DOI: https://doi.org/10.54393/pjhs.v7i6.3922

PAKISTAN JOURNAL OF HEALTH SCIENCES
(LAHORE)
https://thejas.com.pk/index.php/pjhs
ISSN (E): 2790-9352, (P): 2790-9344
Volume 7, Issue 06 (June 2026)

Original Article

OPEN ACCESS

Frequency of Pneumonia in Children Presenting with Measles at DHQ Hospital, Dera Ismail Khan

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ARTICLE INFO

Keywords:
Measles, Pneumonia, Pediatric, Vaccination, Malnutrition

How to Cite:
Javed, F., Ibrahim, M., Khan, A. M., Burki, F. U., Ullah, F., & Ullah, I. (2026). Frequency of Pneumonia in Children Presenting with Measles at DHQ Hospital, Dera Ismail Khan: Frequency of Pneumonia in Children Presenting with Measles. Pakistan Journal of Health Sciences, 7(6), 63-68. https://doi.org/10.54393/pjhs.v7i6.3922

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Received Date: 3rd February, 2026
1st Revision Received: 2nd March, 2026
Acceptance Date: 24th March, 2026
Published Date: 30th June, 2026

ABSTRACT

Measles remains a significant cause of pediatric morbidity and mortality worldwide, particularly in low- and middle-income countries. Pneumonia is one of the most frequent and serious complications of measles, contributing substantially to adverse outcomes in affected children. **Objectives:** To determine the frequency of pneumonia among children presenting with measles at DHQ Hospital, Dera Ismail Khan, and to assess associated demographic and clinical factors. **Methods:** This cross-sectional analytical study was conducted in the Department of Pediatrics, District Headquarters Hospital, Dera Ismail Khan, from September 2024 to January 2025. A total of 169 children aged 2–15 years with laboratory-confirmed measles were enrolled using consecutive non-probability sampling. Pneumonia was diagnosed based on clinical findings and radiographic confirmation. Data on age, gender, vaccination status, nutritional status, socioeconomic status, and residence were collected using a structured proforma. Statistical analysis was performed using SPSS version 25.0. Associations were evaluated using chi-square and Fisher's exact tests, and multivariable logistic regression was conducted. **Results:** Among 169 children, 54 (32.0%) developed pneumonia. Pneumonia was significantly associated with malnutrition ($p<0.001$), younger age ($p<0.001$), rural residence ($p=0.028$), and lack of immunization ($p<0.001$). No pneumonia cases were observed among immunized children. **Conclusions:** Pneumonia was observed in approximately one-third of children with measles. Malnutrition, younger age, and non-immunization were associated with higher pneumonia frequency.

INTRODUCTION

Measles remains one of the most contagious viral diseases affecting children worldwide, despite the availability of a safe and effective vaccine for more than five decades. Globally, measles continues to contribute substantially to pediatric morbidity and mortality, particularly in low- and middle-income countries [1]. Recent global estimates indicate approximately 100,000 measles-related deaths annually, with the majority occurring in children under five years of age [2]. The virus is transmitted through respiratory droplets and aerosols and has an exceptionally high basic reproduction number (R_0), with one infected individual capable of transmitting the infection to 12–18 susceptible persons [3]. Although widespread immunization has significantly reduced disease burden in many regions, suboptimal vaccination coverage, population displacement, and vaccine hesitancy continue to fuel recurrent outbreaks, threatening global elimination goals [4]. The World Health Organization reported a substantial resurgence of measles cases during 2022–2023, reflecting persistent immunity gaps in vulnerable populations [5]. Beyond its characteristic clinical manifestations of fever and maculopapular rash,

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measles is associated with profound transient immunosuppression that may persist for weeks to months following acute infection [6]. This immunological impairment increases susceptibility to secondary infections, among which pneumonia represents the most frequent and life-threatening complication [7]. Measles-associated pneumonia may occur as primary viral pneumonia resulting from direct viral involvement of pulmonary tissue, secondary bacterial pneumonia due to impaired mucosal immunity, or a mixed viral-bacterial process. Clinically, affected children commonly present with cough, tachypnea, chest indrawing, and hypoxemia, often necessitating prompt medical intervention [8]. Reported case-fatality rates vary considerably depending on nutritional status and access to healthcare, remaining below 1% in well-resourced settings but exceeding 10% in resource-limited environments[9].

Despite the recognized burden of measles-associated pneumonia globally, there is limited contemporary data from southern Khyber Pakhtunkhwa, particularly from district-level referral hospitals serving predominantly rural populations. Furthermore, the interaction between vaccination status, nutritional status, socioeconomic conditions, and pneumonia occurrence among children with laboratory-confirmed measles has not been adequately explored in this setting. Addressing this gap is essential to inform targeted preventive strategies and optimize clinical management. Therefore, this study aims to determine the frequency of pneumonia among children aged 2–15 years presenting with measles at DHQ Hospital, Dera Ismail Khan, and to examine its association with key demographic, vaccination, nutritional, socioeconomic, and residential factors.

METHODS

This cross-sectional analytical study was conducted in the Department of Pediatrics, District Headquarters (DHQ) Hospital, Dera Ismail Khan, the main public-sector tertiary referral center for pediatric infectious diseases in the district, serving an estimated population of approximately 1.7 million in southern Khyber Pakhtunkhwa, Pakistan. The study was carried out from September 2024 to January 2025 following approval from the Ethical Review Committee of Gomal Medical College (Reference No. 146/GJMS/JC; dated 25th Sepetmber, 2024) and registration with the Research Training and Monitoring Cell of the College of Physicians and Surgeons Pakistan (RTMC Registration No. CPSP/REU/PED-2023-029-7549; dated 25th October 2024). The sample size was calculated using the World Health Organization (WHO) sample size calculator for descriptive studies, assuming an expected pneumonia frequency of 31.13% [10] among measles cases, a 95% confidence level, and a 7% margin of error, resulting in a required sample of 169 participants. Consecutive non-probability sampling was used to recruit eligible participants presenting to the Department of Pediatric Emergency, Outpatient Department, and inpatient wards during the study period. Inclusion criteria comprised children aged 2–15 years of either gender presenting with clinically suspected measles, defined as fever ≥38.3°C, maculopapular rash, and at least one of cough, coryza, or conjunctivitis, with laboratory confirmation by detection of measles-specific IgM antibodies in serum. Measles IgM testing was performed for all enrolled patients using the enzyme-linked immunosorbent assay (ELISA) method at the DHQ Hospital Dera Ismail Khan laboratory, following manufacturer protocols and internal quality control procedures. Exclusion criteria included children with pre-existing congenital heart disease, chronic respiratory disorders (including bronchial asthma), documented neurological disorders, known immunodeficiency, or those receiving immunosuppressive therapy, as these conditions may independently increase the risk of pneumonia and confound study outcomes. After obtaining written informed consent from parents or legal guardians, demographic and clinical data were recorded using a structured proforma. Collected variables included age (in years), gender, weight, vaccination status (verified through immunization cards or parental recall), residence (urban/rural), and socioeconomic status. Nutritional status was operationally defined using weight-for-age Z-scores according to WHO growth standards. Children with a weight-for-age Z-score ≥ -2 standard deviations were categorized as well-nourished, while those with a Z-score < -2 standard deviations were classified as malnourished [11]. Socioeconomic status was assessed using the Modified Kuppuswamy Socioeconomic Scale (2023 updated version) [12], with income categories adapted to Pakistani Rupees (PKR) according to prevailing economic standards during the study period. Participants were classified into lower, middle, and upper socioeconomic groups based on composite scores. Pneumonia was operationally defined as the presence of cough, fever ≥38.3°C, and age-adjusted tachypnea, confirmed radiographically by chest X-ray demonstrating alveolar opacity, patchy infiltrates, or pleural effusion. Radiographs were interpreted independently by consultant radiologists blinded to clinical data.

Data were entered and analyzed using IBM SPSS Statistics version 25. Categorical variables were summarized as frequencies and percentages, while continuous variables were reported as mean ± standard deviation and range. Associations between categorical variables and pneumonia were assessed using the chi-square test. Fisher's exact test was applied when expected cell counts were less than five or when zero-cell frequencies were

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observed. Multivariable logistic regression analysis was performed to identify factors independently associated with pneumonia. Adjusted odds ratios (AORs) with 95% confidence intervals were reported. Model fit was evaluated using the Hosmer–Lemeshow goodness-of-fit test and Nagelkerke R^2. A two-tailed p-value < 0.05 was considered statistically significant.

RESULTS

A total of 169 children diagnosed with measles were enrolled in this study. Pneumonia was observed in 54 children, yielding an overall prevalence of 32.0% (95% CI: 25.0%–39.0%). The mean age of participants was 7.1 ± 3.6 years (range: 2–15 years), with the largest proportion belonging to the 6–10 years age group (42.6%), followed by 2–5 years (40.2%) and 11–15 years (17.2%). Male children constituted 55.0% of the sample. The mean weight was 21.2 ± 8.5 kg. Most participants were malnourished (58.0%), belonged to lower socioeconomic households (63.9%), and resided in rural areas (62.1%). Detailed demographic and baseline characteristics are presented in table 1.

Table 1: Demographic Characteristics of Stroke Patients (n=177)

Variables	Categories	n (%) / Mean ± SD
Age (years)	Mean ± SD	7.1 ± 3.6
	Range	2–15
Age Groups	2–5 Years	68 (40.2%)
	6–10 Years	72 (42.6%)
	11–15 Years	29 (17.2%)
Gender	Male	93 (55.0%)
	Female	76 (45.0%)
Weight (kg)	Mean ± SD	21.2 ± 8.5
	Range	9.1–41.8
Vaccination Status	Immunized	47 (27.8%)
	Not Immunized	122 (72.2%)
Nutritional Status	Well-Nourished	71 (42.0%)
	Malnourished	98 (58.0%)
Socioeconomic Status	Lower Class	108 (63.9%)
	Middle Class	49 (29.0%)
	Upper Class	12 (7.1%)
Place of Residence	Urban	64 (37.9%)
	Rural	105 (62.1%)

The mean fever temperature at presentation was 38.9 ± 0.4°C, and the mean duration of symptoms before hospital presentation was 4.4 ± 1.3 days. Cough was reported in 89.9% of children, and tachypnea was observed in 35.5%. Pneumonia occurred in 32.0% of cases. Clinical features are summarized in table 2.

Table 2: Clinical Characteristics and Pneumonia Frequency (n=169)

Variables	Categories/Values	n (%) / Mean ± SD
Pneumonia	Present	54 (32.0%)
	Absent	115 (68.0%)
Fever Temperature	°C	38.9 ± 0.4
	Range	38.3–39.8
Duration of Measles	Days	4.4 ± 1.3
	Range	3–7
Cough	Present	152 (89.9%)
	Absent	17 (10.1%)
Tachypnea	Present	60 (35.5%)
	Absent	109 (64.5%)

In bivariate analysis, significant associations were observed between pneumonia and age group (χ^2 = 19.432, p<0.001), nutritional status (χ^2 = 52.536, p<0.001), and place of residence (χ^2 = 4.811, p=0.028). Malnourished children demonstrated markedly higher pneumonia frequency (54.1%) compared with well-nourished children (1.4%). Pneumonia was most common among children aged 2–5 years (45.6%) and was not observed in adolescents aged 11–15 years. No significant association was found between gender or socioeconomic status and pneumonia occurrence. These findings are detailed in table 3.

Table 3: Bivariate Association Between Risk Factors and Pneumonia (n=169)

Variables	Categories	Pneumonia Present, n (%)	Pneumonia Absent, n (%)	χ^2 (p-value)*	Cramer's V
Age Group	2–5 Years	31 (45.6%)	37 (54.4%)	19.432 (<0.001)	0.339
	6–10 Years	23 (31.9%)	49 (68.1%)		
	11–15 Years	0 (0.0%)	29 (100.0%)		
Gender	Male	33 (35.5%)	60 (64.5%)	1.186 (0.276)	0.084
	Female	21 (27.6%)	55 (72.4%)		
Nutritional Status	Well-Nourished	1 (1.4%)	70 (98.6%)	52.536 (<0.001)	0.558
	Malnourished	53 (54.1%)	45 (45.9%)		
Socioeconomic Status	Lower	38 (35.2%)	70 (64.8%)	1.448 (0.485)	0.093
	Middle	13 (26.5%)	36 (73.5%)		
	Upper	3 (25.0%)	9 (75.0%)		
Place of Residence	Urban	14 (21.9%)	50 (78.1%)	4.811 (0.028)	0.169
	Rural	40 (38.1%)	65 (61.9%)		

*Chi-square test applied; p <0.005 considered statistically significant

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Pneumonia occurred exclusively among non-immunized children (44.3%) and was not observed among immunized children (0%). Because of a zero-cell frequency, Fisher's exact test was applied, demonstrating a statistically significant association ($p<0.001$). Using the Haldane–Anscombe continuity correction to account for the zero cell, non-immunized children had significantly higher odds of pneumonia compared with immunized children (crude OR = 75.6; 95% CI: 4.6–1254.2) as shown in table 4.

Table 4: Association Between Vaccination Status and Pneumonia (n=169)

Vaccination Status	Pneumonia (Yes), n (%)	Pneumonia (No), n (%)	Total, n (%)	p-value
Immunized	0 (0.0%)	47 (100.0%)	47 (27.8%)	<0.672*
Not immunized	54 (44.3%)	68 (55.7%)	122 (72.2%)	
Total	54 (32.0%)	115 (68.0%)	169 (100%)	

*Fisher's exact test applied due to zero cell frequency. †Crude odds ratio calculated using Haldane–Anscombe continuity correction(OR = 75.6; 95% CI: 4.6–1254.2)

To identify independent factors associated with pneumonia, multivariable logistic regression analysis was performed. Vaccination status was excluded from the regression model due to complete separation (no pneumonia events among immunized children). The overall model was statistically significant (Omnibus test $\chi^2 = 97.051$, $p<0.001$) and demonstrated good fit (Hosmer–Lemeshow $p=0.460$; Nagelkerke $R^2 = 0.612$). After adjustment for confounders Malnutrition remained strongly associated with pneumonia (AOR = 125.96, 95% CI: 15.70–1010.86, $p<0.001$). Rural residence was independently associated with higher odds of pneumonia (AOR = 2.91, 95% CI: 1.04–8.12, $p=0.041$). Increasing age was protective, with each additional year associated with a 27% reduction in odds of pneumonia (AOR = 0.73, 95% CI: 0.63–0.85, $p<0.001$). Gender and socioeconomic status were not independently associated with pneumonia. Multivariable results are presented in table 5.

Table 5: Multivariable Logistic Regression Analysis of Factors Associated with Pneumonia (n=169)

Variables	Adjusted OR	95% CI	p-value
Age (Per Year Increase)	0.73	0.63 – 0.85	<0.001
Male Gender	1.62	0.65 – 4.07	0.305
Malnourished vs Well-Nourished	125.96	15.70 – 1010.86	<0.001
Rural Residence vs Urban	2.91	1.04 – 8.12	0.041
SES – Lower vs Upper	2.65	0.44 – 16.13	0.289
SES – Middle vs Upper	0.92	0.14 – 6.12	0.931

DISCUSSION

This frequency is comparable to findings reported in similar hospital-based studies from low- and middle-income countries. Turaiche *et al.* reported pneumonia in 28.4% of unvaccinated children with measles in Romania [2], while Mehta *et al.* documented a frequency of 35.2% among pediatric measles cases in India [13]. Regional Pakistani data have reported pneumonia frequencies ranging from approximately 29% to 42% among hospitalized children with measles [14, 15]. These comparisons suggest that the burden observed in Dera Ismail Khan is broadly consistent with patterns reported in comparable socioeconomic and healthcare contexts. Younger children demonstrated higher pneumonia frequency in bivariate analysis, particularly those aged 2–5 years. This observation aligns with existing literature indicating that younger children may be more vulnerable to severe measles complications due to immature immune responses and higher baseline rates of malnutrition [16]. However, in multivariable logistic regression, age was analyzed as a continuous variable and demonstrated a protective association, with increasing age associated with lower odds of pneumonia. This finding should be interpreted cautiously, as cross-sectional data cannot establish temporal or causal relationships. Vaccination status showed a strong inverse association with pneumonia in bivariate analysis, with no pneumonia cases observed among immunized children. Because of complete separation, vaccination status was excluded from the multivariable model. Using Fisher's exact test and Haldane–Anscombe correction, non-immunized children had significantly higher crude odds of pneumonia (OR = 75.6; 95% CI: 4.6–1254.2). Although the magnitude of this association appears large, the wide confidence interval reflects statistical imprecision related to the zero-cell frequency and sample size limitations. Therefore, the strength of association should be interpreted with caution. These findings are biologically plausible and consistent with evidence that measles vaccination reduces the risk of severe complications and case-fatality [17, 18]. However, given the study design, causality cannot be inferred. Malnutrition demonstrated the strongest independent association with pneumonia after adjustment (AOR = 125.96; 95% CI: 15.70–1010.86). Despite the large adjusted odds ratio, the wide confidence interval suggests variability and possible overestimation influenced by event distribution and sample size. The association between undernutrition and severe measles outcomes has been consistently reported in the literature [14, 19]. Malnutrition impairs cell-mediated immunity, reduces mucosal barrier integrity, and predisposes children to secondary bacterial infections. Furthermore, vitamin A supplementation has been shown to reduce measles-related morbidity and mortality in children [20]. These study findings support existing evidence emphasizing the importance of nutritional assessment and supportive care in children with

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measles. Rural residence was independently associated with higher odds of pneumonia (AOR = 2.91; 95% CI: 1.04–8.12). This association may reflect disparities in healthcare access, delayed presentation, lower immunization coverage, and higher prevalence of malnutrition in rural communities. Similar patterns have been observed in regional studies examining measles complications in underserved populations [14, 15]. These findings highlight the potential influence of social determinants of health on complication severity.

The present study contributes district-level data from southern Khyber Pakhtunkhwa, where contemporary hospital-based evidence remains limited. Nevertheless, several limitations should be acknowledged. First, the cross-sectional design does not allow assessment of temporal sequence or causal inference. Second, the single-center setting may limit generalizability to other regions. Third, the zero-cell frequency in vaccination status limited regression modeling and resulted in wide confidence intervals for crude estimates. Despite these limitations, laboratory confirmation of measles and multivariable adjustment strengthen the internal validity of the findings.

CONCLUSIONS

In conclusion, pneumonia was observed in approximately one-third of children hospitalized with measles at DHQ Hospital, Dera Ismail Khan. Malnutrition and rural residence were independently associated with higher odds of pneumonia, while increasing age demonstrated a protective association. Vaccination status showed a strong inverse association with pneumonia in bivariate analysis; however, due to complete separation and study design limitations, this finding should be interpreted cautiously. These findings suggest that strengthening routine immunization coverage and addressing childhood malnutrition may contribute to reducing the burden of severe measles-related complications in similar settings. Further multicenter prospective studies are recommended to confirm these associations and provide more precise effect estimates.

Authors' Contribution

Conceptualization: FJ
Methodology: MI, FUB, FU, IU
Formal analysis: FU, IU
Writing and Drafting: FJ, MI, AMK, FUB, FU, IU
Review and Editing: FJ, MI, AMK, FUB, FU, IU

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflicts of Interest

All the authors declare no conflict of interest.

Source of Funding

The authors received no financial support for the research, authorship and/or publication of this article.

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