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Vitamin A deficiency disorders among the rural pre-school children of South India

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Abstract

Objectives: Vitamin A deficiency (VAD) among the rural pre-school children in India is continues to be a major nutritional problem of public health significance, even after the implementation of national vitamin A prophylaxis programme for more than four decades. The aim of the study was to assess the prevalence of vitamin A deficiency among rural pre-school children of South India.

Methodology: A community based cross-section study; adopting multi-stage random sampling procedure was carried out by the National Nutrition Monitoring Bureau (NNMB) among rural pre-school children of four South Indian states viz. Kerala, Tamil Nadu, Andhra Pradesh and Karnataka during 2003-05. A total of 35,480 (Boys: 18,216; Girls: 17,264) rural children of 1-5 year age group was covered for this study.

Key Results: The prevalence of Bitot's spot, an objective ocular sign of VAD among the rural pre-school children of South Indian was 0.6% (95%CI:0.5-0.7). Similarly, the proportion of children with sub-clinical VAD was 59.3%, suggestive of a severe public health problem. In general, the prevalence of VAD was significantly higher ($p<0.001$) among the children of socio-economically marginalized sections of the communities, labourers, illiterate mothers and those residing in the households with no sanitary latrine.

Conclusion: The prevalence of clinical and sub-clinical VAD among the rural pre-school children of south India is suggestive of a public health concern. Therefore, rural communities are encouraged to consume diets rich in pre-formed and pro-vitamin A and administer periodic massive dose vitamin A solution to the children of under five for the prevention and control of VAD.

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Introduction

Vitamin A is an essential fat soluble micro-nutrient that cannot be synthesized within the human body, so it must be obtained through diet.[1] It is available in two forms; preformed vitamin A i.e. retinoids found in foods of animal sources (fish liver oils, liver (goat, sheep, ox), egg yolk, dairy products etc.) and provitamin A i.e. carotenoids found in foods of plant sources (orange, yellow, red colored fruits and vegetables & dark green leafy and non-leafy vegetables). Vitamin A is a key ingredient for the normal functioning of many vital bodies' activities. Vitamin A is essential nutrient required for normal vision, cell production, division and differentiation, embryonic development and reproduction, epithelial integrity, production of red blood cells and maintenance of immune system.[2] The extra ocular manifestations include keratinization of the skin and of the mucous membranes in the respiratory, gastro intestinal and urinary tracts.[3] Vitamin A deficiency (VAD) is the leading cause of preventable childhood blindness among the children residing in lower and middle income countries, and contributes significantly to childhood morbidity and mortality from infectious diseases.[4] Vitamin A deficiency increases vulnerability to a range of illnesses including diarrhoea, measles, and respiratory infections. [12,5] Vitamin A is essential for the synthesis of light sensitive pigment 'rhodopsin' in the rod cells of Retina and its deficiency causes diminished function of rod cells leading to poor adoption to dim light and night blindness. Similarly, Vitamin A is needed to maintain normal functioning of the cells that make up the cornea to secrete mucus and tears for the prevention of dryness and bacterial infection and VAD causes xerophthalmia comprising of conjunctival xerosis, Bitot's spots, corneal xerosis, keratomalacia and corneal scar.

Vitamin A deficiency (VAD) is a major nutritional problem of public-health concern in underdeveloped and developing countries,[6] which could be attributed to limited access to foods containing preformed vitamin A (Retinol) from animal-based food sources and poor consumption of foods containing beta -carotene due to poverty and food choices and taboos.[7] According to the World Health Organization (WHO), about one-third of the world's pre-school children are vitamin A deficient and most of them live in South East Asia (91.5 million) with highest proportion of the world's VAD children are from India. [8-10] Similarly, largest numbers of sub-clinical vitamin A-deficient children live in India and 40% of all pre-school children with xerophthalmia in the developing world live in India. [11]

In India, vitamin A deficiency continues to be a major public health nutritional problem even after implementation of supplementation of massive dose vitamin A under The National Prophylaxis Programme against Nutritional Blindness due to Vitamin A Deficiency[12] and other national nutrition programmes for more than four decades. In this regard, several community-based studies reported a high prevalence of both clinical and subclinical VAD among pre-school children residing in rural India.[13-15] A study carried out among pre-school children in the State of Uttar Pradesh reported a high prevalence of xerophthalmia (9.1%), Bitot's Spot (5.4 %) and severe forms of VAD such as corneal ulceration (0.2%) and corneal scar (0.5%).[16] Similarly, a higher prevalence of clinical VAD (Bitot's Spot 2.1%) was reported among urban children in the state of Gujarat.[17] Therefore, keeping in view the magnitude of Vitamin A deficiency in India, this communication was prepared with the objective to study the prevalence of vitamin A deficiency among the rural pre-school children of Southern India, utilizing the large data base collected by the National Nutrition Monitoring Bureau (NNMB).

Material and Methods

A community based cross-section study; adopting multi-stage random sampling procedure was carried out by the NNMB during 2003-05 in four South Indian states viz. Kerala, Tamil Nadu, Andhra Pradesh and Karnataka. In this study, each State was divided into 16 Strata based on agro-climatic characteristics. A district or part of a district with a population of 1.8 million was considered as one stratum. A total of 80 villages @ five villages per stratum were selected randomly from 16 strata. Thus, a total of 320 villages were covered for the study. The list of villages covered for the 54th round of the consumer expenditure survey conducted by the National Sample Survey Organization[18] formed the sampling frame for the present study.

Estimation of sample size

Considering the prevalence of Bitot's spots among the pre-children as 1%,[19] confidence interval (CI) of 95% and relative precision of 20%, a sample size of 9,508 pre-children was arrived at for each State for the clinical examination to detect ocular signs of VAD. Similarly, a sub-sample of 576 pre-children was arrived at for each state, assuming the prevalence of blood vitamin A deficiency (<20 µg dL) among the pre-school children as 50%,[20] 95% of CI and relative precision of 10%.

Selection of villages and households

Five villages were selected randomly from each stratum and the total number of children to be covered from each village was determined by the Probability Proportional to Size (PPS) sampling method. The village was divided into five geographical areas, based on a natural group of houses or streets. In each village, the households belonging to Scheduled Caste (SC)/ Scheduled Tribe (ST) communities, who generally live as a separate group, constituted one of the five geographical areas. All the households with at least one pre-school child and the total number of pre-school children in each geographical area were enumerated. The total number of pre-school children to be covered from each village and the required number of pre-school children to be covered in each geographical area was determined based on the PPS method.

Data collection

The information regarding the households' demographic and socio-economic particulars was obtained from all the selected households. Clinical examination was performed to detect the presence of nutritional deficiency signs of vitamin A among 1-5-year-old children. A free-falling drop of blood from finger-prick was collected on a pre-coded special chromatography filter paper (Whatman) to estimate blood vitamin A in a sub-sample of children covered for clinical examination by the dry blood spot (DBS) method.[21]

Ethics: The study was approved by the scientific advisory committee (SAC) of Indian Council of Medical Research (ICMR), New Delhi and ethical clearance was obtained from the Ethical Review Board (ERB) of National Institute of Nutrition (NIN), Hyderabad. Written informed consent was also obtained from the parents of pre-school children.

Training of the field staff

All the field staff comprising of medical officers, nutritionists and social workers were trained at a central reference laboratory (CRL) of NNMB at National Institute of Nutrition (NIN), Hyderabad for 3 weeks in survey methodology and collection of dried blood spots (DBS). Scientists from the National Institute of Nutrition supervised the data collection and the quality of the data was ensured by repeating the investigations in a sub-sample of the collected data.

Statistical analysis

The Statistical Package for Social Sciences[22] was used for the analysis of data. The prevalence of ocular manifestations of VAD with 95% confidence intervals (CI) by state, age group and gender was analysed. Mean (± SD), median and range of blood vitamin A levels were analysed. The prevalence of sub-clinical VAD with 95% CI was analysed by age group and state. Univariate and bivariate analysis was performed by the chi-square (χ^2)test to study the association between the prevalence of clinical (Bitot's spots) and sub-clinical (Serum vitamin A <20µg/dL) VAD and different socio-demographic variables. P value of <0.05 was considered as statistically significant.

The definition for the 'community' mentioned in the text:

Community (Caste): The Indian community is categorized into four major castes based on their occupations. They include socially underprivileged and economically underdeveloped poorer sections of the society i.e. Scheduled Caste (SC) & Scheduled Tribes (ST), Backward Caste (Different artisans come under this category) and Forward Caste. Generally, the Forward Caste communities are socially highly privileged and economically well off. The Scheduled Caste and Scheduled Tribe communities are provided with certain social and economic guarantees by the government of India.

Results

For the present study, a total of 35,480 (Boys: 18,216; Girls: 17,264) rural children of 1-5 year age group was covered from four South Indian States of India. The prevalence of ocular manifestations of VAD by states and gender is presented in **Table-1**. In general, the prevalence of night blindness and conjunctival xerosis among the rural pre-school children of South India was 0.1% and 1 %, respectively. While, the prevalence of Bitot's spot, an objective ocular clinical sign of VAD (0.6%) was higher than the WHO[23] cut-off of 0.5% indicating VAD as a public health problem among pre-school children. The prevalence of Bitot's spot was ranged from nil in the state of Kerala to a high 1.3% in the state of Andhra Pradesh and its prevalence is a public health concern all the South India states except for the state of Kerala. It is also observed that all the signs and symptoms of vitamin A deficiency were significantly (p<0.001) different between states and gender. In case of sub-clinical vitamin A, the mean and median blood vitamin A were below the cut-off level of 20µg/dL, indicating blood vitamin A deficiency and the overall prevalence of sub-clinical VAD among rural children of South India was (59.3%) higher than the WHO cut-off ≥20%,[23] suggestive of severe public health problem and it ranged from a low 48.8% in the state of Tamil Nadu to a high 79.4% in Kerala (**Table 2**).

The prevalence of Bitot's spots and total VAD increased significantly (p<0.001) with increasing age. The mean blood vitamin A levels (18.9µg/dL) were below the WHO recommended cut-off of 20µg/dL, suggestive of sub-clinical vitamin A deficiency. The

Table: 1. Prevalence (%) of ocular manifestations of VAD among rural pre-school children of South India by states and gender

State	n	Night blindness	Conjunctival xerosis	Bitot's spots	VAD†
Kerala	8329	0.0 [a]	0.1[a] (0.0-0.2)	0.0 [a]	0.1 [a] (0.0-0.2)
Tamil Nadu	9197	0.1 [b] (0.0-0.2)	0.2 [a] (0.1-0.3)	0.5[b] (0.4-0.6)	0.6 [b] (0.4-0.8)
Karnataka	8627	0.2 [b] (0.1-0.3)	2.2 [b] (1.9-2.5)	0.7 [b] (0.5-0.9)	2.8 [c] (2.5-3.2)
Andhra Pradesh	9327	0.2 [b] (0.1-0.3)	1.3 [c] (1.1-1.5)	1.2 [c] (1.0-1.4)	2.1 [d] (1.8-2.4)
Pooled	35480	0.1 (0.05-0.1)	1.0 (0.9-1.1)	0.6 (0.5-0.7)	1.4 (1.3-1.5)
p-value	-	0.000	0.000	0.000	0.000
Gender					
Boys	18216	0.2 (0.1-0.3)	1.2 (1.0-1.4)	0.7 (0.6-0.8)	1.8 (1.6-2.0)
Girls	17264	0.1 (0.1-0.2)	0.6 (0.5-0.7)	0.5 (0.4-0.6)	1.0 (0.9-1.2)
p-value	-	0.000	0.000	0.000	0.000

†: VAD: Total Vitamin A Deficiency

Note: i) Superscripts indicate the variations in the prevalence of VAD is significantly different across States, ii) Figures in the parenthesis are 95% Confidence Intervals (CI)

Table 2: Blood vitamin A levels (µg/dL) by states

State	n	Mean±SD	Median	Range	Sub-clinical VAD† Per cent (95% CI)
Kerala	407	13.1±8.4	10.5	3.6 - 47.0	79.4 (75.5 - 83.3)
Tamil Nadu	482	21.9±10.9	20.1	4.1 - 89.2	48.8 (44.3 - 53.3)
Karnataka	559	20.8±9.4	19.5	3.7 - 58.6	52.1(48.0 - 56.2)
AP*	451	18.2±8.8	17.0	1.8 - 48.1	61.5(57.1 - 66.1)
Pooled	1899	18.9±10.1	17.6	1.8- 89.2	59.3 (57.1-61.5)

AP*: Andhra Pradesh   Sub-clinical VAD†: Blood vitamin A <20µg/dL

Table: 3. Prevalence (%) of Bitot's spots and total and sub-clinical VAD among rural pre-school children of South India by age group

Age (Yrs)	Clinical VAD (95% CI)			Sub-Clinical VAD (95% CI)		
	n	Bitot's spots	VAD†	n	Mean (CI)	<20µg/dL
1+	6971	0.1 (0.0-0.2)	0.3 (0.2-0.4)	277	19.7 (18.5-20.9)	54.9 (49.0-60.8)
2+	8482	0.3 (0.2-0.4)	0.7 (0.5-0.9)	441	19.3 (18.3-.20.3)	57.1 (52.5-61.7)
3+	8894	0.8 (0.6-1.0)	1.8 (1.5-2.1)	538	19.4 (18.6-20.3)	56.9 (52.7-61.1
4+	11133	1.1 (0.9-1.3)	2.3 (2.0-2.6)	643	17.8 (17.1-18.5)	64.9 (61.2-68.6)
Pooled	35480	0.6 (0.5-0.7)	1.4 (1.3-1.5)	1899	18.9 (18.4-19.3)	59.3 (57.1-61.5)
p-value	-	0.000	0.000	-	0.011	0.006

†: VAD: Total Vitamin A Deficiency

Table: 4. The association between the prevalence of vitamin A deficiency and socio-demographic particulars

	Bitot's spot			Serum vitamin A <20µg/dL		
	n	Per cent	p-value	n	Per cent	p-value
Community						
ST	1213	1.8	0.000	80	61.3	0.257
SC	6526	1.1		326	57.4	
OBC	1800	0.5		948	61.4	
Forward Caste	9741	0.3		544	56.6	
Religion						
Hindu	29148	0.7	0.000	160	57.3	0.000
Muslim	3954	0.1		192	72.4	
Christian	2273	0.2		107	66.4	
Occupation						
Laborers	17430	0.8	0.000	928	60.9	0.002
Cultivators	7808	0.5		433	52.2	
Service/ Business	6793	0.2		351	65.0	
Artisans	3449	0.5		150	56.7	
Family size						
1- 4	17030	0.5	0.002	872	60.9	0.206
≥5	18450	0.7		1027	58.0	
Female Literacy						
Illiterate	16524	1.0	0.000	972	63.3	0.000
Literate	18955	0.2		927	55.2	
Sanitary latrine						
Absent	22653	0.9	0.000	1258	67.7	0.000
Present	12827	0.1		641	55.1	

prevalence of sub-clinical vitamin A deficiency among the rural children (59.3%) was more than the WHO cut-off of 20%, indicating VAD as a severe public health problem among all the age groups, and the prevalence increased significantly (p<0.001) with increasing age (**Table 3).** The mean serum vitamin A (p=0.828) and the prevalence of sub-clinical vitamin A deficiency (p=0.639) was statistically not different among the children with and without Bitot's spot. The association between the prevalence of vitamin A deficiency and various socio-demographic particulars is presented in **Table-4**. The prevalence of Bitot's spot, an objective ocular clinical sign of VAD was significantly higher among the rural children of socio-economically marginalized sections of the communities such as Scheduled Caste (SC) & Scheduled Tribe (ST), labourers, illiterate mothers and those residing in the households where the sanitary latrine is absent (p<0.001). Similar trend was observed with respect to sub-clinical VAD except for community.

Discussion

The NNMB for the first time carried out the study in all the states of South India covering large state representative sample and this communication, for the first time reporting the prevalence of clinical and sub-clinical VAD among the rural pre-school children of South India. In general, the overall prevalence of Bitot's spot an objective ocular clinical sign of VAD was 0.6 %, suggestive of VAD as public health concern among the rural children of South India. Similarly, the magnitude of sub-clinical VAD (59.3%) was a severe public health problem among rural children of all the four states of south India. The proportion rural pre-school children with clinical and sub-clinical VAD were higher in North India as compared to their counterparts in South India, where the corresponding figures of Bitot's spot and sub-clinical VAD were 0.9% and 64%, respectively.[24] The prevalence of Bitot's spots was lower in the present study as compared to the figures reported for rural pre-school children of Bihar (4.7%),[25],Maharashtra, [13] Madhya Pradesh (1.4%),[14] eight NNMB states of India (0.8%)[26] and central India (2.2%).[27] Similarly, a higher prevalence of Bitot's spot was reported among the pre-school children of chronic drought affected states.[15] While, the prevalence was comparable with figures reported for the rural pre-school children of West Bengal (0.6%).[28] Similarly, a higher proportion of rural pre-school children of North India (64%),[24] Madhya Pradesh (88%)[14], West Bengal (61.2%)[28] and eight NNMB states of India (61.8%)[26] had sub-clinical VAD, while a lower prevalence of sub-clinical VAD was reported for the rural pre-school children of Maharashtra[13] as compared to children in South India. Furthermore, the prevalence of VAD was significantly higher (p<0.001) among the rural children of socio-economically marginalized sections of the communities such as Scheduled Caste (SC) & Scheduled Tribe (ST), labourers, illiterate mothers and those residing in the households where the facility of sanitary latrine is absent.

In general, we could attribute the vitamin A deficiency to prolonged deficit consumption of vitamin A rich foods and consumption of foods where the bio-availability of vitamin A is poor. This is evident from the NNMB studies carried out in different time points,[19,29-31] where the household and individual consumption of foods rich in vitamin A was grossly deficient as against their recommended dietary intakes (RDIs) and consequently the dietary intake of vitamin A was largely deficit as compared to the recommended dietary allowances (RDA). The NNMB survey carried out during the corresponding period reported that the proportion of rural pre-school children not meeting even 50% of their RDA for vitamin A was highest in the state of Andhra Pradesh (92.9%), followed by Kerala (91.8%), Karnataka (90.4%) and Tamil Nadu (81.9%), and the corresponding figure reported for eight NNMB states was 86.3%.[32] Similar finding was reported for the slum dwelling children of Nagpur, Maharashtra, where the proportion of children not meeting the RDA for vitamin A was about 91%.[33] Furthermore, as per the NNMB periodic surveys, the diets of rural population in India were predominantly vegetarian and the consumption of foods of animal source rich in preformed vitamin A (Retinol) were almost negligible. Thus, we may attribute poor and/or negligible consumption of foods of animal source one of the contributing factor for high prevalence of vitamin A deficiency in India, and the similar observation was reported by dee Pee et al.[34] Pal and Sagar reported significantly a higher prevalence of VAD (7.1%; OR: 5.32) in children on a vegetarian diet as compared to their counterparts.[35] In India, this over dependence of population on plant foods may be attributed to cultural and religious beliefs in conjunction with poverty and ignorance.

The bio-availability of vitamin A from plant foods may be limited and more variable than previously thought,[36] and the low absorption and limited bioconversion of carotenoids may limit the vitamin A activity of carotenes.[37] The bio-availability of vitamin A from the different food sources is highly dependent upon the assumed rate of bioconversion of β-carotene and at conversion rates estimated from recent field studies (21:1), the plant foods in Asia, Africa, and South America are seriously deficient in vitamin A.[38] The NNMB reported figures of gross deficit of dietary vitamin A among rural pre-school children in India was calculated based on the old conversion factor of 4:1 of β-carotene and retinol. If we calculate the dietary vitamin A using the revised Indian Council of Medical Research (ICMR) conversion factor of 8:1, the deficit of vitamin A would be even worse. Therefore, we can assume that it is not possible for young children to consume sufficient quantities of vegetables and fruits to overcome the inefficiencies of β-carotene conversion to meet their RDAs for vitamin A. We could also attribute the high prevalence VAD among the rural children in South India to poor coverage (10-35%) of bi-annual massive dose vitamin A supplementation as against the World Bank recommended ideal coverage of 85% for prevention and control of VAD and its impact on morbidity and mortality among children of under five. National Family Health Survey-3[39] also reported a low (25%) coverage of the rural children aged 12-35 months for bi-annual massive dose vitamin A supplementation. Although the supplementation of a massive dose of vitamin A to pre-school children under the national programme for prophylaxis against Blindness in Children due to Vitamin A Deficiency has been in operation for more than four decades, the coverage of children for the stipulated biannual massive dose of vitamin A was poor in India.[12]

Since the diets of rural children in the present study were grossly deficit in vitamin A, the community needs to be encouraged to diversify their diet by consuming variety of vitamin A-rich foods more frequently through long-term interventions of nutrition education, behavioural change communication (BCC) and information, education & communication (IEC) activities. Similarly, the emphasis should be placed on preventive short-term intervention like strengthening the coverage of children for biannual massive dose vitamin A supplementation[3] as it is one of the most cost

-effective public health interventions in countries where VAD constitutes a public health problem.[40] The Government of India should strengthen existing nutritional programs like integrated child development services (ICDS) scheme and the mid-day meal (MDM) programme through inclusion of vitamin A rich foods in the daily menus of these supplementary nutrition programmes. Furthermore, the Government of India should take initiatives for control of prices food commodities, provision of safe drinking water, employment generation for rural poor, improving literacy status women, empowerment women, appropriate wages for daily labour etc. for improvement of overall nutritional status of the community both quantitatively and qualitatively.

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