

## Diagnosis and Assessment of Severity of Pediatric Pneumonia Using the Respiratory Index of Severity (RISC) Scoring System

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**Objectives:** To evaluate the correlation between the Respiratory Index of Severity (RISC) scoring system and the World Health Organization (WHO) interpretation of chest radiographs, and to evaluate the RISC scoring system in the diagnosis and assessment of severity of pneumonia in children against chest X-ray. **Methods:** 241 children presenting to a tertiary care center with a clinical diagnosis of pneumonia that necessitated a chest radiograph to be taken, were enrolled. The RISC scoring was done for all participants by a single pediatrician and chest X-ray graded by a single radiologist as per the WHO interpretation of chest radiographs. **Results:** There was a statistically significant positive correlation ( $P=0.02$ ) between the two scores. RISC score of  $>1$  had a sensitivity of 80.3%, and score  $\geq 3$  had a specificity of 88.3%, positive predictive value of 61.3% and negative predictive value of 76.8% for diagnosis and to predict severity of pneumonia. **Conclusion:** In a resource-limited setting, RISC scoring can be used to diagnose and predict the severity of childhood pneumonia.

**Keywords:** Community-acquired pneumonia, Severity, X-ray chest.

The Respiratory Index of Severity (RISC) scoring was formulated in South Africa to provide a standardized means of quantifying severity of respiratory illness among children during epidemiologic studies [1]. This score has a negative score for wheezing, which potentially excludes children with wheezing, a probable drawback of the Integrated Management of Childhood Illness (IMCI) developed by the World Health Organization (WHO).

The gold standard for diagnosis of pneumonia is the chest X-ray (CXR). In an attempt to improve the consistency of CXR interpretation between epidemiological studies, the WHO standardized the interpretation of CXRs for the diagnosis of pneumonia in children [2,3]. The CXR interpretation exercise was done and validated under WHO [4]. If the RISC scoring system correlates well with CXR, this scoring system could be of use in resource-poor settings where CXR is not routinely available. The aim of the study was to evaluate the correlation between the RISC scoring system and the WHO interpretation of chest radiographs. It also aims to evaluate the RISC scoring system in the diagnosis and assessment of severity of pneumonia in children by validating it against the CXR.

### METHODS

This descriptive study was undertaken at a semi-urban tertiary care hospital in India from 1 February, 2018 to 31 July,

2018. The study was approved by the institutional ethics committee and informed consent from parents was taken prior to enrollment. Consecutive patients aged 1 month to 12 years, who visited the pediatric OPD and/or got admitted in the pediatric ward with a clinical diagnosis of pneumonia by the treating doctor, and which necessitated a chest radiograph to be taken, were enrolled for the study. Exclusion criteria were subjects with documented congenital heart disease, chronic respiratory illness, congenital lung problems, immunosuppressive conditions or known to have neuromuscular disorders with respiratory system involvement.

For calculation of sample size, prevalence of lower acute respiratory infection was taken as 28% [5]. At significance level of 5%, with 20% relative precision, and power of the study 80%, sample size was calculated as 240. To allow for potential recruitment failure rate, 285 children were assessed for eligibility for enrollment in the study.

A detailed history was taken and respiratory system examination done for all subjects, and RISC scoring for HIV non-infected children [1] was done by the principal investigator. Variables in the RISC score represent known risk factors for severe outcomes of pneumonia in children, with a maximum score of 8 points.

CXR scoring was done by a single radiologist, as per the WHO interpretation of chest radiographs [2,4].

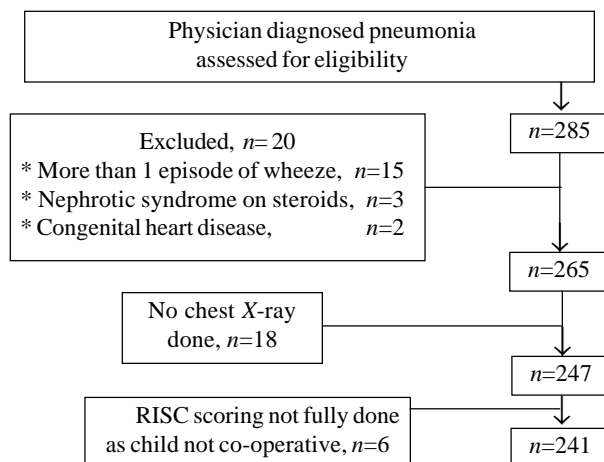
**Statistical analysis:** Analysis was done using Spearman rho ( $\bar{r}$ ) correlation to assess the correlation between RISC score and WHO CXR score. We divided the children into two groups by using the WHO CXR score of 3 (lobar pneumonia on X-ray) as a cut off. Group A with CXR score <3 were clinically suspected by physician but CXR was not suggestive of pneumonia, and group B with CXR score  $\geq$ 3, clinically suspected by physician and also CXR suggestive of pneumonia. By plotting the receiver operating characteristic (ROC) curve, we calculated specificity and sensitivity to determine the appropriate RISC score to diagnose and predict the severity of pneumonia. Analysis was done by Statistical Software Package for Social Sciences Version 23 (SPSS 23)

## RESULTS

A total of 285 children with physician-diagnosed pneumonia were assessed for eligibility to be enrolled in the study (**Fig. 1**). Out of these, 20 were excluded based on exclusion criteria and 18 were excluded as a CXR was not taken/available. A total of 241 children were finally included in the study.

Baseline clinical characteristics are presented in **Table I**. Of the study subjects 34 (14.1%) had a RISC score  $\geq$ 3 and 61 (25.3%) had a CXR score  $\geq$ 3.

There was a statistically significant positive correlation between RISC score and WHO CXR score ( $r=0.144$ ,  $P=0.025$ ). The ROC curve was plotted (**Fig. 2**). Taking WHO CXR score of  $\geq$ 3 (lobar pneumonia score 3) as severe pneumonia, a RISC score of  $>1$  had a sensitivity of 80.3% and specificity of 26.1%, suggesting it is a moderate screening test for pneumonia. A RISC score of  $\geq$ 3 had a sensitivity of 21.3% and specificity of 88.3% for diagnosis and to predict severity of pneumonia (**Table II**).



**Fig. 1** Study flow chart.

**Table I Clinical Profile, Respiratory Index of Severity (RISC) score, and Chest X-ray Score of Children With Physician-Diagnosed Pneumonia (N=241)**

Characteristics	No (%)
Male	142 (58.9)
Age	
1mo-1 y	96 (39.8)
1y-5y	112 (46.5)
5-12 y	33 (13.7)
Symptoms	
Fever	205 (85)
URI symptoms	223 (92)
Breathlessness	40 (16.5)
Feed refusal	219 (90.8)
Immunization as per NIS	239 (99.2)
Disease severity based on treatment	
Outpatient treatment	90 (37.3)
Admission as inpatient	140 (58.1)
Pediatric intensive care unit admission	11 (4.6)
CXR score	
1	141 (58.5)
2	39 (16.1)
3	42 (17.1)
4	16 (6.5)
5	3 (1.2)
RISC score	
1	59 (24.6)
2	148 (61.2)
3	6 (2.5)
4	26 (10.9)
$\geq$ 5	2 (0.8)

URI-Upper respiratory tract infection.

## DISCUSSION

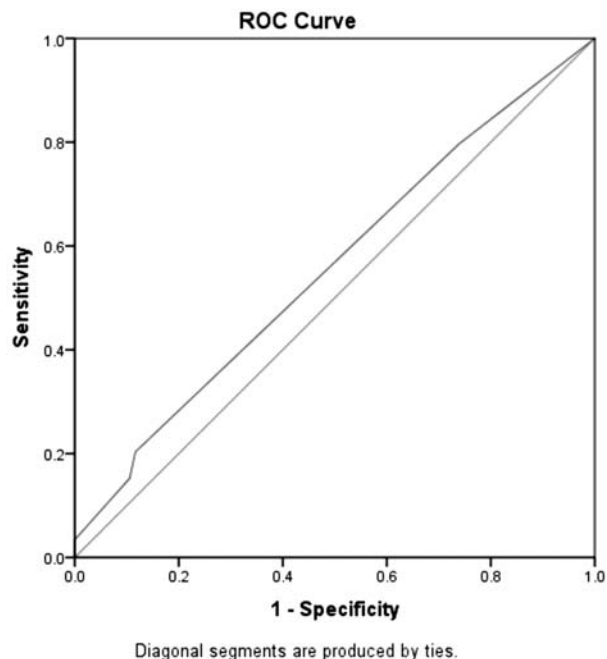
There are hardly any scoring systems which are validated for community-acquired pneumonia (CAP) in Indian children that would have high utility in resource-limited settings. We demonstrated a statistically significant correlation between RISC scoring system [1] and the WHO interpretation of chest radiographs [2].

Limitations of the study were that RISC score is not useful to differentiate between types of pneumonia based on etiology. RISC score is not useful to monitor resolution of symptoms. A negative score for wheeze (-2) may encourage false negatives. When developing detection tests, a balance must be chosen between risks of false negatives and false positives.

The major scoring systems designed to predict mortality risk and serve as guides for admission in community-acquired pneumonia (CAP) are for adults [6], and such scores

### WHAT THIS STUDY ADDS?

- In a resource-limited setting, where chest X-ray is unavailable, RISC scoring can be used for diagnosing and predicting the severity of community-acquired pneumonia.



**Fig. 2** ROC curve for Respiratory Index of Severity (RISC) scoring system in pediatric pneumonia.

for children are scarce [7,8]. Only the modified predisposition, insult, response and organ dysfunction (PIRO) score has so far been applied to children with CAP [6]. We used the RISC score for our study as it has six predictors for assessing the severity of pneumonia (hypoxia, chest indrawing, feed refusal, wheeze, malnutrition, age) and is easy to administer. Other risk models [9,10] are relatively cumbersome to administer.

The WHO introduced the Integrated Management of Childhood Illness (IMCI) to standardize and improve treatment and thus prevent major causes of death in children <5 years [10]. The first drawback of IMCI diagnostic criteria is of over-diagnosing pneumonia by including children with wheezing. In our study too, 36.5% of patients had a wheeze on presentation. However, the RISC scoring system overcomes this by giving a negative score for wheezing. The second drawback of IMCI is a missed diagnosis, as it has a low sensitivity [11,12].

Hooli, et al. [13] did an external validation of RISC by calculated classification performance measures at thresholds of 3 and 4. Using a RISC score of 3 had a

**Table II** Test Characteristics of the Respiratory Index of Severity (RISC) Score (N=241)

Characteristics <sup>a</sup>	RISC threshold score >1	RISC threshold score ≥3
Sensitivity (%)	80.3	21.3
Specificity (%)	26.11	88.3
PPV (%)	25.9	61.7
NPV (%)	79.6	76.8
Accuracy (%)	39.8	71.3

<sup>a</sup>Using CXR WHO score 3 as diagnosis of lobar pneumonia.

sensitivity of 59% and specificity of 78%. With a score threshold of 4, the sensitivity was 32.6% and specificity was 93.1%. A median RISC score of 1 corresponded with a risk of mortality of 0% (95% CI: 0%-0.6%) in the study by Reed, et al. [1]. In our study, using a RISC score of >1 had a higher sensitivity and was a moderate screening test to predict pneumonia.

Validation of Bacterial pneumonia score (BPS) score was done with multiplex PCR examinations of blood specimens by Imilda, et al. [14]. BPS had 69% sensitivity and 60% specificity, 42% positive predictive value, and 81% negative predictive value. In our study, which was validated with X-ray chest, a RISC score of ≥3 had a higher specificity and positive predictive value and almost similar negative predictive value for diagnosis and to predict severity of pneumonia.

To conclude, we propose that RISC score may be used for diagnosing pneumonia in resource-constrained areas to supplement IMCI protocols. Assessment of a combination of the two in community-based studies may provide additional information on this aspect.

*Ethics clearance:* Amala Institute of Medical Sciences; No. AIMSIEC/05/2018 dated January 22, 2018.

*Contributors:* KP: concept and design of the study; ERS: analyzed and collected data; drafted the manuscript; TPL: analyzing data; VKP: supervised cognitive and behavioral assessments. All authors approved the final version of manuscript, and are accountable for all aspects related to the study.

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