Vitamin A Deficiency and Malnourishment among Young Children in Papua New Guinea

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ABSTRACT

Context: Papua New Guinea (PNG) has been classified by the World Health Organization as a country where Vitamin A deficiency (VAD) exists.

Aims: To determine the vitamin A status and identify risk factors of VAD in children aged between 6 months to 6 years in PNG.

Setting and Design: A cross-sectional study was carried out on randomly selected children ages 6 months to 6 years in the Ramu region of Madang Province in PNG.

Methods and Material: Vitamin A status was assessed by clinical indicators (ocular signs of xerophthalmia), subclinical indicators (self-reported night blindness), biochemical indicators (serum retinol, beta carotene, retinol binding protein(RBP) levels, conjunctival impression cytology) nutritional indicators (breast feeding patterns, vitamin A rich food), anthropometric measures, and associated morbidity conditions (diarrhea, malaria).

Statistical analysis used: Epi Info 6 (Center for Disease Control, Atlanta, USA).

Results: From 609 children enrolled in the study, the prevalence of serum retinol levels ≤ 0.7 µmol/L was 10.3% (n = 62.7). Night blindness was reported in 4 children with no xerophthalmia evident. The prevalence of stunting was 35.2% (n = 214.4) in our study.

Conclusions: No evidence of clinical VAD was found, but subclinical VAD occurred at a level of mild-moderate public health importance in our study. Further studies need to be carried out to assess VAD in different regions in PNG.

INTRODUCTION

Vitamin A is critical for children’s growth and deficiency of this nutrient can result in protein energy malnutrition (PEM), micronutrient deficiency, and infections, in addition to decelerated growth [1]. Xerophthalmia caused by a severe vitamin A deficiency (VAD), if untreated, can lead to corneal ulceration and night blindness [2]. Clinical VAD is noted with apparent xerophthalmia and serum retinol levels of < 0.35µmol [3,4]. Subclinical VAD effects such as night blindness are seen when levels of serum vitamin A are low enough to have adverse health consequences even if there is no evidence of clinical xerophthalmia [5,6]. VAD appears to increase the risk of death even before xerophthalmia is apparent clinically [6,7]. Children between the ages of 6 months and 6 years are highly vulnerable to VAD [8]. The effects of vitamin A status on childhood mortality depend on the severity and prevalence of pre-existing VAD, concomitant nutritional disorders, and co-existing infections [9]. It is estimated that over one million deaths in children could be prevented each year with improvement to vitamin A nutrition [10].

Papua New Guinea (PNG) has been classified by the World Health Organization (WHO) as a country where VAD exists. The aim of this study was to establish the vitamin A status of children aged 6 months to 6 years in the Madang province in PNG and determine associated risk factors.
lower and middle Ramu region of the Madang province of PNG, to evaluate the vitamin A status of children aged between six months and six years. An estimated 7000 children (age between 6 months and 6 years), live here in 11 different isolated villages, located in four regions (Anaberg, Kwanga, Bogen and Bunapas). In our study, we included via random selection 609 children age six to 72 months, located from the four regions to determine their vitamin A status. We excluded children with presence of obvious illness, diarrhea or major injuries, diarrhea or fever in the last 2 weeks, non-residents, children on medications, children whose age was unknown, those with incomplete forms / interviews and unreliable information from parent.

Households in the villages were randomly selected. When people in a village lived scattered over a big area, the selection procedures were adjusted and clusters of households and children were enrolled in the survey. Children were selected so that approximately 10% of children in each age group were represented. The survey was carried out by 4 teams consisting of two trained health workers in pediatric and ophthalmic examination, a nutritionist and a pediatrician. The teams were accompanied by a local health worker from the nearest health center.

Ethical clearance

Ethical approval for the study was obtained from the Ethics Committee of PNG National Department of Health prior to study commencement. When the survey team arrived in the village, the purpose of the study was explained to the village leaders and parental informed consent was obtained for their child's study participation.

Interviews

Mothers were asked to bring their children to a central point (usually the local school). The interviews were held in the local language, where medical history, immunization status, diet and night blindness were ascertained. Night blindness was assessed in all children using the WHO (1996) questionnaire: Can your child see in the daytime? Can your child see at night? If the answer to question 2 was “yes”, the child would be asked “is your child different from other children in the village? Or “does your child have night blindness (translated locally to “aitutak long nait”)? A family history of night blindness was also assessed in everyone during screening. Additionally, a household information form collected further socioeconomic information. This survey at the household level used focus groups of women and elders to generate a list of important foods available in homes whether from the home garden, or sources outside the community.

Physical examination

After the interviews had been completed, the following anthropometric data was recorded: weight (kg), and height/length (cm). A weighing scale was used for weight evaluation. Children below 2 years of age had their length measured. For those over 2 years of age, height was measured. The child was then examined by the local pediatrician and a trained ophthalmologist for xerophthalmia or any corneal lesions.

Conjunctival impression cytology (CIC)

CIC was collected from 100 randomly selected children by the Ophthalmologist. The sampled cells were stained and evaluated for described histological changes that are specific for VAD at the Department of Pathology, Port Moresby General Hospital (PMGH).

Laboratory biochemical markers

Blood was taken with steel butterfly needles from an appropriate vein on the forearm or hand and put in a non-Zinc containing heparinized Vacutainer tubes. Serum retinol binding protein (RBP), prealbumin, total proteins, β-carotene, and hemoglobin levels were analyzed at PMGH. The serum retinol levels were measured at the Children’s Hospital in Westmead, Australia, using a high pressure liquid chromatography column as recommended by WHO (1996) [11].

Statistical analysis

The children’s questionnaires were checked for completeness and data was transferred from the individual and household questionnaires to Epi Info 6 Program (Center for Disease Control, Atlanta, USA) and Microsoft Excel. These two programs were used for data analysis. A P-value less than 0.05 was considered statistically significant. The prevalence of each indicator of VAD as suggested by WHO (1996) was calculated [11].

RESULTS

Six hundred and nine children were enrolled from 50 households in our study. 49.1% (n=299) came from Anaberg, 31.1% (n=189.4) from Bogen, 11.3% (n=68.8) from Bunapas and 8.5% (n=51.8) from Kwanga. 53.7% were male. The average age was 37.2 months. The mean age of the children was 34.3 months for boys and 34.9 years for girls.

History of night blindness and ocular signs

The prevalence of night blindness was 1.1%. These four children had no evidence of a fundus abnormality or a positive family history of the disease. Almost all (98%) of the children had normal eyes on external examination. 1.3% of them had purulent conjunctivitis. One child had nystagmus and 2 had corneal scars due to trauma. These were cross-checked and validated by the ophthalmologist.

Biochemical indicators

The mean serum retinol level was 1.22µmol (σ = 0.481) and 15% of the children had a serum retinol < 0.70µmol. There was no statistically significant difference in the serum retinol levels of boys (1.153 µmol) and girls (1.274) (p-value 0.21). Twenty five percent of children with night blindness had a serum retinol of greater than 0.7µmol. The largest percentage of children with low serum retinol were in Anaberg (49.1%) There was no correlation between the serum retinol and the anthropometric parameters.

The mean βCarotene level was 0.502µmol; RBP 19.23 mg/L, prealbumin 137.2 mg/L, and total protein levels 70.4 mg/L. The mean hemoglobin was 92 g/L. There was a weak correlation between serum retinol and hemoglobin (r=0.17). The mean
hemoglobin levels in children with serum retinol<0.7µmol was 8.75 g/L. There was no correlation between hemoglobin and serum retinol in children with serum retinol below 0.7 µmol. There was good correlation between serum retinol and RBP levels (r=0.51, r²=0.26 95%CI 0.07 and 0.43). There was a significant correlation between RBP and prealbumin (r=0.54, r²=0.29 95% CI 0.10 and 0.46).

CIC

Due to cost considerations, a total of 101 CIC smears were studied. 36 found to be unsatisfactory as the cells could not be studied properly due to paucity of the cells or poor staining.

Nutritional indicators

Breast feeding patterns: 41.5% of the children were still breast-feeding. The mean age of boys still breast-feeding was 20.4 months (n=26, 6.1-65 months) and girls (n=18, 5-53 months). In the younger age group, 93.1% of children below 18 months of age were being breast fed and the mean age of stopping breast feeding was 22.2 months (median 24 months, SD 11.09). Solids were introduced at a mean age of 4.9 months (SD 2.76, median 4 months, and range 3-12 months).

Vitamin A rich food intake: We found that 69.8% of children consumed dark green leafy vegetables (DGLV, AKA "kumu") every day of the week. The mean number of days/week that kumu was eaten was 5.6 and less than 14.2% of children consumed DGLV less than 3 days/week. The mean serum retinol in children consuming DGLV < 3 days/week was 1.033 µmol. Cooked bananas was a commonly consumed vegetable (70.2% ≥ 3 days/week; mean 4.5 days/week). 55.7% of children ate fresh bananas > 3 days/week; mean 3.3 days/week). Sweet potatoes were eaten by 28.3% children ≥ 3 days/week). This is the same situation with pawpaw (2.6%> 3-days/week; mean 1.5). Carrots were not consumed by any of the children. Whole fish was consumed by 51.5% of children ≥ 3 times/week (mean 3.2). Chinese cabbage, tomatoes, pumpkin, pandanus, pineapples, guava, shellfish, avocado peas, whole milk and eggs were consumed infrequently or not at all.

Market, household food and safe water availability: Only 2% of the people depended on food obtained from the market. 68% of households had a regular income most of which was earned by selling produce in the local market. More than 75% had DGLV (kumu) and bananas growing in their garden, and more than 60% had corn, sweet potato, beans and pumpkins in their garden. Pawpaw and bananas were available to more than 80% of households on a regular basis. Only 20% of the households had access to safe water. The rest of them relied on the rivers and streams (38%), bore holes (4%) and unprotected wells (24%) for their water supply.

Anthropometric data: The prevalence of stunting was 35.2% (z score < -2 SD for height/age). 51.6% had a weight-for-age Z (WAZ) score of < -2 SD for weight/age. There was no correlation between weight for height and age, serum retinol, total protein, prealbumin and RBP. There was a positive correlation between weight for height and β Carotene (r=0.15) and hemoglobin (r=0.15) levels.

Morbidity

Disease rates: The one-week diarrhea prevalence in the population was 11.3%. The fever prevalence rate was 34%. The commonest infections encountered were those of the skin / upper respiratory tract (2.2%) and clinical malaria (3.3%). A positive malaria slide was encountered in 2.1% of the children.

Immunization: Only 12% of the children had complete immunization, and 53% incomplete while 34% was unknown. None of them were fully immunized against measles. The BCG vaccination coverage was 62.1%. Other immunizations included Sabine vaccination (51.5%), triple antigen (49.5%), hepatitis B - 3 doses (14.6%), and measles - 3 doses (2.9%).

DISCUSSION

Our study found no children with definite clinical eye signs of VAD, although 1.1% had night blindness, which is indicative of mild VAD in the population. The mean serum retinol level was 1.22µmol, and 15% of the children had a serum retinol < 0.70µmol, which is in keeping with a moderate level of VAD severity.

Sommer recommended that the cut-off values for each country be defined, taking into consideration the local characteristics of infections, PEM, etc [12]. Furthermore, Sommer suggested that a prevalence of >40% of serum retinol at <0.7µmol be used as a cut-off point, as this encompasses a >5% prevalence of serum retinol values at <0.35µmol and requires a sample size that is eight times smaller than when attempting to work with the 5% (0.35µmol) definition to define severely deficient populations [12]. These suggestions fit with our observations using the 0.7µmol cut-off for defining this population as moderately deficient.

The mean hemoglobin in our study was 92 g/L, which is low. We found a weak correlation between serum retinol and hemoglobin (r=0.17), which is in line with the findings of other studies [13,14]. Anemia is widespread in both boys and girls living in lowland areas, [15,16] and is amongst the top ten causes of admissions and deaths in health facilities for infants in PNG [17]. Anemia in a pregnant mother may have a profound effect on the outcome of the pregnancy, causing the infant to suffer from iron deficiency anemia right from the womb or from insufficient iron in the mother’s breast milk [18]. Most cases of anemia in PNG children are believed to be iron deficiency anemia caused by inadequate nutritional intake, repeated malaria attacks, hookworm infestations, or a combination of these factors that needs to be addressed [19, 20].

In our study, malnutrition was most often seen in the second and third years of life, which is the time when the mother is likely to be pregnant again and the child has been weaned from breastfeeding [21]. A weaning diet poor in vitamin A predicts a childhood diet that is also poor in vitamin A [22]. PNG promotes breastfeeding as the best source of nutrition for infants and actively discourages mothers from bottle feeding their babies [23]. It was the first country to enact the Breast Feeding Supplies (Control) Act in an effort to protect babies from infections, diarrhea, and malnutrition brought on by artificial feeding and as a measure to support and encourage traditional feeding practices [24]. The act prohibits the sale of feeding teats, bottles,
and dummies without prescription [24]. Despite the legislation, more women are now choosing to bottle feed their babies, and they are obtaining bottles and formula without legally required prescriptions [24]. Weaning practices are important as the infrequent consumption of DGLV or yellow fruits is associated with a 4- to 6-fold increase in the risk of xerophthalmia, compared to the 2- to 3-fold increased risk from fish, meat, milk, and eggs [22].

According to the WHO guidelines, a low risk exists when vitamin A-rich foods are available in the home fewer than 3 times per week for >75% of households [11]. The risk of VAD is greater when the consumption of foods of animal origin does not regularly occur [25]. In many villages in PNG, some fruit trees are considered “common property,” and mothers collect fruit for their household consumption. In our study, pawpaw and bananas were available to more than 80% of households on a regular basis whereas carrots were not consumed by any of the children as they are more commonly grown in higher altitude areas in the country. Fish were plentiful in the rivers and creeks, and tinned fish, canned meats, and cooking oils were also available in the store in the village.

The prevalence of stunting in our population was 35.2%. A ≥30% prevalence of stunting in children under 5 years indicates an area/population at risk of VAD [11]. Stunting (< -2 z-scores for height/age) is a surrogate measure of chronic dietary deprivation associated with VAD [10,26]. The longer the duration of VAD, the greater the degree of stunting, as was evident in our study, as older children tended to have more negative z-scores (r = -0.10). A chronic state of mild VAD may be significant enough to cause increased susceptibility to infections, with reduced linear growth [10,26]. Wasting (< -2 z-scores for weight/height), a measure of present malnutrition from inadequate food intake, is associated with an increased risk of VAD [27]. Our study revealed that the prevalence of wasting was 30.8%. WHO defines wasting (weight/height z, WHZ scores > -2) at ≥10% in children under 5 years as a high-risk area/population for VAD [11]. We found a negative correlation (r = -0.14) between CRP and WHZ, indicating that children prone to acute infections had some degree of wasting. A positive correlation was found between WHZ and the β-carotene (r = 0.15) and hemoglobin (r = 0.15) levels. Better nourished children tended to eat more and had higher carotene levels. Innovative research is needed in PNG to assess micronutrient bioavailability and develop food fortificants that optimize the nutritional value of food.

The high incidence of diarrhea (11.3%) and fever (34%) in a growing child remains a problem and can cause malnutrition or worsen existing malnutrition [28]. Likewise, a child with malnutrition is more susceptible to infectious diseases, thereby triggering a vicious cycle [29]. Regardless, fever—irrespective of etiology and helminthic infection—usually depresses appetite, nutrient absorption, and circulating blood levels of vitamin A [30]. Diarrhea is a common cause of childhood death in PNG [31]. Diarrhea is a disease that reflects sanitation and hygiene conditions. Only about a quarter of the study population in PNG had access to safe water, while approximately 10% of the population had adequate means of excreta disposal. High rainfall and the mountainous terrain create the ideal conditions for fecal contamination of surface water, which is the most common source of drinking water in many communities throughout PNG [32]. The need to improve potable water supplies and sanitation in the villages is self-evident [33]. Educating parents on hand washing, food preparation, water purification, and improvements in sanitation in the home environment are essential for preventing diarrhea [32,34].

In our study, two patients had a positive malaria slide, with serum retinol levels ≥ 0.7 μmol. In many areas of PNG, malaria is endemic and a major cause of infant and child mortality [15]. Children between the ages of three months and five years are in the greatest danger of contracting malaria, as they have insufficient immunity. The importance of malaria as a cause of low serum retinol in endemic areas such as parts of PNG and the impact of vector control programs on serum retinol require further study.

Immunization rates in children between 12 and 23 months were generally poor in the regions of our study, and none of the children were fully immunized against measles. The risk of VAD increases when coverage rates for full immunization, particularly for measles, falls below 50% in children 12 to 23 months old [11]. Following the WHO guidelines, this puts the whole population at risk of developing VAD [11]. As long as villages have no permanent health facilities and the measles case fatality ratio remains high, the case can be made for providing vitamin A supplementation along with the expanded program on immunization.

CONCLUSIONS

In summary, our study found no evidence of clinical VAD among the children in PNG. However, subclinical VAD with concurrent malnourishment occurred at a level of mild to moderate public health importance, which warrants further attention. Measures to improve general nutrition and prevent infectious diseases seem to be the best way forward.

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