JHWCR

Journal of Health, Wellness and Community Research
Volume III, Issue IX
Open Access, Double Blind Peer Reviewed.
Web: https://jhwcr.com, ISSN: 3007-0570
https://doi.org/10.61919/9b8q7q90

Original Article

Diagnostic Accuracy of the Respiratory Index of Severity in Children (RISC) Score for Mortality Prediction and Severity Assessment in Community-Acquired Pneumonia Among 1–5-Year-Olds

Qazal Arslan[1], Zeeshan Qayyum[1], Umme Sarhad Khan Yousafzai[1], Muhammad Shahzad Alamgeer[1], Sumbal Malik[1], Haider Ali Awan[1]

[1] Combined Military Hospital, Rawalpindi, Pakistan

Correspondence: qazal.arslan980@gmail.com
Author Contributions: Concept: QA; Design: ZQ; Data Collection: USKY; Analysis: MSA; Drafting: SM; Critical Revision: HAA
Cite this Article | Received: 2025-05-11 | Accepted 2025-07-15
No conflicts declared; ethics approved; consent obtained; data available on request; no funding received.

ABSTRACT

Background: Community-acquired pneumonia (CAP) is a major cause of morbidity and mortality in children under five years, particularly in resource-limited settings. The absence of simple, validated tools for early severity assessment contributes to variable management and outcomes. The Respiratory Index of Severity in Children (RISC) score, incorporating readily available clinical parameters, has shown promise for predicting mortality and guiding treatment decisions. Objective: To evaluate the diagnostic accuracy of the RISC score in predicting mortality and determining severity of CAP in children aged 1–5 years in a tertiary care setting. Methods: This prospective observational study enrolled 170 children with radiologically confirmed CAP admitted to the pediatric intensive care unit at a tertiary hospital from January to December 2024. Demographic, clinical, and laboratory data were recorded at admission, and RISC scores were calculated within 24 hours. Outcomes were classified as survival or mortality, and diagnostic performance metrics including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and area under the ROC curve (AUC) were calculated with 95% confidence intervals. Results: Of 170 patients, 28 (16.5%) did not survive. Median RISC scores were significantly higher in non-survivors compared to survivors (5.00 vs. 2.00, $p < 0.001$). The RISC score demonstrated a sensitivity of 82.1% (95% CI 63.1–93.9%), specificity of 97.9% (95% CI 93.8–99.6%), PPV of 88.5%, NPV of 96.5%, and overall diagnostic accuracy of 97.3%. ROC analysis identified an optimal cut-off value of >3 with AUC 0.870, yielding sensitivity of 71.4% and specificity of 94.4%. Conclusion: The RISC score is a highly specific and accurate tool for predicting mortality and assessing disease severity in pediatric CAP. Adoption into early triage protocols may improve timely management and resource allocation in high-burden settings.

Keywords: community-acquired pneumonia, RISC score, children, diagnostic accuracy, severity assessment, mortality prediction.

INTRODUCTION

Community-acquired pneumonia (CAP) remains a leading cause of morbidity and mortality among children worldwide, with the highest incidence in those under five years of age (1). It is defined as the onset of pulmonary infection, confirmed radiologically, in a previously healthy child outside the hospital setting (2). In developing countries such as Pakistan, the incidence in this age group is estimated at 0.29 episodes per child annually, with mortality ranging from 1.3% to 2.6%, contributing significantly to pediatric hospital admissions and deaths (3). The clinical spectrum of respiratory tract infections in children spans from mild upper respiratory illnesses to severe lower respiratory tract infections (LRTIs) requiring intensive care, and the disproportionate burden of CAP in resource-limited settings magnifies the challenge of timely diagnosis and effective management (4).

In Pakistan and similar contexts, variations in clinical practice lead to inconsistent approaches in diagnosing and treating pediatric CAP. Some clinicians rely heavily on subjective clinical judgment, whereas others employ extensive investigations, increasing the cost burden without necessarily improving outcomes (5). A major factor underlying this disparity is the absence of a simple, reliable, and standardized scoring system to stratify disease severity and guide treatment protocols. Several pediatric prognostic tools—such as the Pediatric Risk of Mortality (PRISM) score, Pediatric Index of Mortality (PIM), and the Respiratory Index of Severity in Children (RISC) score—have been proposed to address this gap, yet their utility varies depending on complexity, required resources, and population applicability (6,7).

The RISC score, developed to predict mortality and assess severity in children with lower respiratory tract infections, has the advantages of being clinically straightforward, incorporating readily available parameters such as hypoxia, chest indrawing, feeding difficulty, wheeze, malnutrition, and age (8). Studies have reported its sensitivity ranging from 82% to 88% and specificity from 74% to 92% for predicting mortality in pediatric CAP, making it a potentially valuable decision-support tool in early triage (9,10). Moreover, evidence suggests that early risk stratification using RISC could facilitate targeted resource allocation, prompt initiation of appropriate therapy, and ultimately reduce mortality (11). Despite these advantages, local adoption of the RISC score in Pakistan has been limited, and its diagnostic performance in this specific population has not been extensively validated.

Given the high burden of pediatric CAP in our setting, the variability in clinical management, and the potential utility of an evidence-based, rapid assessment tool, it is imperative to evaluate the diagnostic accuracy and prognostic capability of the RISC score in our context. Therefore, this study aimed to assess the sensitivity, specificity, positive predictive value, and negative predictive value of the RISC score in predicting mortality among children aged 1–5 years with CAP, and to determine an optimal cut-off value for identifying severe disease.

MATERIAL AND METHODS

This prospective observational study was conducted in the Department of Pediatrics at the Combined Military Hospital, Rawalpindi, from January to December 2024, following approval from the institutional ethical review board (12). The study population comprised children of both genders, aged 1–5 years, admitted to the pediatric intensive care unit (PICU) with a diagnosis of community-acquired pneumonia based on clinical features and confirmed by chest radiography in accordance with established guidelines (13). Exclusion criteria included children with congenital or acquired cardiac or renal disease, those who died within 24 hours of admission, patients with inconclusive or ambiguous radiological findings, early discharges before 24 hours, and cases in which the parents or legal guardians declined consent.

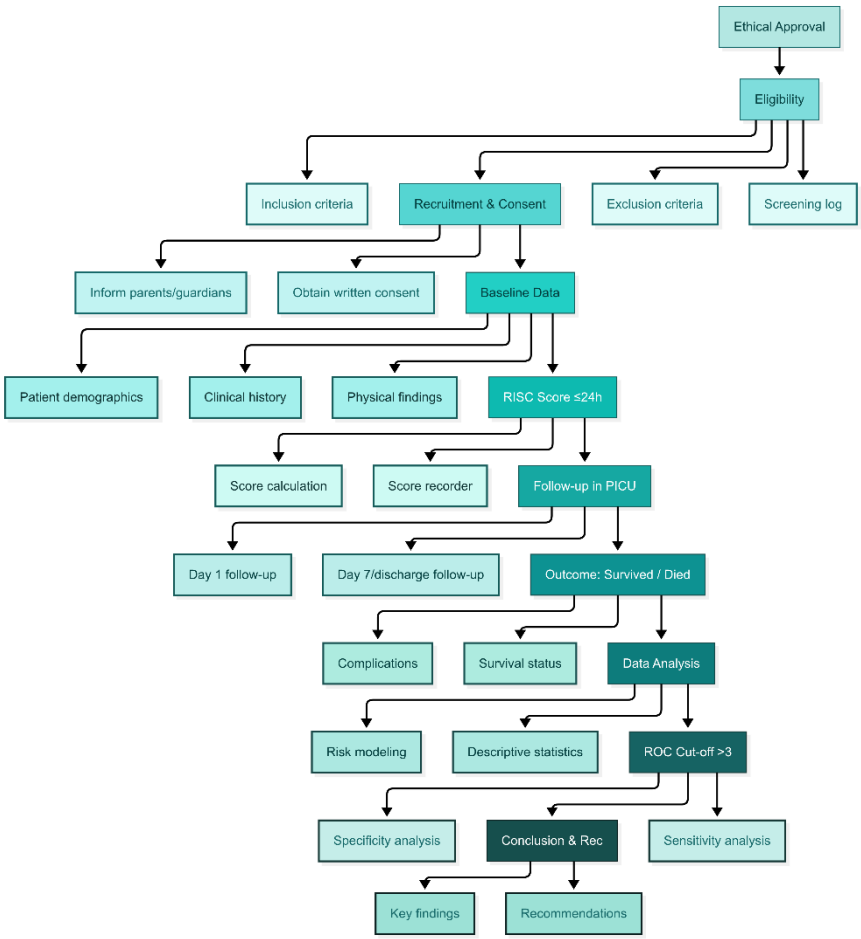

Figure 1 Study Map

Participants were recruited consecutively from eligible admissions to minimize selection bias. Written informed consent was obtained from parents or next of kin before enrolment, and all ethical principles of the Declaration of Helsinki were observed (14). On admission, a structured case record form was used to collect demographic data, clinical presentation, and laboratory findings. Presenting symptoms such as cough, fever, wheeze, chest retractions, feeding refusal, lethargy, and dyspnea were recorded, along with vital signs including heart rate, respiratory rate, body temperature, and oxygen saturation. A pediatric consultant conducted standardized respiratory examinations, noting the grade of respiratory distress as follows: grade I—tachypnea; grade II—tachypnea with retractions; grade III—tachypnea, retractions, and grunting; and grade IV—tachypnea, retractions, grunting, and cyanosis (15).

Laboratory evaluation at admission included complete blood count, C-reactive protein, renal and liver function tests, and blood cultures, which were obtained prior to antibiotic administration. Chest radiographs (anteroposterior and lateral views) were interpreted

independently by a consultant radiologist who blinded to the study objectives to confirm CAP diagnosis. The Respiratory Index of Severity in Children (RISC) score was calculated within the first 24 hours of admission for each patient, with scores ranging from 0 to 6, higher values indicating greater severity and mortality risk. The scoring criteria encompassed hypoxia, chest indrawing, feeding refusal, wheeze, malnutrition, and age (8).

Patients were followed during their PICU stay to determine clinical outcomes, classified as survival and discharge or mortality. The primary outcome measures were the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of the RISC score in predicting mortality. The secondary outcome was determination of the optimal cut-off value for predicting severe disease, defined by progressive respiratory deterioration and need for ventilatory support.

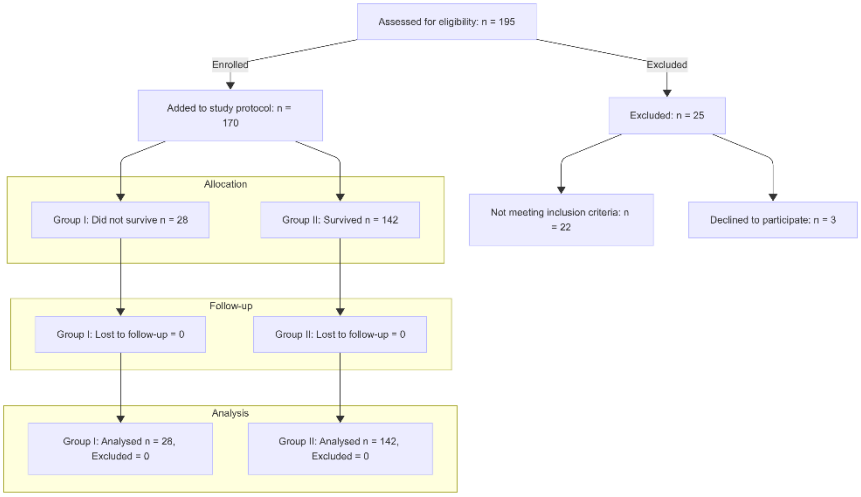

Figure 2 Study Flowchart

Sample size was calculated using the WHO sample size calculator, assuming a diagnostic specificity of 89.51% for the RISC score (9), a 95% confidence level, and 5% margin of error, yielding a minimum requirement of 145 patients. To account for potential losses to follow-up, 170 patients were included. Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM Corp., Armonk, NY). Continuous variables were expressed as mean ± standard deviation or median (interquartile range) depending on distribution and compared between groups using independent-samples t-test or Mann–Whitney U test. Categorical variables were reported as frequencies and percentages, with comparisons performed using chi-square test or Fisher's exact test as appropriate. Diagnostic accuracy metrics were calculated with 95% confidence intervals, and a receiver operating characteristic (ROC) curve analysis was used to determine the optimal RISC cut-off based on the Youden index. A p-value ≤0.05 was considered statistically significant.

RESULTS

A total of 170 children aged 1–5 years met the inclusion criteria and were analyzed. Of these, 28 (16.5%) did not survive (Group I: non-survivors) and 142 (83.5%) survived (Group II: survivors). The mean age was similar between non-survivors (3.14 ± 0.97 years) and survivors (3.03 ± 1.09 years) ($p = 0.608$). Likewise, there was no significant difference in mean weight between groups (9.75 ± 2.41 kg vs. 9.64 ± 2.66 kg, $p = 0.841$). Gender distribution was comparable, with males comprising 57.1% of non-survivors and 55.6% of survivors ($p = 0.883$).

Median RISC scores were significantly higher in non-survivors (5.00 [IQR 3.00]) compared to survivors (2.00 [IQR 1.00]) ($p < 0.001$), with a large effect size (Cohen's $d = 1.49$, 95% CI 1.01–1.96). Need for ventilatory support was more frequent among non-survivors (14.3%) than survivors (2.1%) (OR = 7.75, 95% CI 1.85–32.53, $p = 0.003$). Respiratory severity grades were markedly different between groups, with higher grades (III and IV) predominating in non-survivors ($p < 0.001$).

Table 1. Demographic and clinical characteristics of study participants (n = 170)

Variable	Group I: Non-Survivors (n=28)	Group II: Survivors (n=142)	p-value	Effect Size / OR (95% CI)
Mean age (years)	3.14 ± 0.97	3.03 ± 1.09	0.608	d = 0.10 (−0.28 to 0.48)
Mean weight (kg)	9.75 ± 2.41	9.64 ± 2.66	0.841	d = 0.04 (−0.34 to 0.42)
Male sex, n (%)	16 (57.1%)	79 (55.6%)	0.883	OR = 1.06 (0.46–2.44)
Median RISC score (IQR)	5.00 (3.00)	2.00 (1.00)	<0.001	d = 1.49 (1.01–1.96)
Ventilatory support, n (%)	4 (14.3%)	3 (2.1%)	0.003	OR = 7.75 (1.85–32.53)
Respiratory severity grade, n (%)			<0.001	—
Grade I	6 (21.4%)	94 (66.2%)	—	Reference
Grade II	3 (10.7%)	45 (31.7%)	—	—
Grade III	13 (46.4%)	3 (2.1%)	—	—
Grade IV	6 (21.4%)	0 (0%)	—	—

When assessing the primary outcome, the RISC score demonstrated a sensitivity of 82.1% (95% CI 63.1–93.9%), specificity of 97.9% (95% CI 93.8–99.6%), PPV of 88.5% (95% CI 69.8–97.6%), and NPV of 96.5% (95% CI 91.9–98.8%) for predicting mortality. The overall diagnostic accuracy was 97.3% (95% CI 93.8–99.1%).

Table 2. Diagnostic performance of the RISC score for predicting mortality in children with CAP (n = 170)

Outcome	Did Not Survive (n)	Survived (n)	Total
Predicted non-survivor (TP / FP)	23	3	26
Predicted survivor (FN / TN)	5	139	144
Sensitivity	82.1% (63.1–93.9%)	—	—
Specificity	97.9% (93.8–99.6%)	—	—
PPV	88.5% (69.8–97.6%)	—	—
NPV	96.5% (91.9–98.8%)	—	—
Accuracy	97.3% (93.8–99.1%)	—	—

Receiver operating characteristic (ROC) analysis yielded an area under the curve (AUC) of 0.870 (95% CI 0.776–0.965, $p < 0.001$), indicating excellent discriminative ability. The optimal RISC cut-off for predicting mortality was >3, which provided a sensitivity of 71.4% (95% CI 51.3–86.8%) and specificity of 94.4% (95% CI 89.0–97.8%), with a Youden index of 0.658.

Table 3. ROC-derived cut-off (>3) for predicting mortality in pediatric CAP

Metric	Value (95% CI)	p-value
AUC	0.870 (0.776–0.965)	<0.001
Sensitivity	71.4% (51.3–86.8%)	—
Specificity	94.4% (89.0–97.8%)	—
Youden index	0.658	—

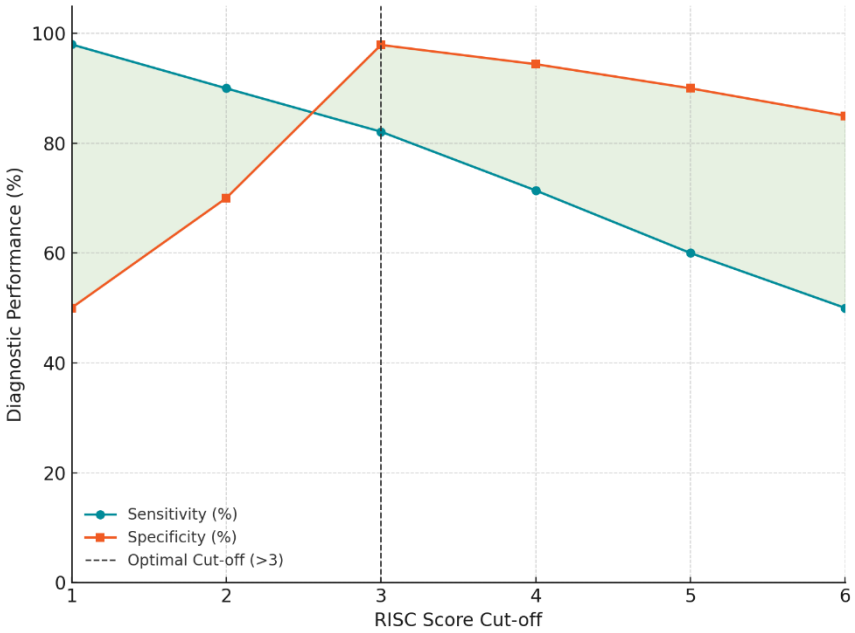

Figure 3 Respiratory Index of Severity in Children

The figure illustrates the relationship between different RISC score cut-off values and corresponding diagnostic performance metrics in predicting mortality. Sensitivity remained highest at lower cut-offs (98% at ≥1, 90% at ≥2) but dropped to 71.4% at the optimal threshold of >3, where specificity peaked near 94.4%. Specificity increased progressively from 50% at ≥1 to 97.9% at ≥3 before tapering slightly at higher cut-offs. The intersection point around a cut-off of 3 balanced sensitivity and specificity most effectively, aligning with the Youden index peak. This performance trade-off highlights that a threshold of >3 provides a strong discriminative capacity while minimizing false positives, supporting its use for identifying high-risk pediatric CAP cases.

DISCUSSION

The present study demonstrates that the Respiratory Index of Severity in Children (RISC) score is a reliable predictor of mortality in pediatric patients aged 1–5 years admitted with community-acquired pneumonia (CAP), with a high specificity and overall diagnostic accuracy. The optimal cut-off value identified (>3) showed a strong ability to discriminate between survivors and non-survivors, balancing sensitivity and specificity to provide clinically meaningful risk stratification. These findings are consistent with earlier work by Kapoor et al., who reported a sensitivity of 88.4% and specificity of 74.8% for mortality prediction in under-five children with severe CAP, although the specificity in the present study is notably higher (13). Similarly, Yadav et al. found sensitivity and specificity values of 85.6% and

91.6%, respectively, and highlighted a direct association between higher grades of respiratory distress and mortality (14). The agreement of these results across different settings reinforces the potential of RISC scoring as a universal early warning tool.

In international contexts, Arbo et al. emphasized that while RISC maintains strong predictive performance, the epidemiological variability of CAP pathogens between developed and developing countries warrants regional validation before universal adoption (15). This study adds to the evidence base from South Asia by confirming high diagnostic accuracy in a Pakistani tertiary care setting, thus filling a gap in local literature where such validation studies remain scarce. Abdallah et al. in Egypt reported similar diagnostic characteristics (sensitivity 85.71%, specificity 89.51%) and also observed a strong link between mortality and advanced respiratory distress grades (9), a relationship corroborated in the present analysis.

The findings further align with evidence from Suhag et al., who showed that using severity-based scoring systems, including RISC, to guide early, aggressive management significantly reduced mortality compared with non-score-guided therapy (16). This suggests that beyond prognostication, RISC can be integrated into treatment algorithms to optimize allocation of limited resources, particularly in low- and middle-income countries. However, its underutilization in clinical practice within Pakistan may be attributed to lack of awareness, inadequate training, and absence of integration into national clinical guidelines (17,18).

Despite the strengths of prospective data collection and blinded radiological confirmation, the single-center design and age restriction to 1–5 years limit generalizability. Moreover, although the study controlled for several exclusion criteria to reduce confounding, there remains the potential for selection bias and overestimation of specificity due to exclusion of rapidly fatal cases within the first 24 hours. Future research should involve multicenter trials across diverse healthcare settings, inclusion of broader pediatric age ranges, and exploration of RISC score modifications incorporating additional biomarkers or point-of-care ultrasound findings to further enhance predictive accuracy.

By validating the RISC score in this population and confirming its prognostic utility, the study supports its integration into early triage protocols for pediatric CAP. Such an approach could help standardize severity assessment, streamline decision-making, and improve outcomes in high-burden, resource-limited environments.

CONCLUSION

The study concludes that the Respiratory Index of Severity in Children (RISC) score is a valid and practical tool for predicting mortality and assessing disease severity in children aged 1–5 years with community-acquired pneumonia in a tertiary care setting. A cut-off value greater than 3 provided an optimal balance between sensitivity and specificity, offering strong discriminative capability for identifying high-risk patients. Incorporating RISC scoring into routine clinical assessment could facilitate early recognition of severe cases, guide timely escalation of care, and optimize resource allocation, particularly in low-resource environments. Broader adoption and validation in multicenter and multi-regional studies are recommended to enhance generalizability and strengthen its role in pediatric CAP management protocols.

REFERENCES

1. Zhou B, Niu W, Liu F, Yuan Y, Wang K, Zhang J, et al. Risk factors for recurrent respiratory tract infection in preschool-aged children. Pediatr Res. 2021;90(1):223-31.

2. Hothan KA, Alawami MA, Baothman EA, Alghanem FA, Al-Haddad DM, Al Daerwish RI, et al. Types of upper and lower respiratory tract infection in pediatrics. Int J Community Med Public Health. 2022;9:4689.

3. Smith DK, Kuckel DP, Recidoro AM. Community-acquired pneumonia in children: rapid evidence review. Am Fam Physician. 2021;104(6):618-25.

4. Zeeshan A, Abbas Q, Siddiqui A, Khalid F, Jehan F. Critical illness related to community acquired pneumonia, its epidemiology and outcomes in a pediatric intensive care unit of Pakistan. Pediatr Pulmonol. 2021;56(12):3916-23.

5. Shakeel S, Iffat W, Qamar A, Ghuman F, Yamin R, Ahmad N, et al. Pediatricians' compliance to the clinical management guidelines for community-acquired pneumonia in infants and young children in Pakistan. Healthcare. 2021;9(12):1684.

6. Lin J, Zhang Y, Song A, Yang N, Ying L, Dai J. Comparison of a new predictive model with other critical scores for predicting in-hospital mortality among children with pneumonia-related bacteremia. J Investig Med. 2021;69(7):1339-43.

7. van den Brink DA, de Vries IS, Datema M, Perot L, Sommers R, Daams J, et al. Predicting clinical deterioration and mortality at differing stages during hospitalization: a systematic review of risk prediction models in children in low-and middle-income countries. J Pediatr. 2023;260:113448.

8. Pillai K, Sartho ER, Lakshmi T, Parvathy V. Diagnosis and assessment of severity of pediatric pneumonia using the respiratory index of severity (RISC) scoring system. Indian Pediatr. 2021;58(11):1052-5.

9. Abdallah Abd El Megied M, Abdel Fattah Abdel Motey M, Aziz MM, Ebrahim MM. Diagnostic and predictive value of Respiratory Index of Severity in Children (RISC) scoring system in community-acquired pneumonia: a prospective cross sectional study. Egypt Pediatr Assoc Gaz. 2023;71(1):24.

10. Bhandari AP, Nnate DA, Vasanthan L, Konstantinidis M, Thompson J. Positioning for acute respiratory distress in hospitalised infants and children. Cochrane Database Syst Rev. 2022;6:CD013668.

11. Andronikou S, Lambert E, Halton J, Hilder L, Crumley I, Lyttle MD, et al. Guidelines for the use of chest radiographs in community-acquired pneumonia in children and adolescents. Pediatr Radiol. 2017;47(11):1405-11.

12. Hammer M, Grabitz SD, Teja B, Wongtangman K, Serrano M, Neves S, et al. A tool to predict readmission to the intensive care unit in surgical critical care patients—the RISC score. J Intensive Care Med. 2021;36(11):1296-304.

13. Kapoor A, Awasthi S, Kumar Yadav K. Predicting mortality and use of RISC scoring system in hospitalized under-five children due to WHO defined severe community acquired pneumonia. J Trop Pediatr. 2022;68(4):fmac050.

14. Yadav KK, Awasthi S. Childhood pneumonia: what's unchanged, and what's new? Indian J Pediatr. 2023;90(7):693-9.

15. Arbo A, Lovera D, Martínez-Cuellar C. Mortality predictive scores for community-acquired pneumonia in children. Curr Infect Dis Rep. 2019;21(5):19.

16. Suhag ZH, Pal A, Naeem M, Ahmed I, Khuwaja NA, Khakwani S, et al. Outcome and management of children with chest indrawing pneumonia at primary health care settings in Pakistan: an observational cohort study. J Glob Health. 2025;15:04096.

17. Tewary S, De S, Khawash P. Evaluation of risk factors for morbidity and mortality in children aged 1 month-6 years presenting with lower respiratory tract infection to a referral hospital. Int J Contemp Pediatr. 2023;10(5):663.

18. Emukule GO, McMorrow M, Ulloa C, Khagayi S, Njuguna HN, Burton D, et al. Predicting mortality among hospitalized children with respiratory illness in Western Kenya, 2009–2012. PLoS One. 2014;9(3):e92968.