

Acute Illness Observation Scale as a Bedside Predictor of Radiological Abnormality, Hypoxaemia and Disease Severity in Children Aged 2–59 Months with Acute Lower Respiratory Tract Infection: A Hospital-Based Observational Study

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Abstract:

Background: Acute lower respiratory tract infection (ALRTI) is a leading cause of childhood morbidity and mortality in resource-limited settings, where rapid bedside risk stratification is often needed before radiography or laboratory results. This study evaluated the association of the Acute Illness Observation Scale (AIOS), a simple six-item observational tool, with chest radiographic findings, pulse oximetry and disease severity in children aged 2–59 months with ALRTI.

Methods: A hospital-based descriptive observational study was conducted in the Department of Pediatrics of a tertiary care teaching hospital in Udaipur, Rajasthan, over 18 months. Eighty-three consecutively admitted children aged 2–59 months with WHO-defined ALRTI were enrolled. AIOS was scored at admission and categorised as mild (≤ 10), moderate (11–15) and severe (≥ 16). Chest radiography, pulse oximetry and WHO severity classification were recorded. Associations were tested using the chi-square test, one-way ANOVA and Pearson/Spearman correlation, with $p < 0.05$ considered significant.

Results: The mean age was 26.61 ± 17.25 months, with a male preponderance (55.4%); 63.8% were malnourished. A severe AIOS score (≥ 16) was present in 71.1% of children. Abnormal chest radiographs occurred in 96.6% of children with AIOS ≥ 16 versus 22.2% with AIOS ≤ 10 ($\chi^2 = 41.82$, $p < 0.001$). AIOS correlated strongly and inversely with oxygen saturation ($r = -0.72$, $p < 0.001$) and positively with WHO severity ($r = 0.68$, $p < 0.001$). An AIOS ≥ 16 showed 100% sensitivity and 42.9% specificity for severe pneumonia and was the strongest independent predictor of severe disease on multivariate analysis (adjusted OR 6.84; 95% CI 2.41–19.42).

Conclusion: AIOS is a rapid bedside tool that reliably reflects radiological involvement, hypoxaemia and clinical severity in children with ALRTI, and may aid early identification of children at risk of severe disease in resource-limited settings.

Keywords: Acute Illness Observation Scale; acute lower respiratory tract infection; children; pulse oximetry; chest radiography; pneumonia severity.

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Introduction

Acute lower respiratory tract infection (ALRTI), predominantly pneumonia, is among the leading infectious causes of death in children younger than five years, with the burden concentrated in low- and middle-income countries including India.[1] Pneumonia and diarrhoea have long been the leading causes of global child mortality, and scaling up existing interventions is one of the greatest opportunities in child health.[2] Early recognition of severe disease is therefore central to reducing

avoidable mortality where diagnostic infrastructure is limited.

The determinants of ALRTI are well characterised. Respiratory syncytial virus and other viral pathogens cause most episodes, with prematurity, low birth weight, male sex, crowding, lack of breastfeeding and maternal smoking among the recognised risk factors,[3] while Indian community data additionally implicate undernutrition, incomplete

immunisation, indoor air pollution and low socioeconomic status.[4] Preterm infants and children in low-income settings carry a disproportionate share of severe viral ALRTI and hospitalisation.[5][6]

Hypoxaemia is the principal complication driving death in childhood pneumonia, and pulse oximetry identifies high-risk children missed by clinical danger signs alone.[7] Yet reliable oxygen monitoring and delivery are often unavailable at the primary and first-referral levels, and sustainable oxygen systems are hard to implement at scale,[8] while even where oximetry is introduced its incremental value must be weighed against cost.[9] Simple, equipment-independent bedside tools therefore remain valuable for triage.

The Acute Illness Observation Scale, derived from the Yale Observation Scale, grades six observable variables—quality of cry, reaction to parental stimulation, state variation, colour, hydration and response to social overtures—for a total score of 6 to 30. Structured assessment of clinical appearance was developed to predict serious illness in febrile children,[10] later refined for the febrile infant with the score thresholds used today,[11] and incorporated into schemes for evaluating fever without a focus.[12] A randomised trial showed that structured teaching of the scale improved the reliability and specificity of caregivers' illness judgements.[13] The scale thus offers a rapid means of quantifying how unwell a child appears, although its performance in isolation has been variable, prompting interest in how well it aligns with objective markers such as radiographic abnormality and oxygen saturation.

Chest radiography, though imperfect as a stand-alone reference standard, remains an important adjunct for confirming pulmonary involvement in hospitalised children,[14] but is subject to intra- and inter-observer variation even with standardised criteria,[15] further supporting the search for simple bedside measures of severity. This study was undertaken to determine the correlation of AIOS with chest radiographic findings and oxygen saturation, and its relationship with WHO severity classification and clinical outcomes in children aged 2–59 months admitted with ALRTI.

Methods

Design and Setting: This hospital-based descriptive observational study was conducted in the Department of Pediatrics of Geetanjali Medical College and Hospital, Udaipur, Rajasthan—a tertiary care teaching hospital serving urban and rural populations—over an 18-month period. The study was approved by the institutional ethics committee, and written informed consent was

obtained from a parent or guardian of each child before enrolment.

Participants and Sampling: Consecutive children aged 2 months to 59 months admitted with a diagnosis of ALRTI according to WHO criteria (fever and cough with age-specific fast breathing, with or without chest retractions) were screened for eligibility. Children with bronchial asthma, respiratory illness of more than two weeks' duration, known congenital or acquired cardiac disease, or chronic lung disease (for example bronchopulmonary dysplasia or cystic fibrosis) were excluded, as were children whose parents declined consent. Consecutive sampling was used, and 83 eligible children were enrolled and analysed.

Instruments and Data Collection: History, demographic data and examination findings were recorded on a pre-structured proforma, and nutritional status classified by WHO growth standards. Oxygen saturation was measured by pulse oximetry at admission, and chest radiography, complete blood count and C-reactive protein were performed in all children. The AIOS was scored at admission before definitive treatment, using six variables each graded 1, 3 or 5 (total 6–30), categorised as mild (≤ 10), moderate (11–15) and severe (≥ 16).[11] Severity was classified by the WHO pneumonia classification, and children were followed through admission for mechanical ventilation, duration of stay, complications and discharge status.

Data Analysis: Data were entered in Microsoft Excel and analysed using SPSS version 20. Continuous variables were summarised as mean $\pm$ standard deviation and categorical variables as frequencies and percentages. Associations between categorical variables were tested using the chi-square test, differences in mean AIOS across groups using one-way ANOVA, and the relationship of AIOS with oxygen saturation and with WHO severity using Pearson and Spearman correlation, respectively. Multivariate logistic regression was used to identify independent predictors of severe pneumonia. A p-value < 0.05 was considered statistically significant.

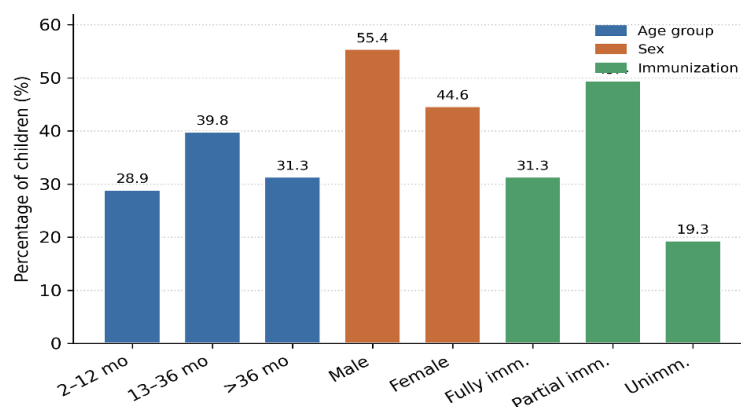
Results

Demographic Profile: Eighty-three children aged 2–59 months were enrolled and analysed. The mean age was 26.61 ± 17.25 months, with the largest group aged 13–36 months (39.8%). Males predominated slightly (55.4% vs 44.6%; ratio 1.24:1). Around three-quarters belonged to lower socioeconomic strata, and immunisation was suboptimal—49.4% partially immunised, 31.3% fully immunised and 19.3% unimmunised (Table 1, Figure 1).

Table 1: Demographic profile of the study population (N = 83).

Variable	Category	n	%
Age group	2–12 months	24	28.9
	13–36 months	33	39.8
	>36 months	26	31.3
Sex	Male	46	55.4
	Female	37	44.6
SES	Upper / upper-middle	20	24.1
	Lower-middle	27	32.5
	Upper-lower / lower	36	43.4
Immunisation	Fully immunised	26	31.3
	Partially immunised	41	49.4
	Unimmunised	16	19.3

Note: SES = socioeconomic status (modified Kuppuswamy classification).

**Figure 1: Demographic profile of the study population (N = 83).**

Note: Values are percentages within each characteristic.

Nutritional Status: Undernutrition was highly prevalent: 37.3% had moderate and 26.5% severe acute malnutrition, so that 63.8% were malnourished overall and only 36.1% had normal nutritional status.

Clinical Symptoms and Signs: Fast breathing (89.2%), cough (85.5%) and fever (79.5%) were the commonest presenting features. On examination,

tachypnoea (89.2%), crepitations (69.9%) and chest retractions (62.7%) predominated (Table 2). Signs of respiratory distress clustered in the more severely scored children—chest retractions were present in 71.2% of the AIOS ≥ 16 group versus 22.2% of the mild group, and nasal flaring, grunting, decreased air entry and cyanosis occurred almost exclusively at higher AIOS scores.

Table 2: Clinical symptoms and signs among the study population (N = 83).

Feature	n	%
Fast breathing / tachypnoea	74	89.2
Cough	71	85.5
Crepitations	58	69.9
Fever	66	79.5
Chest retractions	52	62.7
Wheeze / rhonchi	31	37.3
Lethargy	29	34.9
Nasal flaring	28	33.7
Decreased air entry	24	28.9
Grunting	18	21.7
Cyanosis	11	13.3

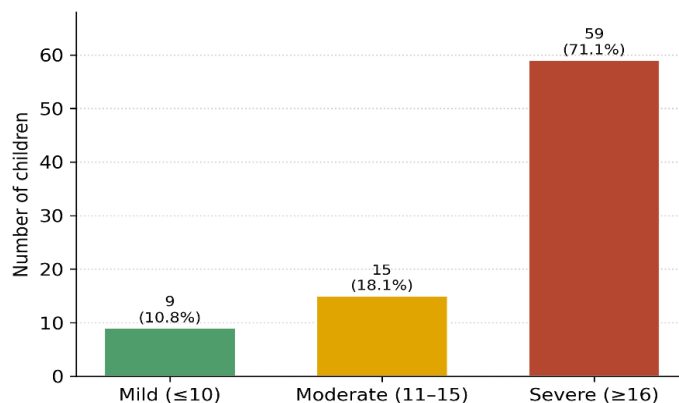
Note: More than one feature may be present in a child; percentages do not sum to 100.

WHO severity classification and AIOS distribution: By WHO classification, 67.5% had pneumonia and 32.5% severe pneumonia. AIOS scores were skewed towards severe illness: 71.1% scored ≥ 16 , 18.1% scored 11–15 and 10.8% scored ≤ 10 , with a mean of 17.42 ± 4.36 (Table 3, Figure 2).

Table 3: Distribution of AIOS score category at admission (N = 83).

AIOS category	Interpretation	n	%
≤10	Mild	9	10.8
11–15	Moderate	15	18.1
≥16	Severe	59	71.1
Total		83	100

Note: Mean AIOS score = 17.42 ± 4.36 .

**Figure 2: Distribution of AIOS score category at admission (N = 83).**

Note: Figures above bars indicate the number and percentage of children in each category.

Mean AIOS declined significantly with age, from 19.63 ± 3.84 in infants aged 2–12 months to 15.54 ± 4.31 in those older than 36 months (ANOVA, $p = 0.003$), so younger children presented with greater illness severity.

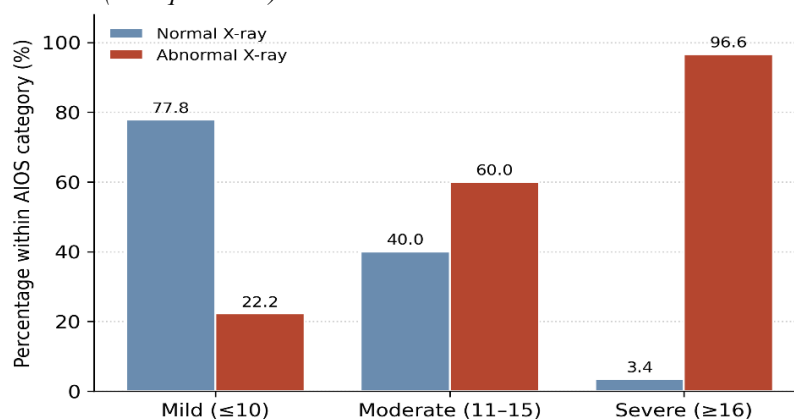
Chest radiographic findings and their association with AIOS: Abnormal chest radiographs were present in 81.9% of children, the commonest findings being hyperinflation (30.1%), patchy

infiltrates (24.1%) and opacities (20.5%). Mean AIOS was higher with abnormal films (19.85 ± 7.79 vs 14.93 ± 3.37 ; $p = 0.019$). Radiological abnormality rose steeply across AIOS categories—22.2% (mild), 60.0% (moderate) and 96.6% (severe) ($\chi^2 = 41.82$, $p < 0.001$) (Table 4, Figure 3); all patchy infiltrates, opacities and effusions occurred in the AIOS ≥ 16 group.

Table 4: Association between AIOS category and chest radiographic abnormality (N = 83).

AIOS category	Normal X-ray n (%)	Abnormal X-ray n (%)	Total
≤10 (Mild)	7 (77.8)	2 (22.2)	9
11–15 (Moderate)	6 (40.0)	9 (60.0)	15
≥16 (Severe)	2 (3.4)	57 (96.6)	59
Total	15 (18.1)	68 (81.9)	83

Note: $\chi^2 = 41.82$, $p < 0.001$ (chi-square test).

**Figure 3: Chest X-ray abnormality by AIOS category ($\chi^2 = 41.82$, $p < 0.001$; N = 83).**

Note: Bars show the percentage of children with normal and abnormal chest radiographs within each AIOS category.

Association of AIOS with pulse oximetry: Oxygen saturation showed a strong graded relationship with AIOS. Among children with AIOS ≥ 16 , 57.6% had saturation of 85–91% and 20.3% below 85%,

whereas none of the mild group fell below 92% (χ^2 , $p < 0.001$) (Table 5). AIOS correlated strongly and inversely with saturation ($r = -0.72$, $p < 0.001$); all children with saturation below 92% had abnormal radiographs.

Table 5: Association between AIOS category and oxygen saturation (SpO₂) at admission (N = 83).

AIOS category	$\geq 95\%$ n (%)	92–94% n (%)	85–91% n (%)	$< 85\%$ n (%)
≤ 10 (Mild)	7 (77.8)	2 (22.2)	0	0
11–15 (Moderate)	4 (26.7)	7 (46.7)	4 (26.7)	0
≥ 16 (Severe)	1 (1.7)	12 (20.3)	34 (57.6)	12 (20.3)
Total	12 (14.5)	21 (25.3)	38 (45.8)	12 (14.5)

Note: χ^2 , $p < 0.001$ (chi-square test).

AIOS also correlated positively with WHO severity (Spearman $r = 0.68$, $p < 0.001$): no child scoring ≤ 15 had severe pneumonia, whereas 45.8% of the AIOS ≥ 16 group did.

AIOS and clinical outcomes: Higher AIOS categories were consistently associated with adverse outcomes. Mechanical ventilation was needed in 39.0% of the AIOS ≥ 16 group (95.8% of all

ventilated children; $p < 0.001$), and mean hospital stay rose from 3.11 ± 1.05 days (mild) to 8.94 ± 3.18 days (severe; $p < 0.001$). Persistent day-5 distress (44.1%) and complications (52.5%) were concentrated in the severe group (both $p < 0.001$), and children who died had a higher admission AIOS score (24.25 ± 2.06) than those discharged (17.08 ± 4.12) (Table 6).

Table 6: Clinical outcomes by AIOS category (N = 83).

Outcome	AIOS ≤ 10	AIOS 11–15	AIOS ≥ 16
Required MV, n (%)	0	1 (6.7)	23 (39.0)
Persistent distress day 5, n (%)	0	2 (13.3)	26 (44.1)
Complications, n (%)	0	2 (13.3)	31 (52.5)
Mean LOS, days	3.11	5.47	8.94

Note: MV = mechanical ventilation; LOS = length of stay. All associations $p < 0.001$.

Independent predictors and diagnostic accuracy:

On multivariate regression, AIOS ≥ 16 was the strongest independent predictor of severe pneumonia (adjusted OR 6.84; 95% CI 2.41–19.42),

followed by SpO₂ $< 92\%$ (OR 5.27), severe undernutrition (OR 3.74) and age < 12 months (OR 2.19) (Table 7). As a screening test, AIOS ≥ 16 showed 100% sensitivity, 42.9% specificity and 61.4% accuracy for severe pneumonia.

Table 7: Independent predictors of severe pneumonia on multivariate logistic regression.

Variable	Adjusted OR	95% CI	p-value
AIOS ≥ 16	6.84	2.41–19.42	< 0.001
SpO ₂ $< 92\%$	5.27	1.88–14.76	0.002
Severe undernutrition	3.74	1.42–9.86	0.008
Age < 12 months	2.19	1.01–5.94	0.041

Note: OR = adjusted odds ratio; CI = confidence interval.

Discussion

In this cohort of 83 children aged 2–59 months admitted with ALRTI, a severe AIOS score at admission was strongly associated with radiological abnormality, hypoxaemia and WHO-defined severity, and independently predicted severe pneumonia and adverse clinical outcomes. These findings support the use of AIOS as a rapid bedside triage aid, particularly where objective assessment tools are not immediately available.

The steep gradient of radiological abnormality across AIOS categories (22.2% to 96.6%) mirrors

reports that clinical severity features correlate closely with chest radiographic findings in severe community-acquired pneumonia,[16] and accords with Indian emergency-department data in which tachypnoea, retractions, fever and low saturation predicted hospital admission.[17] That all patchy infiltrates, opacities and effusions occurred in the AIOS ≥ 16 group reinforces the value of a bedside score that tracks radiographic involvement when imaging is delayed or unavailable.

The strong inverse correlation between AIOS and oxygen saturation ($r = -0.72$) is relevant because hypoxaemia is the dominant pathway to death in

childhood pneumonia. Hypoxia on admission independently predicts prolonged recovery and treatment failure,[18] and hypoxaemia and raised lactate predict mortality alongside age ≤ 12 months,[19] a pattern paralleling the predictors found here (AIOS ≥ 16 , SpO₂ $< 92\%$, severe undernutrition, age < 12 months). An equipment-independent score that flags likely hypoxaemia could strengthen referral where oximetry is not consistently available.

The concentration of adverse outcomes in high-AIOS children is consistent with wider evidence: impaired consciousness and danger signs markedly raise the risk of death in WHO-defined pneumonia,[20] hypoxaemia is common across paediatric respiratory illness in low- and middle-income settings and carries nearly fivefold higher odds of death,[21] and multi-country severity scores show that a small set of features—hypoxaemia, low weight-for-height, young age, impaired responsiveness—discriminates well between survivors and non-survivors.[22]

The performance profile—100% sensitivity but 42.9% specificity for severe pneumonia—fits an appearance-based screening instrument. Early work showed the Yale Observation Scale alone did not reliably detect serious illness in febrile infants,[23] and a large multicentre cohort found neither the score nor clinician suspicion reliably identified invasive bacterial infection.[24] AIOS is therefore best used to rule out severe disease and flag children needing closer evaluation rather than to confirm severity alone; here it captured all severe cases at the expected cost of lower specificity. It is best interpreted alongside pulse oximetry and, where available, chest radiography, and integrating it with selective oximetry could improve early identification of severe disease at modest additional cost.[25]

Limitations

This was a single-centre study with a relatively small, hospital-based sample of 83 children, so the findings may not be generalisable to outpatient or community settings, or to neonates and older children. Because only admitted children were studied, the spectrum of illness was weighted towards severe disease, which may have inflated the proportion with high AIOS scores. Chest radiograph interpretation is itself subject to observer variation, and microbiological aetiology and inflammatory biomarkers were not systematically evaluated. Post-discharge follow-up was not performed, limiting assessment of long-term outcomes. Larger multicentre studies with serial AIOS measurements are needed to confirm these observations and to establish standardised cut-offs for severity prediction.

Conclusion

In children aged 2–59 months admitted with ALRTI, the Acute Illness Observation Scale is a simple, rapid bedside tool that reflects radiological involvement, hypoxaemia and clinical severity. A severe AIOS score was the strongest independent predictor of severe pneumonia and was associated with greater need for mechanical ventilation, longer hospitalisation, more complications and poorer outcomes. Used alongside pulse oximetry and chest radiography, AIOS may support early risk stratification, timely referral and appropriate management of children with lower respiratory tract infection, especially in resource-limited settings.

Declarations

Ethics approval and consent: The study was approved by the institutional ethics committee. Written informed consent was obtained from a parent or guardian of each participating child.

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