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Original Research Article

Performance of WHO-defined clinical criteria for diagnosing pneumonia in children with severe acute malnutrition

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ABSTRACT

Background: Severe acute malnutrition (SAM) and pneumonia are major contributors to childhood morbidity and mortality, particularly in developing countries. Malnourished children often exhibit a blunted inflammatory response, resulting in atypical clinical presentations that may delay the diagnosis of pneumonia. Evidence regarding the performance of the World Health Organization (WHO)-recommended respiratory rate cut-offs for diagnosing pneumonia in children with SAM remains limited. This study aimed to evaluate the diagnostic performance of WHO-defined clinical criteria for pneumonia among under-five children with severe acute malnutrition.
Methods: This prospective hospital-based observational study included 95 children aged 2–59 months with severe acute malnutrition who were admitted with suspected pneumonia. Chest radiography was performed in all participants. Seventy-five children with radiologically confirmed pneumonia were considered cases, while 20 children without radiological evidence of pneumonia served as controls. The diagnostic performance of WHO-defined fast breathing was evaluated by calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and likelihood ratios.
Results: WHO-defined fast breathing demonstrated a sensitivity of 77.3% (95% CI: 66.2–86.2%) and a specificity of 40.0% (95% CI: 19.1–64.0%) for diagnosing radiologically confirmed pneumonia in children with SAM. The positive predictive value was 82.9%, while the negative predictive value was 32.0%. Overall diagnostic accuracy was 69.5%.
Conclusions: WHO-defined respiratory rate criteria retain acceptable sensitivity for identifying pneumonia in children with severe acute malnutrition. The findings support the continued use of WHO clinical criteria in resource-limited settings; however, larger multicenter studies are warranted to further validate their diagnostic performance in this high-risk population.

Keywords: Severe acute malnutrition, Pneumonia, Under-five children, Respiratory rate, Fast breathing, World Health Organization

INTRODUCTION

Pneumonia remains the leading infectious cause of death among children under five years of age worldwide, accounting for approximately 16% of all under-five deaths.[1] Acute respiratory infections are responsible for nearly four million childhood deaths annually in developing countries and continue to pose a major public health challenge.[2] Children living in low- and middle-income countries experience the greatest burden of pneumonia, where the disease is frequently associated with malnutrition and limited access to healthcare.[3,4]

SAM affects nearly 20 million preschool children globally, with the highest prevalence reported in South Asia and sub-Saharan Africa. According to the national

family health survey (NFHS-3), approximately 6.4% of Indian children under five years of age suffer from SAM.[5] Malnutrition impairs both innate and adaptive immune responses, predisposing children to severe infections and increasing the risk of adverse clinical outcomes.

Children with SAM often exhibit a diminished inflammatory response, resulting in atypical manifestations of infections such as pneumonia. Consequently, classical clinical features, including fever, tachypnoea, and chest indrawing, may be less pronounced despite severe underlying disease.[13,14] This altered presentation may delay diagnosis and initiation of appropriate treatment, thereby increasing morbidity and mortality.

The WHO recommends the use of age-specific respiratory rate cut-offs and lower chest wall indrawing as key clinical criteria for the diagnosis of childhood pneumonia, particularly in resource-limited settings where radiographic facilities are unavailable. Although these criteria have been extensively validated in well-nourished children, their diagnostic performance in children with severe acute malnutrition remains uncertain, with published studies reporting inconsistent findings.[9,16,18]

Given the high burden of pneumonia-related mortality among malnourished children, it is essential to determine whether the existing WHO clinical algorithm remains reliable in this vulnerable population. The present study was therefore undertaken to evaluate the diagnostic accuracy of WHO-defined respiratory rate criteria for identifying radiologically confirmed pneumonia among children aged 2–59 months with severe acute malnutrition admitted to a tertiary care hospital.

METHODS

Study design and setting

This prospective hospital-based observational study was conducted in the Department of Pediatrics, Kalawati Saran Children's Hospital, New Delhi, over a period of 18 months after obtaining approval from the Institutional Ethics Committee of Lady Hardinge Medical College. Written informed consent was obtained from the parents or legal guardians of all enrolled children before participation.

Study population

Children aged 2 to 59 months admitted with severe acute malnutrition (SAM) and suspected pneumonia were screened for eligibility. Severe acute malnutrition was diagnosed according to the World Health Organization (WHO) criteria.

A total of 95 children with SAM were enrolled in the study. Of these, 75 children with radiologically confirmed pneumonia constituted the case group, while 20 children without radiological evidence of pneumonia served as the control group.

Inclusion criteria

Children aged 2–59 months. Severe acute malnutrition as per WHO criteria. Informed consent obtained from parents or caregivers.

Exclusion criteria

Children with congenital heart disease. Children with chronic respiratory disorders. Children with congenital anomalies affecting the respiratory system. Children whose caregivers declined consent.

Clinical assessment

A detailed clinical evaluation was performed at admission. Demographic details, medical history, respiratory symptoms, and physical examination findings were recorded using a predesigned case record form.

Respiratory rate was measured according to WHO recommendations after the child had been calm for at least one minute. Fast breathing was defined using age-specific WHO respiratory rate cut-offs.

The clinical signs were recorded fast breathing, lower chest wall indrawing, use of accessory muscles, oxygen saturation measured by pulse oximetry, hypoxemia was defined as oxygen saturation <92%.

Chest radiography

Chest radiographs were obtained for all enrolled children, preferably within 24 hours of admission. Radiographs were interpreted independently by an experienced pediatrician using standardized diagnostic criteria. Radiological pneumonia was defined by the presence of air-space consolidation or alveolar infiltrates on chest radiography. Radiological findings served as the reference standard for diagnosing pneumonia.

Statistical analysis

Data were entered into Microsoft Excel and analyzed using open-source statistical software.

Continuous variables were summarized as mean±standard deviation, whereas categorical variables were expressed as frequencies and percentages. The diagnostic performance of WHO-defined fast breathing was assessed by calculating: sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio, negative likelihood ratio, overall diagnostic accuracy. Receiver operating characteristic

(ROC) curve analysis was performed to evaluate the ability of respiratory rate to predict radiologically confirmed pneumonia. A p value <0.05 was considered statistically significant.

RESULTS

Diagnostic performance of WHO-defined fast breathing

WHO-defined fast breathing demonstrated moderate sensitivity in identifying radiologically confirmed pneumonia among children with severe acute malnutrition. The sensitivity was 77.3% (95% CI: 66.2–86.2%), while the specificity was 40.0% (95% CI: 19.1–64.0%). The positive predictive value was 82.9%, indicating that children meeting the WHO respiratory rate criteria were highly likely to have radiological pneumonia. However, the negative predictive value was relatively low (32.0%), suggesting that absence of fast breathing did not reliably exclude pneumonia. The overall diagnostic accuracy of WHO-defined fast breathing was 69.5%. The positive likelihood ratio was 1.29, whereas the negative likelihood ratio was 0.57.

Association between fast breathing and oxygen saturation

Among children without fast breathing, 29.4% had oxygen saturation below 92%, compared with 37.9% among those with fast breathing. No statistically significant association was observed between fast breathing and hypoxemia (p=0.57), indicating that respiratory rate alone was not a reliable predictor of oxygen desaturation in children with severe acute malnutrition.

Receiver operating characteristic analysis

ROC curve analysis was performed to determine whether respiratory rate could accurately predict radiologically confirmed pneumonia in children with severe acute malnutrition.

The ROC curve demonstrated that respiratory rate had only moderate discriminatory ability for diagnosing pneumonia, suggesting that although WHO respiratory rate cut-offs remain clinically useful, respiratory rate alone may not be sufficient for definitive diagnosis. Clinical assessment should therefore be complemented with chest radiography whenever feasible.

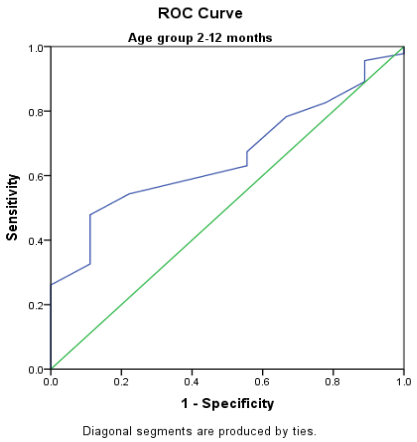

Figure 1: Receiver operating characteristic curve demonstrating the diagnostic performance of respiratory rate for identifying radiologically confirmed pneumonia among children with severe acute malnutrition.

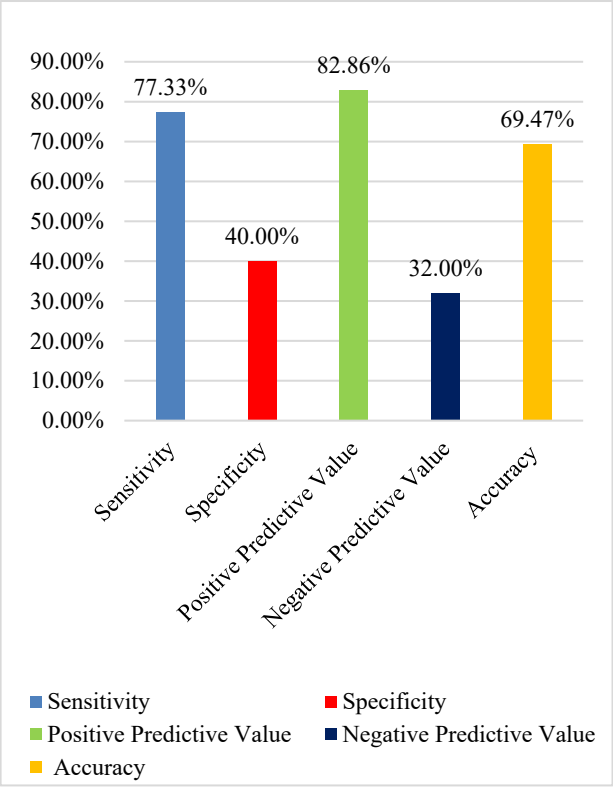

Figure 2: Diagnostic accuracy of fast breathing to predict pneumonia.

Table 1: Association between oxygen saturation and WHO-defined fast breathing among children with severe acute malnutrition.

Oxygen saturation	Fast breathing absent N (%)	Fast breathing present N (%)	Total
<92%	5 (29.4)	22 (37.9)	27
≥92%	12 (70.6)	36 (62.1)	48

P=0.57.

Table 2: Diagnostic performance of WHO-defined fast breathing for diagnosing radiologically confirmed pneumonia.

Parameter	Estimate	95% confidence interval
Sensitivity	77.33%	66.21–86.21
Specificity	40.00%	19.12–63.95
Positive predictive value	82.86%	76.80–87.59
Negative predictive value	32.00%	19.25–48.17
Diagnostic accuracy	69.47%	59.18–78.51
Positive likelihood ratio	1.29	0.88–1.88
Negative likelihood ratio	0.57	0.29–1.12

DISCUSSION

The present prospective hospital-based study evaluated the diagnostic performance of the WHO-defined respiratory rate criteria for identifying radiologically confirmed pneumonia among children with SAM. The findings demonstrate that WHO-defined fast breathing remains a reasonably sensitive clinical indicator of pneumonia in this vulnerable population, with a sensitivity of 77.3% and a specificity of 40.0%. Pneumonia is a major cause of mortality among children with severe acute malnutrition. Malnutrition impairs both innate and adaptive immune responses, resulting in atypical clinical manifestations of infection. Consequently, the reliability of WHO clinical criteria for diagnosing pneumonia in malnourished children has been questioned. The present study was undertaken to determine whether the currently recommended WHO respiratory rate cut-offs remain valid in children with SAM. In the present study, chest radiography was performed in all enrolled children, and radiological pneumonia was defined by the presence of air-space opacification on chest radiograph interpreted by an experienced pediatrician. Radiography was used as the reference standard, thereby reducing the likelihood of misclassification based solely on clinical findings.

WHO-defined fast breathing demonstrated a sensitivity of 77.3%, which is comparable to the findings reported by Cherian et al who observed a sensitivity of approximately 75% among children with acute lower respiratory tract infection.[9] Their study included both well-nourished and malnourished children and reported that the diagnostic performance of WHO clinical criteria was not significantly influenced by nutritional status. In fact, they observed a trend toward greater sensitivity among malnourished children, probably because chest retractions are more easily appreciated in children with marked wasting. In an earlier study conducted by Cherian et al both clinical as well as radiological pneumonia cases were included. They defined it as acute lower respiratory tract infection as characterised by presence of bronchial breath sounds, crepitation, rhonchi or wheeze on auscultation or an abnormal chest roentgenogram. Even the radiological abnormality was more diverse and included pulmonary consolidation, alveolar or interstitial infiltrates in the lungs, hyperinflation of the lungs (in children with wheeze) or fluid or air in the pleural space. Authors did not include hyperinflation as radiological endpoint. Cherian et al reported a comparable sensitivity of found 75% for WHO defined age related cut offs for fast breathing in under 6 years age group.[9] Further, their study group had both malnourished children and children with normal nutritional 7888\/status. The reported sensitivity and specificity of the clinical signs currently recommended in the WHO case management algorithm were not found to be different with change in nutritional status. In fact, there was a trend toward greater sensitivity of the WHO algorithm in detecting acute lower respiratory tract infection in malnourished children.[9]

In contrast, Falade et al reported that malnourished children tend to have lower baseline respiratory rates than well-nourished children and suggested reducing the WHO respiratory rate thresholds by five breaths per minute to improve diagnostic sensitivity.[16] They concluded that the existing WHO respiratory rate cut-offs may underestimate pneumonia in malnourished children. However, our findings do not support this recommendation, as the observed sensitivity of the current WHO criteria was comparable to that reported in adequately nourished child While Falade et al also defined pneumonia on clinical as well as radiological basis like Cherian et al but they reported that malnourished children do breathe at a slower rate than well-nourished children.

With the stress of pneumonia their breathing rate increases at a similar rate, but with malnourished children the final level reached is lower. They suggested that if raised respiratory rate and lower chest wall indrawing are to be used to predict pneumonia in 3 months to 5 years aged malnourished children, the respiratory rate cut-off should be 5 breaths per minute lower than that used for well-nourished children. This would improve the sensitivity to 76% (117/154) while the specificity would fall to 66% (276/419). They concluded that fast breathing, as defined at present by WHO is not sufficiently sensitive as predictor of pneumonia in malnourished children. Among the malnourished

children, a history of cough, fast breathing or difficult breathing was associated significantly with the presence of pneumonia (p value<0.001 for each).[16] Wafula et al reported a considerably lower sensitivity (37%) but higher specificity (85%) for fast breathing in severely malnourished children. Differences between their findings and ours may be attributed to variations in study design, patient characteristics, disease severity, and radiological interpretation.[18] These differences highlight the need for additional multicentre studies using standardized diagnostic criteria. Wafula et al also evaluated the diagnostic utility of commonly used clinical indicators of pneumonia among children with severe malnutrition in children with radiological changes consistent with pneumonia (reported by an experienced radiologist).

Contrary to the findings, they reported that the sensitivity of fast breathing was only 37% in severely malnourished children below the age of five years and specificity of 85%. They reported that all the commonly used clinical parameters performed poorly as diagnostic tests for pneumonia among children with severe malnutrition so it's advisable to treat children with severe malnutrition as if they had pneumonia, even in the absence of suggestive clinical signs.[18] Authors also evaluated other clinical indicators of pneumonia. Lower chest wall indrawing was observed in more than half of the children with radiologically confirmed pneumonia, indicating that this sign remains an important component of the clinical assessment. Accessory muscle use was present in nearly half of the study participants and appeared to reflect more severe respiratory disease rather than serving as an early diagnostic sign.

As a secondary analysis, we assessed the relationship between clinical signs and hypoxemia. Although fast breathing was common among hypoxemic children, no statistically significant association was observed between WHO-defined fast breathing and oxygen saturation at presentation. This finding differs from studies conducted in Bangladesh, where fast breathing and lower chest wall indrawing were identified as significant predictors of hypoxemia in severely malnourished children. Differences in patient characteristics, sample size, and disease severity may explain these discrepancies. To conclude, the study did not find the sensitivity of the WHO defined respiratory rate cut-offs in children with Severe acute malnutrition and pneumonia to be any less than the historical controls for adequately nourished children.

Strengths

The present study has several strengths. All enrolled children underwent chest radiography within 24 hours of admission, and radiographs were interpreted using standardized criteria by an experienced pediatrician. The prospective design minimized recall bias, and uniform clinical assessment enhanced the reliability of the findings.

Limitations

This study has certain limitations. It was conducted at a single tertiary care center with a relatively small sample size, which may limit the generalizability of the findings. The specificity of WHO-defined fast breathing was relatively low, indicating that respiratory rate alone cannot reliably distinguish pneumonia from other respiratory illnesses in children with SAM. Furthermore, chest radiography, although considered the reference standard in this study, may fail to detect early or subtle pulmonary infiltrates. Larger multicenter studies comparing malnourished and well-nourished children are required to further validate these findings.

CONCLUSION

The present study demonstrates that WHO-defined respiratory rate criteria retain acceptable sensitivity for identifying radiologically confirmed pneumonia among children with severe acute malnutrition. Although specificity was relatively low, fast breathing remains a useful screening tool in resource-limited settings where radiological facilities are unavailable. The findings support continued use of the current WHO clinical algorithm for the initial diagnosis of pneumonia in children with SAM. However, clinical assessment should be supplemented with chest radiography whenever feasible, and larger multicentre studies are needed to optimize diagnostic strategies in this high-risk population.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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