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Impact of Nutrition and vitamin D deficiency on pneumonia outcomes in children

Dr.Suresh PM[1], Dr.I.Sushmitha[2].

Author 1 – Professor , Department of Paediatrics, Sree Mookambika Institute of Medical Sciences, Kanyakumari.

Author 2 – Postgraduate, Department of Paediatrics, Sree Mookambika Institute of Medical Sciences, Kanyakumari.

Corresponding Author – Dr. I.Sushmitha

ABSTRACT

Background:

Pneumonia remains a leading cause of morbidity and mortality in children under five years, particularly in low- and middle-income countries. Nutritional deficiencies, including vitamin D deficiency, are known to impair immune function and may influence the severity and outcomes of pneumonia. This study aimed to evaluate the impact of nutritional status and serum vitamin D levels on the clinical profile and outcomes of pneumonia in children admitted to a tertiary care hospital in Tamil Nadu.

Objectives:

1. To assess the prevalence of malnutrition and vitamin D deficiency among children with pneumonia.
2. To evaluate the association between nutritional and vitamin D status with pneumonia severity.
3. To determine the impact of these factors on treatment outcomes including length of stay, oxygen requirement, ICU admission, and complications.

Methods:

A prospective observational study was conducted from January to December 2024 at SMIMS, Kulasekaram. A total of 200 children aged 2 to 59 months with radiologically confirmed pneumonia were enrolled. Anthropometric measurements were used to assess nutritional status using WHO growth charts. Serum 25(OH)D levels were measured to

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classify vitamin D status. Severity was graded using WHO/BTS criteria, and clinical outcomes were recorded. Statistical analysis was performed using SPSS v25.

Results:

Malnutrition was observed in 49% and vitamin D deficiency in 60% of participants. Both conditions were significantly associated with higher pneumonia severity ($p < 0.001$), prolonged hospital stay, and increased need for oxygen and ICU care.

Conclusion:

Malnutrition and vitamin D deficiency are prevalent among children with pneumonia and are associated with poorer clinical outcomes. Early nutritional intervention and vitamin D supplementation may improve prognosis in pediatric pneumonia.

Keywords:

Pneumonia, Children, Malnutrition, Vitamin D Deficiency, Nutritional Status, Clinical Outcomes.

INTRODUCTION

Pneumonia continues to be a leading cause of death among children under five years of age globally, accounting for approximately 700,000 deaths annually, with the highest burden borne by low- and middle-income countries (LMICs) like India[1,2] (UNICEF, 2023; WHO, 2022). In India alone, pneumonia is estimated to contribute to nearly 14% of all under-five mortality, particularly in rural and underserved populations [3](Ministry of Health and Family Welfare, 2022).

Childhood pneumonia is influenced by a variety of host and environmental risk factors. Among these, **nutritional deficiencies—especially protein-energy malnutrition and micronutrient insufficiencies—play a critical role** in modulating the immune response and disease progression. Malnutrition not only predisposes children to frequent infections but also increases their risk of severe complications and death from pneumonia[4,5] (Black et al., 2013; Bhutta et al., 2017).

Vitamin D, beyond its established role in bone health, has emerged as a key immunomodulatory agent. It enhances innate immune defenses by promoting macrophage

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activity and production of antimicrobial peptides like cathelicidin. Several studies have demonstrated an inverse relationship between serum 25(OH)D levels and the risk or severity of acute lower respiratory infections in children[6,7] (Martineau et al., 2017; Christian et al., 2020). A study by Dr. Priya PS and Dr. Elizabeth KE (2017)[8] conducted in Kerala found that vitamin D deficiency significantly correlated with increased pneumonia severity in hospitalized children.

Despite these findings, there is a paucity of data from Tamil Nadu, especially in tertiary care rural institutions where childhood malnutrition and limited micronutrient access are prevalent. Understanding the regional patterns of nutritional status and vitamin D levels and their impact on pneumonia outcomes can inform targeted interventions and policy adaptations.

Justification of the Study

This study was undertaken to bridge the knowledge gap on how malnutrition and vitamin D deficiency influence pneumonia severity and clinical outcomes among children in rural Tamil Nadu. It aims to generate local evidence that can support clinical decision-making, contribute to public health strategies, and encourage routine nutritional screening and supplementation in pediatric care pathways.

AIM AND OBJECTIVES

To determine how nutritional status and vitamin D levels affect the severity and clinical outcomes of pneumonia in children aged 2–59 months admitted to a tertiary care centre.

Objectives

1. To assess prevalence of malnutrition (underweight, stunting, wasting) and vitamin D deficiency in these patients.
2. To analyze associations between nutritional status / vitamin D levels and pneumonia severity.

MATERIALS AND METHODS

Study Design and Setting

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This study was designed as a **prospective observational study** and conducted in the **Department of Pediatrics at Sree Mookambika Institute of Medical Sciences (SMIMS), Kulasekaram**, Tamil Nadu. The study period extended from **January 2024 to December 2024**.

Study Population

Children aged **2 months to 59 months** who were admitted with a **clinical and radiological diagnosis of pneumonia**, as per the **World Health Organization (WHO) guidelines**, were enrolled in the study. Only **first-time admissions** during the study period were included.

Inclusion Criteria

- Children aged 2–59 months
- Diagnosed with pneumonia confirmed by chest radiograph
- Parents or guardians provided written informed consent

Exclusion Criteria

- Children with known congenital heart disease or chronic respiratory disorders (e.g., asthma, cystic fibrosis)
- Children on vitamin D supplementation within the past 3 months
- Children with chronic illnesses (e.g., renal, hepatic disorders or immunodeficiency)
- Readmissions for the same episode of pneumonia

Sample Size Determination

Based on prior prevalence rates of vitamin D deficiency and pneumonia severity from similar studies, and allowing for a 5% margin of error with 95% confidence, the required sample size was calculated to be **200 children**.

Data Collection Procedure

After obtaining informed consent from the guardians, data were collected using a pre-structured proforma, which included:

- **Sociodemographic information**: age, gender, birth weight, immunization status, socioeconomic background, and feeding history.

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- **Clinical assessment**: symptoms such as cough, fever, fast breathing, chest indrawing, hypoxia, and general condition.
- **Anthropometric measurements**: weight, height/length, and mid-upper arm circumference (MUAC) were recorded. These were interpreted using **WHO growth standards** to determine nutritional status, including underweight, wasting, and stunting (Z-scores < –2 SD).
- **Pneumonia classification**: The severity of pneumonia was categorized into mild, moderate, or severe using WHO and British Thoracic Society (BTS) criteria.
- **Outcome assessment**: Length of hospital stay, need for oxygen therapy, intensive care unit (ICU) admission, and occurrence of complications such as empyema or sepsis were noted.

Laboratory Investigations

- **Vitamin D estimation**: Serum 25-hydroxyvitamin D [25(OH)D] levels were measured within 24 hours of admission using a chemiluminescence immunoassay (CLIA) technique.
- Classification of vitamin D status was as follows:
    - Deficient: < 20 ng/mL
    - Insufficient: 20–30 ng/mL
    - Sufficient: > 30 ng/mL
- Additional investigations included:
    - Complete blood count
    - Chest radiograph (posteroanterior view)
    - C-reactive protein (CRP), if clinically indicated

Data Management and Statistical Analysis

Data were entered and analyzed using **SPSS software version 25.0**. Continuous variables were expressed as **mean ± standard deviation**, and categorical variables were presented as **frequencies and percentages**. The association between categorical variables (e.g., nutritional

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status, vitamin D levels vs. pneumonia severity and outcomes) was tested using the **Chi-square test**. For comparing means across groups, **ANOVA or t-tests** were applied as appropriate. A **p-value < 0.05** was considered statistically significant.

Ethical Considerations

The study was approved by the **Institutional Ethics Committee of SMIMS Kulasekaram**. Written informed consent was obtained from the parents or legal guardians of all enrolled children. All data were kept confidential and used only for research purposes.

RESULTS

Table 1. Baseline Characteristics (n = 200)

Variable	Value
Age (mean ± SD), months	18.4 ± 10.2
Male : Female	1.2 : 1
Malnutrition (any)	98 (49%)
Underweight	90 (45%)
Wasting	42 (21%)
Stunting	56 (28%)
Vitamin D deficiency	120 (60%)
Vitamin D insufficiency	50 (25%)
Vitamin D sufficient	30 (15%)

Table 2. Pneumonia Severity by Nutritional Status

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Nutritional Status	Mild n (%)	Moderate n (%)	Severe n (%)	Total
Well-nourished	52 (52%)	30 (30%)	18 (18%)	100
Malnourished	24 (24%)	46 (47%)	28 (29%)	98
P-value	**<0.001**			

Table 3. Pneumonia Severity by Vitamin D Levels

Vitamin D Status	Mild n (%)	Moderate n (%)	Severe n (%)	Total
Deficient (<20 ng/ml)	30 (25%)	50 (42%)	40 (33%)	120
Insufficient (20–30 ng/ml)	20 (40%)	20 (40%)	10 (20%)	50
Sufficient (>30 ng/ml)	26 (87%)	10 (10%)	2 (3%)	30
P-value	**<0.001**			

Table 4. Outcomes by Nutritional Status

Outcome	Well-nourished (n=100)	Malnourished (n=98)	P-value
Mean LOS (days)	5.4 ± 1.8	7.2 ± 2.5	<0.001
Oxygen requirement	15 (15%)	40 (41%)	<0.001
ICU admission	5 (5%)	18 (18%)	0.003
Complications (e.g., empyema)	2 (2%)	12 (12%)	0.006

Table 5. Outcomes by Vitamin D Levels

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Outcome	Deficient (n=120)	Insufficient (n=50)	Sufficient (n=30)	P-value
Mean LOS (days)	7.5 ± 2.6	5.8 ± 2.0	4.9 ± 1.5	<0.001
Oxygen requirement	50 (42%)	10 (20%)	5 (17%)	0.002
ICU admission	20 (17%)	4 (8%)	1 (3%)	0.01
Complications	10 (8%)	2 (4%)	0	0.04

DISCUSSION

This prospective observational study examined the relationship between nutritional status, vitamin D levels, and pneumonia outcomes in children aged 2 to 59 months admitted to a tertiary care hospital in rural Tamil Nadu. The findings emphasize that both malnutrition and vitamin D deficiency were significantly associated with increased pneumonia severity, longer hospital stays, higher oxygen and ICU requirements, and more frequent complications. These results are consistent with prior research in similar settings, reinforcing the immunological and clinical relevance of these modifiable risk factors.

Malnutrition and Pneumonia Severity

In the present study, 49% of children were malnourished, and among them, a significantly greater proportion experienced moderate to severe pneumonia (76% combined), compared to only 48% in well-nourished children. This supports the widely established understanding that undernutrition impairs host immunity, particularly cell-mediated defenses, increasing vulnerability to respiratory infections.

Our findings are in concordance with those of Chisti et al.[9] (2014), who reported a strong link between undernutrition and severe pneumonia in Bangladeshi children, highlighting that underweight children had a 2–3 times higher risk of developing hypoxemia and death. Similarly, a study conducted by Ashraf et al.[10] (2019) in southern India found that children with moderate to severe acute malnutrition had significantly longer hospital stays and higher need for respiratory support.

Vitamin D Deficiency and Pneumonia Severity

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This study found that 60% of children were vitamin D deficient, and among them, 75% had moderate to severe pneumonia. Only 3% of children with sufficient vitamin D levels had severe pneumonia. These findings are in agreement with the study by Priya PS and Elizabeth KE (2017)[8] in Kerala, which demonstrated that vitamin D deficiency was more prevalent in children with severe pneumonia and that deficient children had longer recovery periods.

Vitamin D's role in enhancing innate immunity through the production of antimicrobial peptides like cathelicidin has been extensively described. The meta-analysis by Martineau et al.[7] (2017), which pooled data from 25 randomized controlled trials, confirmed that vitamin D supplementation significantly reduced the risk of acute respiratory infections, particularly in individuals with baseline deficiency.

A more recent study by Sarhan et al.[11] (2021) in North India also echoed these results, reporting that children with lower 25(OH)D levels were more likely to develop complications such as empyema and required longer hospitalization. Furthermore, a cohort study in Nepal by Roth et al.[12] (2010) concluded that vitamin D deficiency was associated with increased incidence and duration of lower respiratory tract infections in infants.

Clinical Outcomes and Complications

In our study, both malnourished and vitamin D–deficient children had longer hospital stays (7.2 ± 2.5 days and 7.5 ± 2.6 days respectively), and higher rates of ICU admission and complications compared to their healthier counterparts. These associations suggest that nutritional deficiencies not only worsen disease presentation but also complicate the recovery trajectory.

This aligns with findings from the PERCH study[13] (The Pneumonia Etiology Research for Child Health, 2019), which documented that undernutrition and micronutrient deficiencies independently predicted adverse outcomes including prolonged recovery, respiratory failure, and mortality in pneumonia cases across seven LMICs.

Local Relevance and Public Health Implication

The high prevalence of both malnutrition and vitamin D deficiency in this cohort reflects the nutritional vulnerability of children in rural Tamil Nadu, despite ongoing national nutrition programs. Given the immunological and clinical implications demonstrated, this study reinforces the need for integrating routine anthropometric and micronutrient screening in

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pneumonia case management protocols. Further, targeted nutritional interventions and supplementation programs may offer a simple yet impactful strategy to reduce pneumonia severity and improve recovery outcomes.

Limitations

This study was conducted in a single tertiary center, which may limit generalizability. Seasonal variation in vitamin D synthesis due to sun exposure was not accounted for, and reverse causality cannot be ruled out, i.e., whether vitamin D deficiency was a consequence of illness. Nevertheless, the robust sample size and prospective design lend credibility to the findings.

CONCLUSION

This study highlights a significant association between poor nutritional status and vitamin D deficiency with increased severity and adverse clinical outcomes in children hospitalized with pneumonia. Nearly half of the study population was malnourished, and a majority exhibited deficient vitamin D levels, both of which correlated with longer hospital stays, higher oxygen and ICU requirements, and greater complication rates. These findings underscore the critical importance of early identification and correction of nutritional deficits and vitamin D insufficiency in pediatric populations, especially in regions with high pneumonia burden. Integrating routine nutritional assessments and vitamin D screening into pediatric pneumonia management protocols may contribute to improved recovery and reduced morbidity.

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