age	Abnormal MRDR*	Retinol Value < 0.7 μmol/L	Retinol Value < 0.35 μmol/L
6 months–1 year	71.4	64.3	21.4
1 year	90.0	90	60.0
2 years	81.1	100	51.4
3 years	75.7	100	51.4
4 years	83.8	94.6	43.2
5 years	63.3	86.7	30.0
6 years	70.6	94.1	35.3
Total	77.1	92.7	43.8

* DR/R ratio ≥ 0.06.

DISCUSSION

Population

The sample studied seems to be representative of the population as the distribution by age and by gender was similar to the Malian population as provided by the 1987 census.

Chronic malnutrition is a consequence of inadequate food and/or illnesses lasting for a relatively long period. About one fifth of the children demonstrated slow growth. In the case of the under-three-years-olds almost one third were affected. These figures are close to the 1996 demographic and health study [13] of under-three-year-olds, which recorded 27.6% of stunted children in the Mopti region. The World Health Organization considers a prevalence of stunting of 30% to represent a vulnerability threshold above which vitamin A deficiency may be suspected to exist in a population, when used as an indirect indicator of risk, in the absence of direct measures of vitamin A status [12]. Wasting indices give an estimate of the body mass in relation to the height as a reflection of the current nutritional status. In this study, 12.8% of the children were affected by emaciation. The figure of 12.8% (17.6% under three years) is slightly better than the one to come out of the 1996 DHS which was 26.6% in the Mopti region, but higher than the WHO threshold of 8% [12]. It indicates a vulnerable population and reflects an troublesome food and nutritional situation.

The prevalence of body weight insufficiency seems low (22.5%) given that stunting was 20.9% and wasting 12.8%. Nevertheless, for children under three years, our results (39.3%) are very similar to those given by the demographic and health study (41.3%).

Vitamin A Status

Xerophthalmia. The data relating to xerophthalmia must be discussed in relation to the dry season in which the study was carried out. In this season there is a shortage of sources of vitamin A, few fresh vegetable foods are available.

Night blindness is a subjective but valid indicator of vitamin A deficiency [12,16]. The 4.3% rate is therefore higher than the 1% threshold established by the WHO as defining a public health problem in a given community.

Preceding Malian studies had also revealed high prevalence of night blindness: 2% in Koutiala [1], 9% in Douentza [5]. During a national survey in 1996, prevalence ranged from 0.3 to 4.1 depending on the region (2.6% in the Mopti region) [14]. Nevertheless, night blindness diagnosis rests on questions to each child's mother, and figures should therefore be cautiously interpreted. Nevertheless the disorder is well known, as in all villages a local term existed for the condition.

Night blindness was far more frequent between the ages of two and four years. This period corresponds to the weaning phase when the child switches from mother's milk to the family cereal-based meal, a group of foods that is poor in vitamin A content and can result in a higher risk of vitamin A deficiency.

The more frequent occurrence of night blindness among boys had been reported in several studies [1–3]. Several explanations may be given: first of all, young girls often stay close to their mothers, joining in cooking-related tasks and receiving more food in the course of a day; also small boys more often suffer from diarrhea, which can involve a loss of vitamin A and an absorption deficit.

Bitot Spots. Bitot spots are pathognomonic early signs of vitamin A deficiency. The 2% prevalence rate found is higher than the WHO threshold of 0.5%, which designates a public health problem. Bitot spots were also more prevalent in children under three years of age, and also higher in boys than in girls.

These data correspond to those reported in other studies. During the 1996 national Malian survey, levels of Bitot spots ranged from 0.15% to 1.59%, depending on the region (1.09% in the Mopti region). In neighboring countries, the following prevalence were recorded, 4.9% in Benin, 2.69% in Burkina Faso, 1.06% in Chad [15].

Despite a high level of clinical xerophthalmia and a much higher prevalence of biochemical deficiency, no active signs of corneal xerophthalmia were observed. Corneal complications are often the consequence of an attack of severe illness, such as severe measles superimposed on a state of moderate to severe vitamin A deficiency [16]. In our study area, a history of measles was reported in one of ten children during the preceding six weeks, suggesting that the question used may not have been fully understood since no important epidemic had been documented in the region for many years.

MRDR Test. Vitamin A deficiency attested by an abnormal MRDR test is far more frequent than clinical xerophthalmia [17]. It is important to estimate in a population the number of children suffering from a infraclinical deficiency because they are more likely to suffer from pathogenic events: each year, one million children die worldwide as a result of infections related to vitamin A deficiency and immunocompromised conditions [18].

Serum Retinol. A serum retinol value only reflects the vitamin A reserves when these have largely been depleted:

Table 4. Intake of Foods Rich in Vitamin A during the Week Previous to the Survey (n = 430)

Source	Food Source of Vitamin A		Mean Number of Occurrences		Any Consumed (%)	
Animal	Butter, milk		0.41		1.9	
	Eggs		0.05		0.2	
	Liver		0.19		0.9	
	Small and fresh fish		0.11		0.5	
		Subtotal		0.75		3.5
Vegetable	Yellow and orange tuber and fruits		4.25		20.0	
	Green leafy vegetables		0.40		1.9	
	Sauces with green leafy vegetables		4.43		20.8	
	Other vegetables		7.34		34.5	
	Fruits		2.65		12.4	
	Dry vegetables		1.45		6.8	
		Subtotal		20.56		96.4
		Total		21.26		100

concentrations under 0.7 μmol/L reflect a low status, whereas a deficiency is said to be severe when the level falls below 0.35 μmol/L. For WHO criteria, a severe public health problem exists when more than 20% of children are situated below the 0.7 μmol/L threshold level or when more than 10% have a level lower than 0.35 μmol/L.

We acknowledge that the MRDR abnormalities (77.1%) are very high as regard to the 20% alarm WHO threshold [12]. Handling procedures have been rigorously conducted and we had continuous evaluation of laboratory processes allowing us to argue for the critical values reported.

These results are quite comparable to those reported in other African areas: 78% of abnormal results in Zambia [19] and 64.8% in Labbé, Guinea [20].

Deficient vitamin A status can usually be found to be associated with chronic, low vitamin A intakes, as we observed in our study population. However, low serum retinal can also be aggravated by an insufficient hepatic protein supply and infection which can affect retinal transport and utilization, respectively [21]. Whichever test is considered, there are far more children suffering from a biochemical deficiency than of xerophthalmia. Indeed when attested by MRDR test, biochemical vitamin A deficiency is 14 times more frequent than xerophthalmia prevalence.

This phenomenon is supported by high xerophthalmia rates, but surprisingly no active corneal disease was observed during the survey. This could be due to the absence of measles epidemic in the population during the past years despite low measles immunization coverage (41.8% in the Mopti region in 1996) [13].

Food Habits

Breast-feeding would be a protective factor in the case of xerophthalmia. Thus in Nepal the risk fell by 61% for children breast-fed [22]. In Bandiagara, almost all of the children aged from 6 to 11 months were breast-fed exclusively, whereas the WHO recommends that from six months upwards, all children should receive supplementary food [17]. The 23.8 months average weaning age is close to the 21.6 months given by the demographic and health study.

In Bandiagara, cereals largely dominate the caloric supply, and children rarely consume vitamin A rich foods. Foods of animal origin are extremely rare, whether this be fresh fish, milk products or eggs for which there is a social proscription (children are not allowed to eat eggs otherwise they will become thieves later in life). Yellow fruits or green-leafed vegetables are not very common; the latter are often consumed in sauces but, given the long preparation times, the carotenoids can be partially destroyed. Some way of preparation of these foods (drying and baking) can significantly lessen the food retinol or beta-carotene content.

CONCLUSION

Vitamin A deficiency appears as a serious public health problem in the Bandiagara circle. The frequency of clinical indicators of a vitamin A deficiency was largely higher than that established by WHO and more than three-fourths of children demonstrated evidence of insufficient hepatic retinol stores.

Prevention measures have been addressed elsewhere [23]. As a follow-up to our study, the Ministry of Health, together with UNICEF decided to distribute vitamin A in the Mopti region during the national immunization days in December 1997. This measure was successful and extended to all regions in 1998.

In addition, it is desirable to improve the production of beta-carotene rich foods by developing gardening and to enhance population awareness on nutrition to promote regular consumption of vitamin A rich foods.

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