



MAGNITUDE AND ASSOCIATED FACTORS OF VITAMIN A DEFICIENCY AMONG SCHOOL-GOING CHILDREN

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Abstract

Background: Vitamin A deficiency (VAD) is an important public health problem in India and recent evidence suggests that school-age children could still carry a measurable burden of VAD despite the presence of national supplementation programmes aimed at pre-school children.

Objective: The study aimed to assess the magnitude and ocular manifestations of vitamin A deficiency and its associated socio-demographic, nutritional and morbidity factors amongst school going children in rural government schools of central India.

Methods: 500 students aged 7–14 years from rural government schools of central India were selected for a school based cross-sectional study spread over one year. Vitamin A deficiency was assessed based on the ocular clinical signs according to WHO. The collection of data on socio-demographic, dietary, anthropometric, and morbidity was done using a structured proforma. The associations were evaluated using the Fisher exact test and also Firth's penalized logistic regression considering the few VAD cases.

Results: The overall prevalence of vitamin A deficiency was 1.8 percent (9/500). Bitot spots were the most common manifestation among children with VAD 88.9%. Others were corneal xerosis/ulceration/keratomalacia 11.1%. There was no night blindness or conjunctival xerosis cases noted. A significant association was found between VAD and maternal education below secondary level ($p=0.013$), undernutrition/obesity ($p=0.004$), less intake of green leafy vegetables ($p=0.047$), less intake of yellow/orange fruits ($p=0.039$), recent diarrhoea ($p=0.012$), and history suggestive of measles ($p=0.020$). In multivariable analysis, independent predictors were maternal education below secondary level (AOR 4.18, 95% CI 1.09–16.08), undernutrition/obesity (AOR 5.74, 95% CI 1.44–22.91) and recent diarrhoea (AOR 4.69, 95% CI 1.20–18.27). In addition, having a history suggestive of measles indicated an increased risk. This association was seen with an AOR of 4.21 and a 95% CI 1.01–17.54.

Conclusion: Despite a low prevalence of vitamin A deficiency (1.8%) among school-going children from rural central India, presence of ocular manifestations like Bitot spots and corneal disease warrants serious public health concern. The main predictors include maternal education, nutritional status, and recent infections. It is recommended that maternal education and nutrition programmes, deworming and infection prevention be strengthened.

Keywords: Vitamin A deficiency, school children, xerophthalmia, socio-demographic factors, malnutrition

Introduction

The micronutrient Vitamin A, which is fat soluble, is essential for visual function, maintenance of epithelial integrity, immune defence, normal growth and development in children. [1] A deficiency of

vitamin A leads to a range of disorders; an initial subclinical lowering of serum retinol concentrations to clinical disorders. Moreover, night blindness, conjunctival xerosis, Bitot spots, and corneal xerosis with ulceration. In addition, keratomalacia, which causes the most disabling cause of preventable nutritional blindness in children.[2] According to the World Health Organization, 250,000 to 500,000 children who lack adequate vitamin A become blind each year.[3] Globally, vitamin A deficiency continues a public health issue especially in low- and middle-income countries of South-East Asia and Sub-Saharan Africa.[4] In India, 57% of preschool children have been found to be subclinically deficient in vitamin A. This shows the highest burden of vitamin A deficiency among South Asian countries. The Comprehensive National Nutrition Survey uncovered that the inflammation-adjusted prevalence of VAD among school-age children was about 18-22% between 2016 and 2018. However, there were state-level differences, with a greater burden in central, eastern and north-eastern states[5,6]. The National Vitamin A Supplementation Programme (NVASP) is aimed at the infants and children aged 9 months to 5 years for the most part through public health programmes in the country. School-going children aged 6 years and above, however, are largely out of the routine supplementation arena.[7] Evidence from school-based surveys suggests VAD does continue well beyond preschool years despite this gap. Sinha et al (2015), who conducted their Central India Children Eye Study in Nagpur, noted that Xerophthalmia (defined as Bitot spots and/or night blindness) was found in 6.5% of schoolchildren enrolled in government schools in low to lower-middle socioeconomic strata.[8] A study conducted in Jodhpur revealed a much higher prevalence rate of xerophthalmia which was 9.89% among 5135 school children of age 6-16 years.[9]

Research done on communities in India have further identified dietary inadequacy, undernutrition, lower socio-economic status, illiterate mothers, recurrent infections as important determinants of VAD. [10,11,12] A research study was conducted in Madhya Pradesh, which documented prevalence of night blindness and Bitot's spot was 0.8% and 1.4% and a extremely high subclinical deficiency (88%) among rural preschool children. It also noted that Bitot spots were significantly more common in lower socioeconomic groups and also in children of illiterate mothers.[13] The aim of the school-based study reported here was to determine the magnitude and ocular manifestations of vitamin A deficiency and evaluate its association with socio-demographic, nutritional, and morbidity-related factors among the school-goers aged 7 – 14 years studying in rural government schools in central India.

Material and Methods

Study Design and Setting

A school-based cross-sectional study was conducted among students of government schools in rural areas of central India over a period of one year. The primary objectives were to determine the magnitude and ocular manifestations of vitamin A deficiency and identify its associated socio-demographic, nutritional, and morbidity-related factors among school-going children.

Sample size and sampling technique

In study sample size of 500 students was considered, using cochrane formula where p is taken as 50% (anticipated prevalence) with 95% confidence level, relative precision of 10%, and allowance for non-response of about 20%. Schools were selected by simple random sampling from an updated list of rural government schools, and all eligible students in the specified classes were assessed until the required sample size was achieved.

Inclusion and Exclusion Criteria

All students aged 7–14 years enrolled in the selected schools and present on the day of the visit were eligible. Children were included if written informed consent was obtained from parents or guardians and the child assented to participate. Children with known chronic liver disease, chronic renal failure, malabsorption syndrome, congenital ocular abnormalities unrelated to VAD, or those who had received therapeutic high-dose vitamin A supplementation within the preceding 3 months were excluded.

Data Collection

A predesigned and pretested structured proforma was used to collect data on:

- **Socio-demographic variables:** age group, sex, family type, socioeconomic status (modified BG Prasad classification, updated for the study year), parental education, and family size.
- **Dietary intake:** food frequency questionnaire with specific assessment of green leafy vegetables, yellow/orange fruits, milk, and non-vegetarian food consumption (frequency per week).
- **Anthropometry:** weight and height were measured using standard techniques; nutritional status was assessed using age- and sex-appropriate reference standards (IAP/WHO criteria) and children below normal range were classified as undernourished.
- **Morbidity history:** episodes of diarrhea, acute febrile illness suggestive of measles, or repeated respiratory infections in the preceding 3 months were recorded.
- **Supplementation and deworming history:** receipt of vitamin A supplementation or deworming drugs in the past 6 months.

Clinical Assessment for Xerophthalmia

All children underwent clinical examination for ocular signs of VAD by a trained clinician under adequate illumination, including history of night blindness, and examination for conjunctival xerosis (X1A), Bitot spots (X1B), corneal xerosis (X2), and corneal ulceration/keratomalacia (X3). WHO classification of xerophthalmia was used.³

Statistical analysis

Data were entered into Microsoft Excel and analyzed using standard statistical methods. Categorical variables were expressed as frequencies and percentages. Associations between vitamin A deficiency and explanatory variables were assessed using the Chi-square test or Fisher's exact test, as appropriate. Logistic regression was used to estimate adjusted odds ratios (AORs) with 95% confidence intervals. A p-value <0.05 was considered statistically significant.

Results

Socio-demographic Profile of Study Participants

A total of 500 students aged 10.39 ± 2.32 years on average participated in the research. Out of 500 study participants 9 were having Vitamin A Deficiency, Prevalence was 1.8%.

Among the children with vitamin A deficiency ($n = 9$), the majority were aged 7–10 years (77.8%) and males (55.6%). Most belonged to joint/extended families (55.6%) and had fathers with education below secondary level (55.6%) and mothers with education below secondary level (77.8%). A majority of fathers were engaged in unskilled work or labour (66.7%), and most children were either undernourished or obese (66.7%). Socioeconomically, the largest proportion belonged to Class I–II (33.3%).

Table 1. Socio-demographic characteristics of study participants having VAD ($n = 9$)

Variable	Category	n	%
Age group	7–10 years	7	77.8
	11–14 years	2	22.2
Sex	Male	5	55.6
	Female	4	44.4
Family type	Nuclear	4	44.4
	Joint/extended	5	55.6
Socioeconomic class (BG Prasad)	Class I–II	3	33.3
	Class III	2	22.2
	Class IV	2	22.2
	Class V	2	22.2

Fathers' education	Secondary and above	4	44.4
	Below secondary	5	55.6
Maternal education	Secondary and above	2	22.2
	Below secondary	7	77.8
Father occupation	Unskilled/ labourer	6	66.7
	Skilled/Govt. Job	3	33.3
Nutritional status	Normal	3	33.3
	Undernourished/Obese	6	66.7

Among 9 children with vitamin A deficiency, Bitot spots were the most common manifestation observed in 8 (88.9%). Corneal xerosis/ulceration/keratomalacia was observed in one child (11.1%). No cases of night blindness or conjunctival xerosis were reported.

Table 2. Clinical profile of vitamin A deficiency (n = 9)

Parameter	n	%
Night blindness (XN)	0	0
Conjunctival xerosis (X1A)	0	0
Bitot spots (X1B)	8	88.9
Corneal xerosis/ulceration/keratomalacia (X2/X3)	1	11.1

VAD was statistically significant with maternal education and nutritional status. Children whose mothers had education below secondary level and those who were undernourished/obese had a significantly higher prevalence of VAD ($p < 0.05$). No significant association was observed with age, sex, socioeconomic status, father's education, or father's occupation. (Table 3).

Table 3. Association of vitamin A deficiency with socio-demographic factors (VAD present = 9, VAD absent = 491, total participants=500)(Fisher's exact test).

Variable	Category	VAD present n/N (%)	VAD absent n/N (%)	p value*
Age group	7–10 years	7/259 (2.7)	252/259 (97.3)	0.178
	11–14 years	2/241 (0.8)	239/241 (99.2)	
Sex	Male	5/278 (1.8)	273/278 (98.2)	1.000
	Female	4/222 (1.8)	218/222 (98.2)	
Socioeconomic status	Class I–III	5/404 (1.2)	399/404 (98.8)	0.074
	Class IV–V	4/96 (4.2)	92/96 (95.8)	
Maternal education	Secondary and above	2/320 (0.6)	318/320 (99.4)	0.013
	Below secondary	7/180 (3.9)	173/180 (96.1)	
Father's education	Secondary and above	4/291 (1.4)	287/291 (98.6)	0.501
	Below secondary	5/209 (2.4)	204/209 (97.6)	
Father occupation	Unskilled/labourer	6/187 (3.2)	181/187 (96.8)	0.085
	Skilled/Govt. job	3/313 (1.0)	310/313 (99.0)	
Nutritional status	Normal	3/395 (0.8)	392/395 (99.2)	0.004
	Undernourished/Obese	6/105 (5.7)	99/105 (94.3)	

*P values calculated using Fisher's exact test because of the small number of VAD cases (n = 9). Vitamin A deficiency was significantly associated with low consumption of green leafy vegetables ($p=0.047$), low intake of yellow/orange fruits ($p=0.039$), recent diarrhoea ($p=0.012$), and history

suggestive of measles ($p=0.020$). No significant association was observed with milk intake, non-vegetarian intake, or deworming status ($p>0.05$). (Table 4).

Table 4. Association of vitamin A deficiency with nutritional and morbidity-related factors (n = 9)(Fisher's exact test).

Variable	Category	VAD present n/N (%)	VAD absent n/N (%)	p value
Green leafy vegetables	<3 times/week	7/220 (3.2)	213/220 (96.8)	0.047
	≥ 3 times/week	2/280 (0.7)	278/280 (99.3)	
Yellow/orange fruits	<2 times/week	7/210 (3.3)	203/210 (96.7)	0.039
	≥ 2 times/week	2/290 (0.7)	288/290 (99.3)	
Milk intake	<5 days/week	7/230 (3.0)	223/230 (97.0)	0.087
	≥ 5 days/week	2/270 (0.7)	268/270 (99.3)	
Non-Vegetarian intake	<1 time/week	6/180 (3.3)	174/180 (96.7)	0.077
	≥ 1 time/week	3/320 (0.9)	317/320 (99.1)	
Recent diarrhoea (past 3 months)	Yes	5/90 (5.6)	85/90 (94.4)	0.012
	No	4/410 (1.0)	406/410 (99.0)	
History suggestive of measles (past year)	Yes	3/35 (8.6)	32/35 (91.4)	0.020
	No	6/465 (1.3)	459/465 (98.7)	
Deworming in past 6 months	Yes	3/200 (1.5)	197/200 (98.5)	0.747
	No	6/300 (2.0)	294/300 (98.0)	

*P values calculated using Fisher's exact test (two-sided).

In univariate analysis using Fisher's exact test, maternal education, nutritional status, green leafy vegetable intake, yellow/orange fruit intake, recent diarrhoea, and history suggestive of measles were significantly associated with vitamin A deficiency ($p<0.05$), whereas age, sex, socioeconomic status, father's education, father's occupation, milk intake, non-vegetarian intake, and deworming status showed no significant association ($p>0.05$).

In multivariable analysis using Firth's penalized logistic regression, maternal education below secondary level, undernutrition/obesity, recent diarrhoea, and history suggestive of measles remained independent predictors of vitamin A deficiency ($p<0.05$). Although low consumption of green leafy vegetables and yellow/orange fruits was significant in univariate analysis, these associations lost statistical significance after adjustment.

Table 5. Univariate and multivariable (Firth's penalized logistic regression) analysis of factors associated with vitamin A deficiency among school-going children (n = 500)

Variable	Category	Crude OR (95% CI)	Adjusted OR (95% CI)	p value
Maternal education	Secondary and above (Ref)	1.00	1.00	—
	Below secondary	6.43 (1.32–31.21)	4.18 (1.09–16.08)	0.037
Nutritional status	Normal (Ref)	1.00	1.00	—
	Undernourished/Obese	7.92 (1.83–34.24)	5.74 (1.44–22.91)	0.013
Green leafy vegetable intake	≥ 3 times/week (Ref)	1.00	1.00	—
	<3 times/week	4.57 (1.01–20.71)	2.86 (0.74–11.09)	0.127

Yellow/orange fruit intake	≥ 2 times/week (Ref)	1.00	1.00	–
	<2 times/week	4.98 (1.09–22.69)	3.31 (0.85–12.90)	0.083
Recent diarrhoea	No (Ref)	1.00	1.00	–
	Yes	5.97 (1.54–23.18)	4.69 (1.20–18.27)	0.026
History suggestive of measles	No (Ref)	1.00	1.00	–
	Yes	7.17 (1.65–31.10)	4.21 (1.01–17.54)	0.049

Note: Univariate associations were evaluated using Fisher's exact test. Adjusted odds ratios were estimated using Firth's penalized logistic regression because of the small number of vitamin A deficiency cases (n=9)

Discussion

The study revealed that the prevalence of vitamin A deficiency in a sample of 500 children in the age group 7-14 in a school setting was 1.8%. This prevalence is considerably more modest than the 21.4% biochemical VAD reported among the attendees to tertiary care in another study and also lower than the national Community Nutrition Network System (CNNS) estimate of 18-22% for school-age children. To summarise, the school-going community population in rural central India may be better endowed with vitamin A than either those attending tertiary care or those tested by serum retinol surveys. Notwithstanding, the study of Bitot spots (88.9% of VAD cases) and corneal xerosis/ulceration/keratomalacia (11.1%) shows that low prevalence can still show public health significance when severe disease is present.[3,6,8].

The clinical spectrum observed in this study is different from that seen in tertiary care settings. The present study revealed that Bitot spots were the most common manifestation (88.9%), and night blindness and conjunctival xerosis were not found. Only 11.1% had any corneal involvement. In contrast to the tertiary care-based study in which biochemical deficiency was more common than ocular disease, Bitot spots were found in only 4.1% of children overall. The discrepancy is probably due to the fact that community school surveys capture children with more severe ocular signs, while children with subclinical deficiency are over-represented at tertiary care settings due to referral patterns.[5].

The predominance of Bitot spots over night blindness and conjunctival xerosis in this study were akin to earlier Indian school surveys from Jodhpur as Bitot spots were also a significant component of xerophthalmia. WHO information indicates that the existence of Bitot spots indicates a later stage of conjunctival xerosis, although this condition can still be reversed through vitamin A supplementation. In contrast, the presence of corneal disease is irreversible and life-threatening. In our study, the fact that 11.1% of deficient children have corneal involvement is worrisome as it indicates that some children already have sight-threatening disease which needs prompt therapy.[3,9]

Maternal education was one of the strongest independent predictors of VAD. Children of mothers educated below secondary level had more than four times the odds of having VAD compared with children of mothers educated to secondary level or higher (AOR 4.18, 95% CI 1.09–16.08). This finding corroborates the data from urban slums in Pune where an illiterate mother was found to be a very strong independent risk factor for xerophthalmia (OR 15.4, 95% CI 4.4–64.1). The report indicated that illiterate mothers in Madhya Pradesh were significantly associated with higher prevalence of Bitot spot. Maternal schooling has an impact on the dietary diversity of the child, health-seeking behaviour, adherence to supplementation programmes and overall quality of care which mediates risk of micronutrient deficiency.[11,12,13].

Both undernutrition/obesity was also independently and significantly associated with being VAD (AOR 5.74 95% CI 1.44–22.91). Which means children who were undernourished or obese had nearly six times higher odds of VAD compared with normally nourished children. The relationship between protein-energy malnutrition and vitamin A deficiency is biologically plausible because protein-energy malnutrition can impair the synthesis of retinol-binding protein, reduce hepatic storage of vitamin A, and depress overall dietary intake[12]. Studies conducted in India's communities and

hospitals have widely reported VAD and undernutrition to co-occur. Notably, in this study undernutrition and obesity were clustered together inside the same group indicating that abnormal nutritional status in both directions can be associated with VAD. [1,5,13,14,]

Infection associations were also common. Independent predictors of vitamin A deficiency were recent diarrheal illness (AOR 4.69, 95% CI 1.20–18.27) and history suggestive of measles (AOR 4.21, 95% CI 1.01–17.54). The explanations for both relations are mechanistically sound. Diarrhea interferes with vitamin A absorption while increasing the excretion rate in urine.[1,15] Measles has been shown to cause acute depletion of vitamin A stores in the liver and from India and other developing countries, the occurrence of frank xerophthalmia after measles has been recorded. The findings related to infection is consistent with some of the earlier studies from India which had identified the histories of diarrhoea and measles as important antecedent risk factors for xerophthalmia. [1,2,3,10,14]

Nutrition influenced point prevalence rates. In a Univariate analysis, low consumption of green leafy vegetables ($p=0.047$) and yellow/orange fruits ($p=0.039$) was significantly associated with VAD. These findings fit well within the general evidence base that diets deficient in pro-vitamin A carotenoids and preformed retinol are the main cause for deficiency in Indian children.[1,14] The regression analysis of Central India Children Eye Study also indicated that the low consumption of green leafy vegetables was indicative of xerophthalmia. However, these associations became non-significant after adjustment in our multivariable analysis which suggests that maternal education and nutritional status are stronger confounders that explain much of the dietary effect.[2,5,8].

In contrast to the tertiary care-based research where factors like rural residence, lower socio-economic class and maternal education were all significantly associated with VAD, from this school-based study only maternal education and nutritional status remained significant after adjustment. The analysis suggests that VAD has no significant association with socioeconomic status, father's education and father's occupation. This may be due to the fact that in the population of rural government schools, the socioeconomic variation is lesser than that in mixed urban-rural population of tertiary care settings and maternal education becomes a more particular marker of household disadvantage.[10,15]

In this study, sex was not a statistically significant predictor for VAD and is in agreement with some earlier surveys including the Aligarh study[12]. Nevertheless, marginally higher prevalence of night blindness in boys has been reported in certain Indian studies, which may be due to sex-linked phenomena such as different dietary patterns or food allocation in households. The Central India Children Eye Study found male sex to be inversely related to xerophthalmia in regression analysis.[8] This study that reported a low prevalence of 1.8% better than the biochemical prevalence of 21.4% among those attending the tertiary level of care and the national CNNS estimate of 18–22% could mean that screening in a rural government school rather identified children with more severe ocular disease and not subclinical cases.[8] The present findings support the continued implementation of school health programmes with ocular examination for early detection of Bitot spots and corneal disease and nutrition programme focusing on maternal education and child nutritional status.

The study is strengthened by the large sample size of 500 children, school-based sampling from rural government school, collection of extensive socio-demographic, dietary and morbidity data, and multivariable Firth's penalized logistic regression to deal with small number of VAD cases.

Study limitations included a relatively small sample size for VAD ($n=9$), limiting the statistical power and precision of the calculated odds ratios. The cross-sectional design also precludes causal inference. Furthermore, vitamin A status assessment was clinical (as opposed to biochemical), which may underestimate the true rate of subclinical deficiency.

The findings of the study are clinically relevant, despite these limitations, because they show that, in a population with low overall prevalence, severe ocular manifestations of VAD do in fact still occur and that maternal education, nutritional status, and recent infections are essential determinants that must be tackled through integrated nutrition and health programmes. The findings further emphasize the importance of expanding nutritional monitoring and action plans in accordance with school-age children of disadvantaged rural segments to enhance overall health and nutrition.

Conclusion

Vitamin A deficiency was present in 1.8% of school-going children from rural government schools. Although the prevalence was low, severe ocular manifestations such as Bitot spots and corneal disease were observed. Maternal education below secondary level, undernutrition/obesity, recent diarrhea, and history suggestive of measles were independent predictors of VAD. These findings underscore the need to extend nutritional screening, dietary counselling, community education, deworming, and targeted micronutrient strategies to school-age children in this region of central India.

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