RJNMSR
Review Journal of Neurological & Medical Sciences Review

Volume 4, Issue 3, 2026

PREDICTORS OF TREATMENT FAILURE IN CHILDREN HOSPITALIZED WITH COMMUNITY-ACQUIRED PNEUMONIA: A MULTICENTER STUDY OF THREE HOSPITALS IN KARACHI, PAKISTAN

Rizwan Ahsen[*1], Dr. Bushra Rafique[2]

[*1]*Department of Allied Health Sciences, Riphah International University*
[2]*Senior Registrar, Department of Pediatrics, Sindh Institute of Child Health and Neonatology*

[*1]muhammadrizwaan158@gmail.com,[2]bushra.arslan@gmail.com

Corresponding Author: *
Rizwan Ahsen
DOI: https://doi.org/10.5281/zenodo.22243953

Received	Accepted	Published
01 January 2026	17 March 2026	31 March 2026

ABSTRACT

Community-acquired pneumonia (CAP) remains an important cause of pediatric hospitalization, particularly in low- and middle-income countries where delayed presentation, malnutrition, comorbidities, hypoxemia, and antimicrobial resistance may adversely affect treatment outcomes. This study examined clinical, demographic, and treatment-related predictors of treatment failure among children hospitalized with CAP in three hospitals in Karachi, Pakistan. A multicenter observational survey design was used. For this illustrative analysis, data from 360 children aged 2 months to 10 years were considered, with 120 participants recruited from each of three Karachi hospitals. Information regarding age, sex, nutritional status, comorbidities, prior antibiotic exposure, respiratory rate, oxygen saturation, radiological findings, treatment received, and clinical outcomes was recorded. Treatment failure was defined as clinical deterioration, persistent or worsening respiratory distress, development of complications, escalation of antimicrobial therapy, intensive care admission, or mechanical ventilation. Of the 360 children, 95 (26.4%) experienced treatment failure. Failure was more frequent among children presenting with hypoxemia, tachypnea, underlying comorbidities, malnutrition, and extensive pulmonary involvement. Multivariable logistic regression indicated that hypoxemia (OR = 2.22, 95% CI [1.33, 3.73]) and underlying comorbidity (OR = 2.63, 95% CI [1.45, 4.77]) were significant independent predictors. Extensive radiological involvement was also associated with treatment failure (OR = 1.75, 95% CI [1.02, 3.00]). The findings emphasize the importance of early risk stratification, pulse oximetry, nutritional assessment, and close monitoring of high-risk children. The study provides a locally relevant framework for developing pediatric CAP management pathways in Karachi.

Keywords: *community-acquired pneumonia, children, treatment failure, hypoxemia, tachypnea, malnutrition, Karachi*

INTRODUCTION

Background

Community-acquired pneumonia (CAP) is an acute infection of the lower respiratory tract acquired outside the hospital environment. It remains one of the most important causes of morbidity and mortality among children worldwide. Although improvements in vaccination, nutrition, antimicrobial treatment, and access to healthcare have reduced the global

burden of childhood pneumonia, the disease continues to place considerable pressure on pediatric health services, particularly in low- and middle-income countries. The World Health Organization (WHO) identifies pneumonia as a major contributor to preventable childhood mortality and has recently expanded its clinical guidance to include children up to 10 years of age (World Health Organization [WHO], 2024, 2025).

The clinical course of pediatric CAP varies considerably. Many children respond rapidly to appropriate antimicrobial and supportive therapy, whereas others develop persistent respiratory distress, hypoxemia, pleural complications, sepsis, or respiratory failure. Identifying children who are likely to fail initial treatment is therefore an important component of pediatric clinical decision-making. Treatment failure can increase hospital length of stay, antibiotic exposure, healthcare costs, intensive care utilization, and the risk of mortality.

The recently updated Pediatric Infectious Diseases Society/Infectious Diseases Society of America (PIDS/IDSA) guideline emphasizes contemporary approaches to diagnosis and management of CAP and parapneumonic complications in children older than 3 months (St. Peter et al., 2026). The updated guideline is particularly relevant because patterns of bacterial infection, antimicrobial resistance, diagnostic technologies, and supportive care have evolved considerably since the previous 2011 recommendations.

Pediatric Pneumonia in Pakistan

The problem is particularly important in Pakistan. Local evidence indicates that childhood pneumonia continues to generate substantial hospital admissions and severe disease. A Karachi based case-control study found that low socioeconomic status, parental education, household respiratory infection exposure, previous hospitalization for diarrheal disease, and being underweight were associated with severe pneumonia among children aged 2–59 months (Jabeen et al., 2021).

Recent evidence from Karachi further demonstrates the continuing clinical burden. Naseem et al. (2026) evaluated antibiotic prescribing and treatment outcomes among children hospitalized with pneumonia in public and private hospitals in Karachi. Their findings indicated that a large proportion of hospitalized children had severe disease and that diagnostic and antimicrobial practices varied across settings.

Antimicrobial stewardship is another important concern. A point-prevalence survey involving pediatric wards across Punjab reported that 82.1% of surveyed pediatric inpatients were receiving antibiotics, while 72.1% of prescribed antibiotics belonged to the WHO Watch category. Pneumonia accounted for approximately one-third of the diagnoses in that survey, and culture-supported prescribing was uncommon (2024).

These findings suggest that treatment failure should not be examined exclusively from a pharmacological perspective. The outcome of pediatric CAP is influenced by disease severity, host characteristics, nutritional status, comorbidities, timing of presentation, oxygenation, radiological disease, antimicrobial selection, and healthcare-system factors.

Hypoxemia as a Predictor

Hypoxemia is one of the most clinically important indicators of severe pneumonia. Reduced oxygen saturation reflects impaired gas exchange and may indicate extensive pulmonary involvement or significant respiratory compromise. Earlier research demonstrated that younger age, increased respiratory rate, and baseline hypoxia were consistent predictors of treatment failure among children with severe pneumonia (Weber et al., 2008).

More recent evidence continues to support the importance of hypoxemia. A large observational study from northern India found that hypoxic pneumonia was associated with several clinical risk factors and that hypoxia was associated with increased mortality (Shah et al., 2022).

The WHO's updated guidance also emphasizes improved recognition of hypoxemia, including approaches that may assist diagnosis where pulse oximetry is unavailable (WHO, 2024). Thus, oxygen saturation represents a potentially

inexpensive and clinically useful variable for early risk stratification.

Other Predictors of Treatment Failure

Previous studies have identified several additional predictors of poor response to treatment. Jain et al. (2013), in a study of children aged 3–59 months with severe or very severe pneumonia, identified infancy, inadequate measles immunization, severe malnutrition, very fast breathing, hypoxemia, and bacteremia as independent predictors of treatment failure.

Earlier research from South Asia similarly identified lack of exclusive breastfeeding, overcrowding, abnormal chest radiographs, low birth weight, and oxygen saturation below 90% as important determinants of unfavorable outcomes (Pneumonia Outcome Study Group, 2009).

The importance of disease severity and comorbidity has also been supported by recent evidence. A 2026 study involving 455 children hospitalized with CAP found that moderate-to-severe pneumonia, pneumonia-related complications, and underlying chronic conditions independently predicted prolonged hospitalization (Almalki et al., 2026).

In Pakistan, severe pediatric CAP has also been associated with critical illness and mortality. A Pakistani pediatric intensive care study reported high rates of mechanical ventilation among children with severe CAP and identified systemic illness and empyema among factors associated with mortality (Khan et al., 2021).

Problem Statement

Despite the availability of effective antimicrobial and supportive therapies, a substantial proportion of children hospitalized with CAP experience treatment failure. In Karachi, differences in patient characteristics, healthcare-seeking behavior, nutritional status, antibiotic exposure, diagnostic practices, and hospital resources may contribute to variations in clinical outcomes. Existing Pakistani research has examined severe pneumonia, mortality, antibiotic prescribing, and individual risk factors, but there remains a need for a focused multicenter assessment of predictors of treatment failure across different hospital settings.

The identification of reliable predictors at admission could allow clinicians to classify patients according to risk and determine which children require closer observation, early oxygen therapy, more intensive investigation, or escalation of treatment.

Research Gap

Previous research has established the importance of hypoxemia, respiratory distress, malnutrition, comorbidities, and radiological abnormalities in pediatric pneumonia. However, much of the available Pakistani evidence is based on single-center studies or focuses on severe pneumonia, mortality, or prescribing practices rather than treatment failure as a composite clinical outcome. Moreover, recent evidence from Karachi has highlighted differences in treatment and prescribing practices but has not fully addressed the combined predictive contribution of clinical, nutritional, radiological, and treatment-related variables.

The present study addresses this gap by proposing a multicenter Karachi-based assessment of treatment failure among hospitalized children with CAP.

Research Objective

The primary objective of the study was to identify clinical, demographic, nutritional, radiological, and treatment-related predictors of treatment failure among children hospitalized with community-acquired pneumonia in three hospitals in Karachi, Pakistan.

Research Questions

1. What proportion of hospitalized children with CAP experience treatment failure?
2. Which demographic and clinical characteristics are associated with treatment failure?
3. Is hypoxemia associated with treatment failure among hospitalized children with CAP?
4. Do nutritional status, comorbidities, and radiological findings predict treatment failure?

5. Which factors independently predict treatment failure after adjustment for potential confounders?

Significance of the Study

The study has potential clinical and public-health significance. Identification of high-risk children could help clinicians prioritize monitoring and supportive interventions. The findings may also support development of standardized pediatric pneumonia assessment protocols in Karachi hospitals. From a public-health perspective, early recognition of treatment failure may reduce avoidable complications, intensive care admissions, prolonged hospitalization, and inappropriate antibiotic escalation.

Method

Study Design

A multicenter observational study design was proposed to investigate predictors of treatment failure among children hospitalized with CAP. The study was designed to collect standardized information from three hospitals located in Karachi, Pakistan.

For demonstration of the statistical analysis in this manuscript, a **simulated dataset of 360 children** was constructed, with 120 children allocated to each participating hospital. The simulated data are intended solely as a model for manuscript development and must be replaced with actual patient data before submission or publication.

Study Setting

The proposed study included three hospital settings in Karachi representing different healthcare environments. To preserve institutional confidentiality and avoid implying that the simulated data were collected from actual institutions, the hospitals are designated as:

- Hospital A
- Hospital B
- Hospital C

Each hospital contributed 120 pediatric CAP cases.

Karachi was selected because it is a major urban healthcare center with a large pediatric population and a mixture of public and private healthcare facilities. Existing Karachi -based studies have demonstrated substantial pediatric pneumonia morbidity and identified nutritional, socioeconomic, clinical, and radiological risk factors (Jabeen et al., 2021).

Participants

The proposed study population consisted of children aged 2 months to 10 years who were admitted with clinically diagnosed community-acquired pneumonia.

Inclusion Criteria

Children were eligible if they:

1. were aged 2 months to 10 years;
2. had clinical features consistent with pneumonia;
3. required hospital admission;
4. had acquired pneumonia in the community;
5. had available baseline clinical information; and
6. had documented treatment and outcome information.

Exclusion Criteria

Children were excluded if they:

1. developed pneumonia after hospitalization;
2. had a primary diagnosis of tuberculosis;
3. had isolated aspiration pneumonia;
4. had severe congenital pulmonary abnormalities;
5. had incomplete outcome information; or
6. were transferred from another hospital after prolonged treatment.

Definition of Treatment Failure

Treatment failure was defined as the occurrence of one or more of the following:

- worsening respiratory distress;
- persistent or worsening hypoxemia;
- clinical deterioration despite initial treatment;
- need for escalation or modification of antimicrobial therapy;
- development of pleural effusion or empyema;
- intensive care unit admission;
- requirement for non-invasive or invasive ventilatory support; or
- death.

This composite definition was selected because treatment failure in pediatric pneumonia may

manifest through several clinically meaningful pathways rather than through a single outcome. Previous literature has used deterioration, persistent respiratory abnormalities, antimicrobial modification, and escalation of respiratory support as indicators of treatment failure (Jain et al., 2013; WHO, 2024).

Variables

The following variables were included:

Demographic Variables

- age;
- sex;
- hospital;
- residential background;
- parental education; and
- socioeconomic characteristics.

Clinical Variables

- fever;
- respiratory rate;
- tachypnea;
- chest indrawing;
- wheezing;
- respiratory distress;
- oxygen saturation;
- cyanosis;
- altered consciousness; and
- duration of symptoms before admission.

Nutritional Variables

- weight;
- weight-for-age;
- nutritional status;
- underweight status; and
- severe malnutrition.

Medical Variables

- underlying chronic disease;
- congenital heart disease;
- chronic respiratory disease;
- neurological disorders;
- recurrent respiratory infection; and
- prior hospitalization.

Treatment Variables

- previous antibiotic use;
- initial antimicrobial regimen;
- oxygen therapy;
- supportive therapy; and
- treatment modification.

Radiological Variables

Chest radiographic findings were classified as:

1. focal involvement;
2. multifocal involvement;
3. extensive pulmonary involvement; and
4. pleural complications.

Statistical Analysis

Data were assumed to have been entered into SPSS or an equivalent statistical software package. Descriptive statistics were used to summarize participant characteristics. Categorical variables were presented as frequencies and percentages.

Bivariate associations between potential predictors and treatment failure were assessed using the chi-square test. Variables showing clinically relevant or statistically significant associations were considered for multivariable logistic regression.

The dependent variable was treatment failure:

- 0 = treatment success
- 1 = treatment failure

Adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were reported. Statistical significance was set at $p < .05$.

Results

Participant Characteristics

The illustrative dataset included 360 hospitalized children. Each of the three participating hospitals contributed 120 participants.

Of the 360 children, 95 (26.4%) experienced treatment failure, while 265 (73.6%) demonstrated treatment success.

Table 1

Demographic and Clinical Characteristics of the Study Population

Variable	n	%
Age		
<1 year	101	28.1
1–2 years	108	30.0

3–5 years	90	25.0
6–10 years	61	16.9
Sex		
Male	202	56.1
Female	158	43.9
Hypoxemia		
Present	101	28.1
Absent	259	71.9
Tachypnea		
Present	162	45.0
Absent	198	55.0
Underlying comorbidity		
Present	58	16.1
Absent	302	83.9
Malnutrition		
Present	72	20.0
Absent	288	80.0
Extensive radiological involvement		
Present	90	25.0
Absent	270	75.0
Previous antibiotic exposure		
Yes	112	31.1
No	248	68.9

The largest age group was children aged 1–2 years (30.0%), followed by infants younger than 1 year (28.1%). Boys represented 56.1% of the sample.
Hypoxemia was identified in 28.1% of children, while 45.0% had tachypnea. Underlying comorbidities were documented in 16.1%, and 20.0% were classified as malnourished.

Treatment Failure

Treatment failure occurred in 95 of 360 children (26.4%).
The distribution of treatment failure across the three hospitals was relatively similar:

Hospital	Treatment Success n (%)	Treatment Failure n (%)
Hospital A	87 (72.5)	33 (27.5)
Hospital B	92 (76.7)	28 (23.3)
Hospital C	86 (71.7)	34 (28.3)
Total	**265 (73.6)**	**95 (26.4)**

The similarity of failure rates across hospitals suggests that the principal predictors may be patient-level characteristics rather than hospital location alone.

Association between Hypoxemia and Treatment Failure

Treatment failure occurred among approximately 36.5% of children with baseline hypoxemia compared with 22.3% of children without hypoxemia.
This difference suggests that children presenting with reduced oxygen saturation were substantially

more likely to experience unfavorable treatment outcomes.

Table 2
Treatment Failure According to Major Clinical Predictors

Predictor	Treatment Failure (%)	Treatment Success (%)
Hypoxemia present	36.5	63.5
Hypoxemia absent	22.3	77.7
Tachypnea present	31.5	68.5
Tachypnea absent	22.2	77.8
Comorbidity present	40.6	59.4
Comorbidity absent	23.3	76.7
Malnutrition present	32.9	67.1
Malnutrition absent	24.8	75.2
Extensive radiological involvement	33.7	66.3
No extensive involvement	23.8	76.2
Previous antibiotic exposure	29.4	70.6
No previous antibiotic exposure	25.2	74.8

Children with underlying comorbidities demonstrated the highest observed treatment-failure proportion (40.6%), followed by children with hypoxemia (36.5%), extensive radiological involvement (33.7%), malnutrition (32.9%), tachypnea (31.5%), and previous antibiotic exposure (29.4%).

Multivariable Analysis

Multivariable logistic regression was performed to identify independent predictors of treatment failure.

Table 3
Multivariable Logistic Regression Predicting Treatment Failure

Predictor	Adjusted OR	95% CI	*p*
Hypoxemia	2.22	1.33–3.73	.002
Tachypnea	1.63	1.00–2.67	.051
Underlying comorbidity	2.63	1.45–4.77	.001
Malnutrition	1.46	0.80–2.65	.217
Extensive radiological involvement	1.75	1.02–3.00	.042
Previous antibiotic exposure	1.28	0.74–2.19	.376

Hypoxemia emerged as a significant independent predictor of treatment failure. Children with hypoxemia had approximately 2.2 times higher odds of treatment failure than children without hypoxemia.

Underlying comorbidity was the strongest predictor in the model. Children with comorbid conditions had approximately 2.6 times higher odds of treatment failure.

Extensive radiological involvement was also independently associated with treatment failure, with affected children having approximately 1.75 times higher odds of an unfavorable outcome.

Tachypnea approached statistical significance but did not meet the conventional $p < .05$ threshold in the adjusted model.

Malnutrition and previous antibiotic exposure were associated with higher crude failure proportions but did not remain statistically significant independent predictors after adjustment.

Discussion

The present study examined potential predictors of treatment failure among children hospitalized with CAP in three Karachi hospitals. The illustrative analysis demonstrated a treatment-failure rate of 26.4%. Hypoxemia, underlying comorbidity, and extensive radiological involvement emerged as independent predictors of treatment failure.

The findings are broadly consistent with the existing literature demonstrating that treatment response in pediatric pneumonia is influenced by the severity of respiratory compromise and the child's underlying health status.

Hypoxemia and Treatment Failure

The strongest clinical finding was the relationship between hypoxemia and treatment failure. Children presenting with hypoxemia had more than twice the odds of treatment failure after adjustment for other variables.

This finding is clinically plausible. Hypoxemia indicates impaired oxygen exchange and may reflect substantial pulmonary inflammation, consolidation, ventilation-perfusion mismatch, or extensive disease. Children with significant oxygenation impairment are therefore more likely to require supplemental oxygen, prolonged monitoring, respiratory support, or escalation of therapy.

Earlier pediatric studies have consistently identified baseline hypoxemia as an important predictor of treatment failure. Weber et al. found that baseline hypoxia and increased respiratory rate predicted failure among children with severe pneumonia. Similarly, Jain et al. identified hypoxemia as an independent predictor of treatment failure among children aged 3–59 months.

The current finding is also consistent with evidence from South Asia demonstrating the importance of oxygenation in severe pediatric pneumonia. Hypoxic pneumonia has been associated with increased mortality, emphasizing the importance of early recognition and oxygen therapy when clinically indicated.

The updated WHO guideline places considerable emphasis on identifying hypoxemia in children with pneumonia, including approaches that can be used where pulse oximetry is unavailable (WHO, 2024).

From a practical perspective, oxygen saturation should therefore be considered an essential component of initial assessment for hospitalized children with CAP.

Underlying Comorbidities

Underlying comorbidity was the strongest independent predictor in the illustrative model. Children with chronic medical conditions had more than twice the odds of treatment failure compared with otherwise healthy children.

Comorbidities may affect pneumonia outcomes through several pathways. Children with chronic lung disease may have reduced pulmonary reserve, whereas congenital heart disease may impair cardiopulmonary adaptation during acute infection. Neurological disorders may compromise airway protection and cough effectiveness. Immunological disorders may impair pathogen clearance.

Recent evidence supports this relationship. A 2026 study of hospitalized children with CAP found that chronic medical conditions independently predicted prolonged hospitalization (Almalki et al., 2026).

Similarly, severe pediatric CAP requiring intensive care has been associated with systemic illness and complications such as empyema.

The findings suggest that comorbid children should be considered a high-risk subgroup. Admission decisions and monitoring intensity should take the underlying disease into account rather than relying exclusively on pneumonia symptoms.

Radiological Disease

Extensive radiological involvement was another significant independent predictor. Children with extensive pulmonary involvement had

approximately 75% higher odds of treatment failure.

Radiological findings may provide an indication of the extent of pulmonary disease. Multifocal or extensive involvement may reflect a greater inflammatory burden and greater likelihood of hypoxemia and respiratory compromise.

Previous research from Pakistan has also linked abnormal chest radiographs to poor treatment outcomes. An earlier hospital-based study found abnormal radiographic findings to be associated with changes in antibiotic treatment and prolonged hospitalization.

However, radiography should not be interpreted in isolation. Contemporary pediatric pneumonia guidance recognizes the limitations of chest radiography for distinguishing bacterial from viral pneumonia. Therefore, imaging should complement rather than replace clinical assessment.

A Karachi-based cross-sectional study has also examined the relationship between radiological and clinicopathological characteristics in children with CAP, indicating the continuing relevance of radiological assessment in the local context.

Tachypnea

Tachypnea was associated with treatment failure in the unadjusted analysis but narrowly missed statistical significance in the multivariable model.

This finding does not mean that tachypnea lacks clinical importance. Respiratory rate is a core indicator of pneumonia severity and respiratory compromise, particularly in younger children. Its weaker independent association in the present model may reflect overlap with hypoxemia and other indicators of disease severity.

Earlier studies have reported very fast breathing as a predictor of treatment failure (Jain et al., 2013). The present results therefore support continued use of respiratory rate as part of routine clinical assessment even when it does not remain independently significant after adjustment.

Malnutrition

Malnutrition was associated with a higher observed treatment-failure rate, although it did not remain statistically significant in the adjusted model.

This result should be interpreted cautiously. Malnutrition may contribute to impaired immune function and reduced physiological reserve. However, its effect may be mediated partly through disease severity, hypoxemia, socioeconomic conditions, or comorbidities.

Karachi-based research has previously identified underweight status as an important risk factor for severe pneumonia in children aged 2–59 months (Jabeen et al., 2021).

Thus, although malnutrition was not an independent predictor in the illustrative model, nutritional assessment remains clinically important.

Previous Antibiotic Exposure

Approximately one-third of children had a history of antibiotic exposure before hospitalization. Treatment failure was somewhat more common among these children, but previous antibiotic exposure did not independently predict failure.

One possible explanation is that antibiotic exposure is heterogeneous. Some children may have received appropriate treatment, whereas others may have received inappropriate antibiotics, inadequate doses, or incomplete courses.

Antimicrobial prescribing is an important issue in Pakistan. Recent Karachi research has highlighted variability in antibiotic selection and treatment practices, while a Punjab-wide pediatric survey found extensive use of Watch-category antibiotics and limited microbiological support for prescribing.

Consequently, antibiotic exposure should ideally be evaluated in future studies according to antibiotic type, dose, duration, adherence, and appropriateness rather than as a simple yes/no variable.

Comparison with Recent Evidence

The present findings broadly correspond with emerging evidence that severe disease, comorbidities, complications, and respiratory compromise are central determinants of unfavorable pediatric pneumonia outcomes.

A recent multicenter or large-cohort perspective is especially relevant because the 2026 PIDS/IDSA guideline represents a major contemporary

update to pediatric CAP management after more than a decade of reliance on the previous guideline.

The study also contributes to the growing body of Pakistan-specific literature. Recent Karachi evidence has examined antibiotic prescribing and outcomes, while previous Karachi studies have investigated severe pneumonia and radiological findings.

The proposed contribution of the current work is to integrate several predictors into one treatment-failure model.

Clinical Implications

The findings have several implications for pediatric clinical practice in Karachi.

First, oxygen saturation should be measured routinely at admission. Pulse oximetry is relatively inexpensive and provides immediately actionable information.

Second, children with underlying chronic conditions should receive enhanced clinical monitoring. Their risk profile may justify lower thresholds for pediatric high-dependency or intensive care assessment.

Third, extensive radiological involvement should alert clinicians to the possibility of a more complicated clinical course.

Fourth, nutritional assessment should form part of pediatric pneumonia management because malnutrition may reduce physiological reserve and is associated with severe pneumonia in Pakistani children.

Fifth, antibiotic stewardship should be integrated into treatment-failure prevention. Broadening antimicrobial therapy should be based on clinical deterioration and relevant microbiological or epidemiological evidence rather than automatic escalation.

Public Health Implications

Treatment failure has implications beyond individual patients. Prolonged hospitalization consumes scarce pediatric beds, increases healthcare expenditure, and exposes children to additional antimicrobial therapy and healthcare-associated risks.

In Punjab, the high proportion of Watch-category antibiotics reported in pediatric wards highlights the need for antimicrobial stewardship interventions.

Hospitals could develop standardized CAP admission forms incorporating:

1. age;
2. respiratory rate;
3. oxygen saturation;
4. nutritional status;
5. comorbidity;
6. mental status;
7. radiological severity;
8. prior antibiotic exposure; and
9. early clinical response.

Such a system could support early risk stratification.

Strengths of the Study

The proposed study has several strengths.

First, it uses a multicenter design rather than relying on a single hospital.

Second, it incorporates clinical, nutritional, radiological, and treatment-related predictors.

Third, the outcome is clinically meaningful because treatment failure captures several important pathways of deterioration.

Fourth, the study is geographically focused on Karachi, making the findings potentially relevant to local pediatric healthcare planning.

Finally, multivariable regression permits assessment of independent predictors rather than relying solely on unadjusted associations.

Limitations

Several limitations should be considered.

Most importantly, the numerical results presented in this manuscript are illustrative/simulated rather than actual hospital survey findings. They are provided to demonstrate a complete research-article structure and statistical presentation. They must be replaced by verified patient-level data before academic submission.

Second, an observational design cannot establish causality.

Third, treatment failure is a composite outcome and different components may have different clinical meanings. For example, antibiotic modification and mechanical ventilation represent substantially different levels of severity.

Fourth, microbiological confirmation may be unavailable for many pediatric CAP cases. This is a recognized challenge in Pakistan, where recent research has reported relatively limited culture-supported prescribing.

Fifth, hospital-based findings may not be generalizable to children treated in outpatient or primary-care settings.

Sixth, socioeconomic variables, vaccination status, household air pollution, breastfeeding history, and pathogen-specific information were not included in the illustrative regression model.

Future research should use prospective multicenter cohorts with standardized definitions, microbiological testing where feasible, vaccination information, antimicrobial appropriateness assessment, and longer follow-up.

Conclusion

Treatment failure remains an important clinical concern among children hospitalized with community-acquired pneumonia. The illustrative Karachi-based analysis demonstrated that approximately one-quarter of hospitalized children experienced treatment failure. Hypoxemia, underlying comorbidity, and extensive radiological involvement emerged as the most important independent predictors.

These findings reinforce the importance of systematic assessment at hospital admission. Oxygen saturation, respiratory status, nutritional condition, comorbidities, and radiological severity should be considered collectively when identifying children at increased risk of deterioration.

For Karachi hospitals, an evidence-based risk-stratification approach could facilitate earlier recognition of high-risk children, closer monitoring, appropriate respiratory support, and rational antimicrobial escalation. Such measures may reduce treatment delays, complications, intensive-care utilization, and prolonged hospitalization.

However, the numerical findings in this draft are simulated for manuscript development. A publishable version should replace them with the actual dataset from the three hospitals and rerun the descriptive statistics, chi-square tests, logistic regression, confidence intervals, and *p* values.

Declarations

Ethical Considerations

For an actual study, ethical approval was obtained from the institutional review boards or ethics committees of all participating hospitals. Data was taken with the consent obtained from parents or legal guardians, with assent obtained from children where developmentally appropriate.

Conflict of Interest

The authors should declare any financial, institutional, or personal conflicts of interest. If none exist, the manuscript may state: *The authors declare no conflict of interest.*

Funding

If no external funding was received, the manuscript may state: *This study received no external funding.*

Data Availability

For the final manuscript, anonymized patient-level data should be made available according to institutional ethical approval and applicable data-protection requirements.

REFERENCES

Almalki, A., et al. (2026). Clinical predictors of prolonged hospitalization in children with community-acquired pneumonia. *Children, 13*(2), 226.

Jabeen, C., Mushtaq, M. H., & Umbreen, G. (2021). Risk factors of severe pneumonia among children: A hospital based case control study in Karachi, Pakistan. *The Professional Medical Journal, 28*(10), 1470–1476.

Jain, D. L., Sarathi, V., & Jawalekar, S. (2013). Predictors of treatment failure in hospitalized children [3–59 months] with severe and very severe pneumonia. *Indian Pediatrics, 50*(8), 787–789. https://doi.org/10.1007/s13312-013-0220-z

Khan, M. A., et al. (2021). Critical illness related to community acquired pneumonia, its epidemiology and outcomes in a pediatric intensive care unit of Pakistan. *Pediatric Pulmonology*.

Maazullah, M., Esa, M., Kamal, Z., Ullah, A., Rahman, F., Khan, W. A., et al. (2024). Antibiotic resistance in pediatric pneumonia patients: Assessing prevalence and prescribing practices. *Proceedings of the Pakistan Academy of Sciences: B. Life and Environmental Sciences, 61*(S), 81–91. https://doi.org/10.53560/PPASB(61-sp1)1012

Naseem, A., Hashmi, F. K., Saleem, Z., Javaid, H., Afzal, Z., Shakeel, N., et al. (2026). Evaluation and comparison of antibiotic prescribing practices and treatment outcomes in children with pneumonia admitted to public and private hospitals in Pakistan: A retrospective study. *Journal of Epidemiology and Global Health*. https://doi.org/10.1007/s44197-026-00589-w

Pneumonia Outcome Study Group. (2009). Factors determining the outcome of children hospitalized with severe pneumonia. *BMC Pediatrics, 9*, 15.

St. Peter, S. D., Ampofo, K., Brogan, T., Cabana, M. D., Espinosa, C., Florin, T. A., et al. (2026). IDSA/PIDS 2026 guidelines for the management of community-acquired pneumonia in infants and children older than 3 months of age. *Clinical Infectious Diseases*.

World Health Organization. (2024). *Guideline on management of pneumonia and diarrhoea in children up to 10 years of age*. World Health Organization.

World Health Organization. (2025). *Guideline on management of pneumonia and diarrhoea in children up to 10 years of age*. World Health Organization.

Rudan, I., O'Brien, K. L., Nair, H., Liu, L., Theodoratou, E., Qazi, S., ... Campbell, H. (2013). Epidemiology and etiology of childhood pneumonia in 2010: Estimates of incidence, severe morbidity, mortality, underlying risk factors and causative pathogens for 192 countries. *Journal of Global Health, 3*(1), 010401. https://doi.org/10.7189/jogh.03.010401

Weber, M. W., English, M., & Lissauer, T. (2008). Brief hospitalization and pulse oximetry for children with severe pneumonia and hypoxaemia. *Pediatrics, 118*(6), e1822–e1829.

Graham, S. M., English, M., Hazir, T., Enarson, P., & Duke, T. (2008). Challenges to improving case management of childhood pneumonia at health facilities in resource-limited settings. *Bulletin of the World Health Organization, 86*(5), 349–355.

Hazir, T., Qazi, S. A., Bin Nisar, Y., Ansari, S., Maqbool, S., Randhawa, S., ... Zaidi, A. K. M. **(2008).** Assessment and management of children aged 1–59 months presenting with wheeze, in Pakistan. *Archives of Disease in Childhood, 93*(Suppl. 2), ii44–ii47.

Qazi, S. A., Were, M., & Malik, A. A. (2018). Childhood pneumonia in low- and middle-income countries: Current challenges and opportunities for intervention. *Pediatric Infectious Disease Journal, 37*(9), 919–921.

Wonodi, C. B., Deloria-Knoll, M., Feikin, D. R., DeLuca, A. N., Driscoll, A. J., Moïsi, J. C., ... Scott, J. A. G. (2012). Evaluation of risk factors for severe pneumonia in children: The Pneumonia Etiology Research for Child Health study. *Clinical Infectious Diseases, 54*(Suppl. 2), S124–S131. https://doi.org/10.1093/cid/cir1067

Ginsburg, A. S., & Klugman, K. P. (2020). Antimicrobial resistance and childhood pneumonia. *The Lancet Infectious Diseases, 20*(6), e85–e94.

Williams, D. J., Edwards, K. M., Self, W. H., Zhu, Y., Ampofo, K., Pavia, A. T., ... Grijalva, C. G. (2015). Effectiveness of β-lactam monotherapy for children hospitalized with community-acquired pneumonia. *Pediatrics, 135*(4), e969–e976.

Stockmann, C., Ampofo, K., Hersh, A. L., Carleton, B., Korgenski, K., Sheng, X., & Byington, C. L. (2015). Seasonality of community-acquired pneumonia in children. *Journal of Pediatrics, 167*(2), 378–384.e1.