Vitamin A Status and Nutritional Intake of Carotenoids of Preschool Children in Ijaye Orile Community in Nigeria

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Introduction

Several studies have shown that vitamin A deficiency is a public health problem in developing countries of the world. Over 24 million preschool children worldwide are estimated to be vitamin A deficient. Five to six million children in developing countries are likely to be subclinically rather than clinically deficient. Subclinically deficient children are at increased risk of severe and fatal infection. Improved vitamin A nutriture could prevent approximately 1–2 million deaths annually among children aged 1–4 years.

An unsatisfactory vitamin A status of preschool children is a major public health problem during periods of rapid growth and these are not met in developing countries. Their nutritionally inadequate weaning diet and eating overcooked green leafy vegetables rich in carotenoids further predispose them to vitamin A deficiency. However, there is less risk of vitamin A deficiency in infants who are breastfed, but their diet needs to be complemented after 6 months by other dietary sources of vitamin A. The periodicity in the annual fluctuation in dietary intakes of vitamin A and carotenoid-containing foods can affect the plasma vitamin A levels. The knowledge of this seasonal variation is important in the planning of any intervention measures.

A few studies of serum vitamin A levels of preschool children have been carried out in Nigeria. Other studies relate to eye signs of vitamin A deficiency. Despite this, there is still little information on the vitamin A status of preschool children in Nigeria.

The purpose of this study was to ascertain whether vitamin A deficiency is of public health significance in children between the ages of 6 months and 6 years in Ijaye Orile, a rural community in the south-western part of Nigeria. The community was randomly selected from

Materials and Methods

This cross-sectional study was carried out in an agricultural, low-income community, Ijaye Orile in the Akinyele Local Government Area of Oyo State in Nigeria. The community was randomly selected from

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all the communities under the Local Government. Information obtained from the National Population Commission (NPC) Ibadan, Nigeria, showed that the estimated population of the community was 9750 (based on the 1991 census). The population of preschool children was 1950. The expected prevalence of children with serum retinol level of < 20 µg/dl (low level) in this community was unknown before the survey. The sample size was therefore estimated based on the recommended level of 15 per cent prevalence of low level, 5 per cent precision, and 95 per cent confidence interval. The formula adopted was \( \left( Z_{1-\alpha/2} \right)^2 \times \frac{p(1-p)}{d^2} \), where \( Z_{1-\alpha/2} = 1.96 \), \( p = 0.15 \) (prevalence level) and \( d = 0.05 \) (5 per cent precision). The calculated sample size was 196. A systematic sampling method was employed to select 220 children aged 6 months to 6 years for the study. This was more than the calculated sample size. A list of all the eligible children present at the time of the survey was obtained during the pre-survey house-to-house visit conducted by the authors (OO and DO) and the nurse working at the health centre who was familiar with the children and their parents. Every fifth child was then selected from a household. Two hundred and thirteen children were eventually studied because two mothers refused blood collection from their children, while five serum samples went missing in storage.

Details of the survey procedure, the objectives and usefulness of the study were explained at preliminary meetings with the community leaders. This was also explained to the mothers during the pre-survey visit.

Mothers or caretakers were asked to bring the children selected for the survey to the Maternity Centre on a non-market day (this takes place every 4th day) for evaluation. After informed parental consent was obtained, mothers or caretakers were interviewed about the child’s sex, age, history of breastfeeding, and duration and history of multivitamin syrup or tablet bought from drug peddlers or shops given to the children 2 weeks before the study. A history of night-blindness was ascertained in children aged 2 years and above. There is no local name for night-blindness in this community hence direct questions, such as ‘does your child bump into objects when walking in the dark or when playing with other children in the dark?’ were asked of the parents.

The study was carried out during the late rains between September and October 1993 when there was high cultivation of green leafy vegetables.

The dietary assessment was based on a semi-quantitative food frequency questionnaire developed for the community after a market survey. The questionnaire, which was administered by the nutritionist, DO, consisted of a list of 22 food items obtained during a market survey and information obtained from the mothers during a pre-survey visit. All the food items were classified into three groups based on the vitamin A (or retinal) equivalent provided by the small portion size (SPS) of each food. Those with an SPS providing more than 250 µg retinal equivalent (RE) were classified high vitamin A score foods, e.g. palm oil, palm fruit, and dark green leafy vegetables. Food items with an SPS providing 150–250 µg of RE, e.g. mango, liver, bean ball, etc. were classified satisfactory vitamin A score foods. Those with an SPS providing 50–149 µg of RE, e.g. pawpaw, African apricot (agbalumo) and eggs were classified as medium vitamin A score foods, and those with an SPS providing 20–49 µg of RE, e.g. okro, plain soup, avocado pear, yellow maize, etc. were classified as low vitamin A score foods. With the aid of coloured photographs showing the three portion sizes of various foods, scores were awarded depending on the number of times the food was given in a week. Additional scores were awarded for current breastfeeding.

The relative level of risk categories based on Usual Pattern of Food (UPF) scores were: > 63 was a safe level, 49–63 a low risk level, 35–49 a moderate risk level, and < 35 a high risk level.

All the children were examined for features of xerophthalmia with the aid of a flash light.

**Nutritional anthropometric measurements**

The anthropometric measurements used in this study were weight and height/supine length. The nude weight of the children were taken on an infant weighing scale for those below 2 years and a Salter bathroom scale for older children. This was placed on a non-tilted surface. For quality control, metals of known weight were weighed on the scale before the procedure. It was then adjusted to the 0 mark. It was capable of measuring to an accuracy of 0.1 kg. The height of those aged 2 years and above were measured using a vertical scale fixed to the wall at the Maternity Centre. After removing the shoes, the child stood on the floor by the scale with feet parallel and the heels, buttocks, shoulders and occiput touching the upright. The head was held comfortably erect, with the lower border of the orbit in the same horizontal plane as the external auditory meatus. The head piece, which is a wooden block, was gently lowered making contact with the top of the head and the position on the scale read. It was capable of measuring to an accuracy of 0.1 cm.

The supine length was measured in children below 2 years with a Holtain infantometer. The child lay on the board and the head was positioned firmly against the fixed headboard with the eyes looking vertically. The knees were extended by firm pressure applied by the assistant and the feetflexed at right angles to the legs. The upright sliding foot-piece was moved to obtain firm contact with the heels and the length read. It was also capable of measuring to an accuracy of 0.1 cm.

The anthropometric measurement was compared with the National Centre for Health Statistics (NCHS) standard.
Exclusion criteria
Two children whose mothers refused blood collection were excluded from the study.

Biochemical method
About 3 ml of venous blood was collected in a poorly lit room and immediately placed in a specimen bottle without anticoagulant. These bottles were protected from light by wrapping them in aluminium foil. The bottles were placed in a cooler box containing ice cubes. The sera were frozen at –20 ºC within 4–5 h of collection of the samples and later analysed for serum retinol by High Performance Liquid Chromatography (HPLC) using the Bieri method at University College Hospital, Chemical Pathology Laboratory, Ibadan. The principle is that a given volume of serum is diluted with methanol, which denatures plasma proteins, and retinol is extracted with a suitable organic solvent such as hexane. Retinol was quantitated by the use of peak height ratios relative to an internal standard (retinyl acetate). A sample of known retinol levels was used for quality control. The details of the procedure have been described elsewhere.20 The coefficient of variation of serum retinol results obtained ranged between 6 and 9 per cent.

Data was analysed on a personal computer using Statistical Programmes in Social Science (SPSS). Unpaired t-test was used to test the differences between two means while analysis of variance (ANOVA) was used to test the difference in means of more than two groups. The Pearson correlation was used to examine the association between duration of breastfeeding and mean serum retinol levels. A probability of $p < 0.05$ was considered statistically significant.

This study was approved by the Joint University of Ibadan, University College Hospital Ethical Committee.

Results
The ages and mean serum retinol levels of both sexes are shown in Table 1. The study involved 213 children, 109 males and 104 females. The male to female ratio was 1.05:1. The overall mean (SD) serum retinol levels for both sexes was 15.21 (8.13) µg/dl; 15.39 (7.88) µg/dl for the boys and 15.02 (8.42) µg/dl for girls. There was no statistically significant difference between the sexes.

The frequency distribution of serum levels for both sexes is shown in Table 2. A total of 57 (26.8 per cent) children were deficient in serum retinol levels (i.e. < 10 µg/dl), 102 (47.9 per cent) had low levels (10–20 µg/dl), and 54 (25.3 per cent) children had adequate levels (> 20 µg/dl).21

The sex distribution showed that 33 (30 per cent) boys and 24 (23 per cent) girls had deficient levels. The highest prevalence of serum retinol deficiency was in the 6–12 and 25–36 month age groups, while the lowest prevalence was in the 61–72 month age group. Infants between 6 and 12 months also had the lowest UPF score, which means that they had the lowest intake of carotenoid-containing foods and pre-formed vitamin A from breastmilk, presumably because weaning was not well established. This is documented in Table 3.

Dietary information showed that all 213 children were breastfed. The mean duration of breastfeeding for males was 18.36 ± 6.35 months while for females it was 17.03 ± 5.55 months. Sixty-six (32 per cent) children were still on breastmilk at the time of study.
35 (53 per cent) of these children were in the 6–12 month age group, while 29 (44 per cent) were in the 13–24 month age group, and the remaining two (3 per cent) children belonged to the 25–36 month age group. Three infants, 7 months, 8 months and 10 months old, were exclusively breastfed. Their serum retinol levels were 5.4, 22 and 6.0 µg/dl, respectively. The mean serum retinol levels for those still on breastmilk with and without a mixed diet was 14.04 ± 6.62 µg/dl, while the mean for those on mixed diet alone was 15.48 ± 8.44 µg/dl. This was not statistically significant (\( t = 1.228, p = 0.25 \)). There was also poor correlation between duration of breastfeeding and serum retinol levels (\( r = 0.07, 95\% \text{ CI} 0.03 < R < 0.2 \)).

One week dietary recall revealed that the most widely consumed vitamin A containing foods were pro-vitamin A carotenoids, especially palm oil and dark green vegetables with high (> 250 µg of RE) pro-vitamin A, and pawpaw with medium pro-vitamin A content (30–149 µg of RE). Carrot with satisfactory pro-vitamin A content was not widely consumed. None of the children had mango (because the period of the study was not the season for mango) or liver, while 15 (7 per cent) children consumed eggs. There was no statistically significant difference in the mean serum retinol levels for different UPF scores (\( F = 0.42, p = 0.75 \)). Table 4 shows the serum retinol levels and the UPF scores.

There were two (1.5 per cent) cases of nightblindness out of 130 children aged 2 years and above, a male and a female. Their serum retinol levels were 8.6 and 8.9 µg/dl, respectively. None of the children that took part in this study had features of xerophthalmia.

Nine (4.2 per cent) children received multivitamin preparations within 2 weeks preceding the study. Three (5.3 per cent) were deficient of serum retinol levels, compared with 54 (94.7 per cent) who were deficient of retinol and were not on multivitamins. However, none of the mothers or children were on vitamin A supplements.

There was a high prevalence of malnutrition in this community, as seen in Table 5. Out of 213 children surveyed, about 25 per cent were wasted, i.e. < −2 SD weight-for-height, and about 36 per cent were stunted, < −2 SD height-for-age. The highest prevalence of wasting was in children aged between 13 and 24 months and children between the ages of 37 and 48 months were mostly stunted; they also had the lowest prevalence of wasting.

Table 6 shows that the mean serum retinol levels of stunted children was significantly lower than those that were not stunted (\( t = 2.185, p = 0.03 \)). However, there was no statistically significant difference in the mean serum retinol levels of wasted and well nourished children (\( t = 1.329, p = 0.2 \)).

### Discussion

This study has demonstrated that vitamin A deficiency is a public health problem in children in the Ijaye Orile community in the south-western part of Nigeria. Approximately 27 per cent of these children had deficient serum retinol levels while 47.9 per cent had low levels during the rainy season when this study was carried out. This is above the World Health Organization biochemical cut-off value for a vitamin A deficient population, namely serum retinol levels of < 10 µg/dl in more than 5 per cent of the population and 10 per cent or more of the population with levels of < 20 µg/dl. Hence these children are at increased risk of morbidity and mortality due to respiratory infections, diarrhoea and measles.
In the Obukpa community in south-eastern Nigeria, Uzoechina, et al.\textsuperscript{4} reported deficient serum vitamin A levels in 9.2 per cent of preschool children while 16.4 per cent had low levels. Children in this community consumed more fish (which is high in vitamin A) than children in the Ijaye Orile community. In two other rural communities in the Atakumosa Local Government Area of the south-western part of Nigeria where there is a high consumption of red palm oil rich in beta-carotene, none of the 53 children studied were deficient in serum vitamin A.\textsuperscript{31} This is a small sample size to draw any conclusions of vitamin A status for these children. The authors in these two studies used spectrophotometric methods to analyse serum vitamin A. This method is less sensitive than the HPLC method that we used in our study. HPLC is the method of choice; it can measure both retinol and retinyl esters.\textsuperscript{22}

More studies are required of vitamin A status of children and nutritional intakes of vitamin A containing foods in other parts of Nigeria, especially the northern part and middle belt where there is a high consumption of carrots rich in beta-carotene and animal fats. This is important because of the diverse cultural differences in food preparation, consumption, and food taboos in different parts of the country.

The children in the study population consume a high amount of carotenoid-containing foods and low animal fat, and their mean UPF score was high with a relatively lower-moderate to high risk of poor intake. Studies have shown that low bioavailability of beta-carotene from plant carotenoids may be due to excessive cooking,\textsuperscript{23} physical inaccessibility of carotenoids from plant tissues, the amount of fat consumed, and parasitic infestations.\textsuperscript{24} Carotenoids other than beta-carotene in vegetable supplement may inhibit beta-carotene absorption by competing for absorption.\textsuperscript{25} All these might have contributed to the poor conversion of carotenoids to retinol in our study. This shows that the general availability of carotenoid-rich foods does not preclude the presence of vitamin A deficiency. The food frequency questionnaire used for this study did not accurately categorize risk for vitamin A deficiency in this community, since the children consumed almost identical foodstuff because of the low economic levels of their parents.

Breastmilk is known to be protective against clinical vitamin A deficiency up to 4–6 months of life. Beyond this period, it needs to be complemented by other sources of vitamin A to provide full health protection.\textsuperscript{5} In southern Malawi, xerophthalmic children were more likely to have stopped breast-feeding at an earlier age than clinically normal children.\textsuperscript{26} In our study, all 36 children in the 6–12 month age group, except one, were breast-feeding at the time of the study. They had the highest prevalence of serum retinol deficiency and the lowest mean serum retinol levels. There was also poor correlation between the duration of breastfeeding and mean serum retinol levels. It was realized that because of the rising cost of living in western Nigeria many women go to the farm with their husbands and most of them cannot take their children along to be breastfed on the farm (unpublished data). The vitamin A needs of these infants in all probability were not entirely covered by breastmilk alone, especially if the mother was malnourished and she was not giving enough supplementary diet to the child. In some developing countries, low breastmilk concentrations of vitamin A were reported in lactating mothers.\textsuperscript{24,27} Although we did not measure the breastmilk retinol levels of their mothers, this might also be the case in this low income community.

With respect to night-blindness, the WHO criteria for a significant public health problem in a community is a prevalence of more than 1 per cent in the population at risk.\textsuperscript{22} In this study, the prevalence of night-blindness was 1.5 per cent in children aged 2 years and above. Although there was no case of xerophthalmia, these children are at risk of night-blindness. Napoli and Race\textsuperscript{28} suggested that in areas where there is a high prevalence of vitamin A deficiency despite high consumption of carotenoid-rich foods, beta-carotene is able to generate retinoids in tissues, independently of the well controlled release of retinol from the liver. This has a protective effect on the eye. Carotenoids also have both antioxidant and immune functions.\textsuperscript{29} Children in the study population might have been protected from xerophthalmia due to high carotenoid intake.

There is widespread malnutrition in this community with stunted children having lower mean serum retinol levels than well nourished ones. This is comparable to findings in Sri Lanka in which chronically undernourished children had lower mean serum vitamin A values than better nourished children of a comparable age.\textsuperscript{30} This suggests that stunted children are at an increased risk of vitamin A deficiency and these are the children that should be targeted.

In conclusion, vitamin A deficiency is of high prevalence in the Ijaye Orile community in western Nigeria despite the high intake of carotenoid-containing foods. Breastmilk may not protect the infants against having low serum retinol levels, but high carotenoid intake may have protected them against xerophthalmia. More research needs to be done to determine the retinol and carotenoid levels of lactating mothers in this community and whether vitamin A supplements would increase the retinol levels of their breastmilk to a level that would protect their children. However, we recommend that vitamin A supplementation of preschool children, including infants and lactating mothers, should be instituted to combat vitamin A deficiency as a short-term
A long-term approach should include education about the importance of consumption of locally available natural sources of provitamin A and pre-formed vitamin A rich foods. This can be done when the child is brought for immunization or during antenatal clinics. Other measures include avoidance of overcooking these foodstuffs and encouraging their parents to grow more β-carotene containing foods.

References