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Prevalence of Vitamin A Deficiency in Children Aged 6 Months to 5 Years with Pneumonia: A Cross-Sectional Study

Rishita Sharma[1], Shailendra Kumar Gautam[2], Arun Kumar Arya[3], Santosh Kumar Barman[4], Yogendra Narayan Verma[5], Navin Kumar[6], Seema Barman[7]

[1]Junior Resident, Department of Paediatrics, GSVM Medical College, Kanpur, Uttar Pradesh
[2,3]Professor, Department of Paediatrics, GSVM Medical College, Kanpur, Uttar Pradesh
[4]Professor, Department of Community Medicine, GSVM Medical College, Kanpur, Uttar Pradesh
[5] Associate Professor, Department of Pathology, GSVM Medical College, Kanpur, Uttar Pradesh
[6]Statistician Cum Assistant Professor, Department of Community Medicine, UNS ASMC, Jaunpur, Uttar Pradesh
[7]Assistant Professor, Department of Forensic Medicine, Government Medical College, Kannauj, Uttar Pradesh

Corresponding Author: Dr. Navin Kumar

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ABSTRACT

Background: Vitamin A plays an important role in maintaining epithelial integrity and supporting immune function. However, serum retinol concentrations may decrease transiently during acute infection and inflammation. This study assessed the prevalence of low serum retinol and its association with pneumonia severity among children aged 6 months to 5 years.
Methods: This hospital-based cross-sectional study was conducted among 70 children aged 6 months to 5 years with clinically and radiologically diagnosed pneumonia admitted to a tertiary-care teaching hospital in Kanpur, India, between June 2024 and February 2026. Serum retinol was measured at admission using an enzyme-linked immunosorbent assay and categorized as normal (≥20 µg/dL), low (10 to <20 µg/dL), or severely low (<10 µg/dL). Pneumonia severity was classified according to World Health Organization criteria. Associations between serum retinol status and pneumonia severity were assessed using Fisher's exact test and odds ratios (ORs) with 95% confidence intervals (CIs). Pearson's correlation was used to assess relationships between serum retinol concentration and clinical severity indicators. Multivariable logistic regression was performed to identify factors independently associated with severe pneumonia.
Results: Among 70 children, 51 (72.9%) had serum retinol concentrations below 20 µg/dL, including 19 (27.1%) with severely low concentrations. Severe pneumonia was present in 32 (45.7%) children. Severe pneumonia occurred in 28/51 (54.9%) children with low serum retinol compared with 4/19 (21.1%) with normal serum retinol (OR=4.57; 95% CI: 1.33–15.67;

p=0.015). In multivariable analysis, low serum retinol (adjusted OR [AOR]=3.92; 95% CI: 1.18–13.01; p=0.025), moderate/severe malnutrition (AOR=2.61; 95% CI: 1.01–6.74; p=0.047), and absence of previous vitamin A supplementation (AOR=3.36; 95% CI: 1.22–9.24; p=0.018) were independently associated with severe pneumonia. Lower serum retinol was correlated with higher respiratory rate and longer hospital stay, and positively correlated with oxygen saturation.

Conclusion: Low serum retinol was common among children hospitalized with pneumonia and was associated with severe disease. Because serum retinol was measured during acute infection, these findings do not establish chronic vitamin A deficiency, temporality, or causality. Larger prospective studies incorporating inflammatory biomarkers and convalescent retinol measurements are warranted.

Keywords: Vitamin A; Serum Retinol; Pneumonia; Child; Malnutrition; Cross-Sectional Studies

INTRODUCTION

Pneumonia is the leading infectious cause of death in children under five years of age, surpassing malaria, measles, and HIV/AIDS combined, and is responsible for an estimated 700,000–750,000 deaths globally each year. [1,2] South Asia and sub-Saharan Africa bear more than two-thirds of this burden, with India alone contributing nearly one-fifth of global paediatric pneumonia cases. [3,4] Within this age group, children between 6 months and 5 years are at heightened vulnerability due to waning maternal immunity, immature immune systems, and increased exposure to environmental pathogens.

Vitamin A- a fat-soluble micronutrient essential for epithelial differentiation, mucosal barrier integrity, and both innate and adaptive immunity—has been recognized as a critical determinant of host resistance to respiratory infections. [5,6] Vitamin A plays an important role in maintaining epithelial and mucosal integrity and in regulating both innate and adaptive immune responses, thereby contributing to host defense against infectious diseases. [11] Vitamin A deficiency (VAD) impairs the structural integrity of the respiratory epithelium by promoting squamous metaplasia, reducing mucin secretion, and delaying epithelial repair. [7] Immunologically, VAD diminishes IgA class switching in mucosal tissues, curtails $CD8^+$ cytotoxic T-cell responses, and dysregulates cytokine production—collectively increasing susceptibility to severe and prolonged pneumonia episodes. [8,9]

National surveys in India have reported approximately 62% of preschool children with serum retinol below 0.70µmol/L, indicating widespread subclinical VAD. [10] Despite long-standing national supplementation programs, deficiency persists and may silently potentiate severe outcomes in hospitalized children. Contemporary, region-specific data on the burden of VAD among children presenting with pneumonia remain limited, restricting evidence-based integration of nutritional assessment into pneumonia management protocols.

The present study was therefore conducted to determine the prevalence of VAD in children aged 6months to 5 years admitted with pneumonia at a tertiary care teaching hospital in northern India, and to evaluate the association between vitamin A status and clinical severity of pneumonia.

MATERIALS AND METHODS

Study Design and Setting: A hospital-based, cross-sectional observational study was conducted at the Department of Paediatrics, GSVM Medical College and the affiliated Lala Lajpat Rai (LLR) Hospital, Kanpur, Uttar Pradesh, India, from June 2024 to February 2026 (20 months). The hospital is a major tertiary referral centre for Kanpur Nagar district (population approximately 4.58 million) and surrounding

regions, managing a high volume of paediatric respiratory admissions.

Sample Size and Participants Using the formula $n=4pq/d^2$, with a reference prevalence (p) of 20%, margin of error (d) of 10%, and q= 80%, and 10% non-response error the estimated sample size was 70. Consecutive children fulfilling eligibility criteria were enrolled.

Inclusion criteria:
(i) Age 6 months to 5 years.
(ii) Diagnosis of pneumonia based on WHO/IMNCI guidelines confirmed clinically (tachypnea, chest in drawing, crepitations, reduced air entry) and radiologically (lobar, bronchopneumonia, or interstitial pattern on chest X-ray).
(iii) Written informed consent from parent or guardian.

Exclusion criteria: infections involving non-respiratory systems; congenital heart or structural lung disease; autoimmune conditions; prior surgery; bronchiolitis or tuberculosis; chronic diarrhoea; here dietary metabolic or immune deficiencies; long-term immune suppressive therapy.

Clinical Assessment:
A structured proforma was used to record demographic characteristics, socio-economic status (Modified BG Prasad Scale), residential background, immunisation and vitamin A supplementation history, anthropometric measurements (weight, height/length, MUAC), and detailed clinical examination. Pneumonia severity was classified per the 2014 WHO revised classification: Pneumonia (fast breathing: ≥50 breaths/min for 2–12 months; ≥40 for 1–5 years; and/or chest in drawing) vs. Severe Pneumonia (general danger signs: unable to drink/feed, persistent vomiting, convulsions, cyanosis, lethargy, unconsciousness, stridor in calm child, severe malnutrition).

Vitamin A Assessment:
Venous blood samples were collected at admission under aseptic conditions. Serum vitamin A was measured using the Merilyzer EIA Quant ELISA-based assay. Serum retinol concentrations were classified according to WHO criteria as normal (≥20 µg/dL; ≥0.70 µmol/L), low (10 to <20 µg/dL; 0.35 to <0.70 µmol/L), and severely low (<10 µg/dL; <0.35 µmol/L) [15]. Because serum retinol was measured during acute pneumonia, the term "low serum retinol" was used instead of definitive vitamin A deficiency, as acute inflammation may transiently reduce circulating retinol concentrations.

Statistical Analysis

Data were entered and analyzed using Microsoft Excel. Continuous variables were summarized as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. The association between serum retinol status and pneumonia severity was assessed using Fisher's exact test, as appropriate for the categorical data, and the strength of association was expressed as odds ratios (ORs) with 95% confidence intervals (CIs). The relationship between serum retinol concentration and continuous clinical severity indicators, including respiratory rate, oxygen saturation (SpO_2), and duration of hospital stay, was assessed using Pearson's correlation coefficient (r). A multivariable binary logistic regression analysis was performed to identify factors independently associated with severe pneumonia. The results of the regression analysis were expressed as adjusted odds ratios (AORs) with 95% CIs and corresponding p-values. All statistical tests were two-sided, and a p-value <0.05 was considered statistically significant.

Ethical Considerations:
The study was approved by the Institutional Ethics Committee of GSVM Medical College, Kanpur, Uttar Pradesh, India (Approval No.: [Ref. No. EC / 425/

nov/2024], dated [04.11.2024]) and adhered to the Declaration of Helsinki (2000). Written informed consent was obtained from each participant's parent or guardian prior to enrolment.

RESULTS

A total of 70 children 41 males (58.6%), 29 females (41.4%) were enrolled. Age distribution is presented in Table 1. The majority (45.7%) belonged to the 13–36 months group—a developmentally critical period of immune maturation. Most children were from rural areas (61.4%) and from lower socioeconomic strata (upper-lower 37.1%, upper-middle 34.3%). Nutritional assessment revealed moderate acute malnutrition (MAM) in 54.3% and severe acute malnutrition (SAM) in 17.1%; only 28.6% were adequately nourished. History of previous chest infection or diarrhea was present in 32.9% of cases.

Table 1: Distribution of Study Participants by Age Group

Age group (in years)	Frequency	Percentage
6-12 months	18	25.7
13-36 months	32	45.7
37-60 months	20	28.6

Prevalence of Vitamin A Deficiency

Vitamin A status data are shown in Table 2. Of the 70 children, 32 (45.7%) had subclinical VAD and 19 (27.2%) had severe VAD. Only 19 children (27.1%) had normal serum vitamin A. The overall prevalence of VAD (combining subclinical and severe) was 72.9%, indicating a substantial micronutrient burden in this population.

Table 2: Prevalence of Vitamin A Deficiency Among Study Participants

Serum retinol category	Definition	Frequency	Percentage
Normal	≥20 µg/dL (≥0.70 µmol/L)	19	27.1
Low	10 to <20 µg/dL (0.35 to <0.70 µmol/L)	32	45.7
Severely low	<10 µg/dL (<0.35 µmol/L)	19	27.1

Association Between Vitamin A Status and Pneumonia Severity

Among the 70 children, 38 (54.3%) had pneumonia and 32 (45.7%) had severe pneumonia. Table 3 presents the association between vitamin A status and pneumonia severity. Among the 51 children with serum retinol below 20 µg/dL, 28 (54.9%) had severe pneumonia, compared with 4 of the 19 children (21.1%) with normal serum retinol. Fisher's exact test demonstrated a statistically significant association between low serum retinol and severe pneumonia ($p = 0.015$). Children with low serum retinol had higher unadjusted odds of severe pneumonia than children with normal serum retinol (OR = 4.57; 95% CI: 1.33–15.67).

Table 3: Association Between Vitamin A Deficiency and Pneumonia Severity

Serum retinol status	Pneumonia, n (%)	Severe pneumonia, n (%)	OR (95% CI)	p-value
Low, <20 µg/dL	23 (45.1)	28 (54.9)	4.57 (1.33–15.67)	0.015
Normal, ≥20 µg/dL	15 (78.9)	4 (21.1)	Reference	—

Correlation Between Serum Vitamin A and Clinical Severity Indicators

Correlation analysis (Table 4) demonstrated that lower serum Vitamin A levels were significantly associated with higher respiratory rates ($r=-0.41$, $p=0.002$), lower oxygen saturation ($r=+0.38$, $p=0.004$), and longer duration of hospital stay ($r = -0.29$, $p = 0.030$), collectively reflecting greater clinical severity.

Table 4: Correlation Between Serum Vitamin A Level and Clinical Severity Indicators

Clinical Parameter	Correlation (r)	p-value	Direction
Respiratory rate	-0.41	0.002	Negative
SpO_2	+0.38	0.004	Positive
Duration of hospital stay	-0.29	0.030	Negative

Multivariable Logistic Regression

After adjustment for the variables included in the multivariable logistic regression model, low serum retinol was associated with higher adjusted odds of severe pneumonia (AOR = 3.92; 95% CI: 1.18–13.01; p = 0.025). Moderate/severe malnutrition (AOR = 2.61; 95% CI: 1.01–6.74; p = 0.047) and absence of previous vitamin A supplementation (AOR = 3.36; 95% CI: 1.22–9.24; p = 0.018) were also associated with severe pneumonia. Age (AOR = 1.74; 95% CI: 0.61–4.98; p = 0.290) and male sex (AOR = 1.28; 95% CI: 0.48–3.44; p = 0.620) were not statistically significantly associated with severe pneumonia in the adjusted analysis. Because only 32 children had severe pneumonia, the adjusted estimates should be interpreted cautiously.

Table 5. Multivariable Logistic Regression Analysis of Factors Associated with Severe Pneumonia

Predictor	AOR	95% CI	p-value
Low serum retinol (<20 µg/dL)	3.92	1.18–13.01	0.025
Moderate/severe malnutrition	2.61	1.01–6.74	0.047
No previous vitamin A supplementation	3.36	1.22–9.24	0.018
Age	1.74	0.61–4.98	0.290
Male sex	1.28	0.48–3.44	0.620

DISCUSSION

51 of the 70 children (72.9%) hospitalized with pneumonia had a serum retinol level below 20µg/dl, with 27.1% of them having a level below 10µg/dl. The age group of most participants (13-36 months) is one that is vulnerable to respiratory infections, due to maturing immune systems, transition to complementary feeding, and heightened environmental exposure. However, the cross-sectional design of the present study does not allow for establishing a temporal or causal relationship between low serum retinol and pneumonia severity, since the study does not focus on the cause of pneumonia and vitamin A deficiency [5]. The incidence of severe pneumonia was 28/51 children with low serum retinol vs. 4/19 with normal serum retinol. The Fisher's exact test also revealed a strong, statistically significant association of low serum retinol with severe pneumonia (p = 0.015), with an unadjusted odds ratio of 4.57 (95% CI: 1.33 – 15.67). After controlling for the variables in the multivariable analysis, severe pneumonia was associated with low retinol level (AOR = 3.92; 95% CI: 1.18–13.01; p = 0.025). Moderate/severe malnutrition (AOR = 2.61; 95% CI: 1.01–6.74; p = 0.047) and absence of previous vitamin A supplementation (AOR = 3.36; 95% CI: 1.22–9.24; p = 0.018) were also associated with severe pneumonia [6]. The adjusted estimates are thus somewhat prone to caution, as the number of outcome events (32 children with severe pneumonia) was small in relation to the number of predictor variables in the model (a large number), which might result in unstable estimates and wide confidence intervals. There was a negative correlation between serum retinol and respiratory rate (r = −0.41; p = 0.002) and length of hospital stay (r = −0.29; p = 0.030); and a positive correlation between serum retinol and oxygen saturation (r = 0.38; p = 0.004), so that lower serum retinol at admission was associated with worse clinical indicators. The relationship between lack of past vitamin A supplementation and severity of pneumonia could be a reflection of variation in dietary habits, access to health care, socioeconomic factors, or compliance with child-health programmes. [14] Evidence from southern India has also shown that

regular vitamin A supplementation can reduce childhood mortality in populations where vitamin A deficiency and undernutrition are prevalent; however, these findings concern mortality outcomes and do not establish that previous supplementation prevents severe pneumonia in the present observational study. [13] This should not be considered as evidence that supplementation prevented severe pneumonia, as supplementation was not randomized and the amount, frequency, effectiveness, and completeness of supplementation were not evaluated separately [7]. Care must be taken in the interpretation of the present study as it is cross-sectional, has a small sample size, has not included a healthy comparison group, has large confidence intervals, and has the potential for model instability of the multivariable model in the present study. No evaluation of inflammatory markers (serum C-reactive protein, serum α1-acid glycoprotein) was performed, and serum retinol was only measured in the acute phase of pneumonia. Acute respiratory infections may adversely affect the improvement of serum vitamin A status, supporting the possibility that low serum retinol observed during acute illness may partly reflect the acute-phase response rather than pre-existing chronic vitamin A deficiency. [12] The dietary intakes of vitamin A were not available, nor were convalescent serum retinol concentrations. Thus, in this study, it was not possible to determine whether low serum retinol was a preceding factor of severe pneumonia, or if the low retinol level was a part of the acute phase response. Future prospective studies of children in multiple centres are warranted to consider inflammatory markers in addition to detailed dietary assessment, supplement history and repeated measurement of serum retinol after clinical recovery; such studies will be able to measure the potential for persistently low vitamin A status to be a risk factor for severity of pneumonia and outcomes.

CONCLUSION

Severe pneumonia was associated with low serum retinol at admission for children hospitalised with pneumonia, 6 months to 5 years of age, both in the unadjusted and adjusted analysis. The results of this study in turn cannot rule out chronic vitamin A deficiency, suggest temporal relationships, or imply causality, since serum retinol was measured during acute infection and the study had a cross-sectional design. It should therefore be interpreted with some caution when considering inflammation and nutritional status, as this will affect the results of serum retinol. Multicentre prospective studies with inflammatory biomarker, confirmed history of supplementation and convalescent serum retinol measurements are needed in the future to better elucidate the relationship between vitamin A deficiency and severity of pneumonia.

Authors' Contributions: RS conceptualised and conducted the study, collected the data, and drafted the manuscript. SKG provided overall guidance and supervision. AKA, PS, SK, and YNV contributed to co-supervision, methodological review, and manuscript revision. All authors read and approved the final manuscript.

Declaration

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