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ORIGINAL ARTICLE

HYPOXEMIA WITH PNEUMONIA IN UNDER FIVE CHILDREN: A HOSPITAL-BASED STUDY IN DHAKA, BANGLADESH

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Abstract

Background: *Pneumonia causes significant child morbidity and mortality globally, especially in developing countries. Hypoxemia is a critical complication in pediatric pneumonia and a key indicator of severe disease needing urgent medical intervention. This study aimed to investigate the clinical predictors of hypoxemia in children with pneumonia.* ***Methods:*** *This is a cross-sectional comparative study was conducted at Sir Salimullah Medical College & Mitford Hospital, Dhaka, Bangladesh, from January to December 2022. A total of 394 children aged 2-59 months with pneumonia were purposively enrolled. Of these, 132 (33.5%) had hypoxemia, while 262 (66.5%) did not. All demographic, diagnostic, and clinical data were recorded and analyzed usingSPSS version 22.0.* ***Results:*** *In univariate analysis, hypoxic status correlated significantly with vomiting, fast breathing, inability to drink, unusual sleepiness($p<0.05$), unconsciousness / lethargy, immobility during examination ($p<0.001$),abnormal sleepiness, and palm pallor($p<0.05$). Indicators included nasal flaring, chest indrawing, head nodding, continuous grunting, diminished breath sounds ($p<0.05$),and heart rate ($p<0.001$)..Sensitivity was higher for heart rate, fast breathing, palm pallor, and chest indrawing. Specificity was higher for vomiting, lethargy/unconsciousness, unusual sleepiness, head nodding , grunting, and nasal flaring.*
Conclusion: *Among children with pneumonia, nearly one-third may behypoxic, with a higher frequency in females. Sensitivity for predictors of hypoxemia is better in fast breathing, pallor of the palm, lower chest indrawing, and increased heart rate. Specificity is better in persistent vomiting, lethargy, unusual sleepiness, head nodding, grunting, and nasal flaring.*

Keywords*: Clinical predictors, Hypoxemia in Children, Pneumonia, Fast breathing, Nasal flaring*
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Introduction:

Pneumonia is the leading cause of death in young children worldwide, with the highest number of cases occurring annually in the Asia-Pacific region.[1] Hypoxia, which is generally defined as a peripheral oxygen saturation of less than 90%, is a frequent complication in childhood pneumonia and is an important marker of its severity.[2] Hypoxemia is partial arterial oxygen pressure below 8.0 kPa (60 mmHg) or SpO2 less than 90% by pulse oximetry.[3] It results from a ventilation-

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perfusion mismatch due to alveolar congestion from fluid or inflammatory cells caused by infection.[4] Prolonged hypoxemia in children with pneumonia can worsen the illness duration and increase mortality.[5] Oxygen therapy can reduce mortality in children with hypoxic pneumonia by 20%, but detecting hypoxemia is difficult where pulse oximetry is inconsistent.[6] Case management helps identify severe cases in resource-limited settings for in-patient treatment.[7] The revised Integrated Management of Childhood Illness (IMCI) guidelines of 2013 categorize pneumonia into two types: pneumonia with fast breathing and/or chest indrawing, treatable at home with oral amoxicillin, and severe pneumonia with any general danger sign, requiring hospital referral and injectable therapy.[8] The WHO recommends using clinical signs to detect hypoxemia when pulse oximetry is unavailable.[9] Children presenting to healthcare facilities are classified as having mild, moderate, or severe pneumonia based on clinical parameters.[10] This classification, following IMCI principles with some variations, guides decisions on hospital admission, antibiotics, and oxygen therapy. While case management in resource-poor countries reduces overall and pneumonia-specific mortality, it has limitations, including over-referral and accurate recognition of hypoxemia.[11] The clinical criteria are designed to be highly sensitive to identify cases needing hospitalization and antibiotics. However, this can lead to unnecessary referrals, which are costly for parents and offer limited benefits to the child.[12] Studies have shown that detecting hypoxemia using clinical signs is sub-optimal, and pulse oximetry is the preferred method for assessing the need for and response to oxygen therapy.[13]

Methods:

This was a prospective observational study that was conducted at Sir Salimullah Medical College & Mitford Hospital, Dhaka, Bangladesh, from January 2022 to December 2022. A total of 394 children, aged between 2 and 59 months and diagnosed with pneumonia, were selectively enrolled in the study. Out of these, 132 children (33.5%) exhibited hypoxemia, while the remaining 262 children (66.5%) did not. The hospital's ethical committee approved the study, and informed consent was obtained from all participants before data collection. The entire intervention adhered to the principles of human research outlined in the Helsinki Declaration[14] and was conducted following current regulations and GDPR provisions.[15] The inclusion criteria encompassed children aged 2-59 months suffering from pneumonia, based on the WHO guidelines of 2005,who were attending the Pediatrics OPD, Emergency Department, or In-patient Department of Sir Salimullah Medical College & Mitford Hospital in Dhaka. The exclusion criteria included children younger than 2 months or 60 months and older, any patient having precordial murmur, a history of repeated breathlessness improved with bronchodilators, and playful children with breathlessness and rhonchi. Data were collected and recorded using a structured questionnaire, with interviews conducted personally by the investigator. Oxygen saturation levels were measured with a pulse oximeter (NONIN Model 7500,USA). Sensitivity specificity and predictive values of the clinical findings significantly associated with hypoxemia in pneumonia were generated based on the standard formula. For data analysis, SPSS version 16.0 was utilized. In the statistical analysis, a P value of less than 0.05 was considered indicative of significance.

Results:

In this study, 394 subjects were interviewed and examined. Hypoxemia was diagnosed based on peripheral oxygen saturation measured via pulse oximetry, with 132 (33.5%) having hypoxemia and 262 (66.5%) not having it. Socio-demographic data and symptoms were collected through interviews, while general and respiratory signs were obtained through physical examination. Univariate analysis identified significant characteristics, that were further assessed for their predictive capacity using sensitivity, specificity, positive predictive value(PPV), and negative predictive value (NPV)

Table-I

Socio-demographic characteristics (n=394)

Variables	Hypoxic (n = 132)	Non-hypoxic (n = 262)	X^2	p-value
Age group				
2-11 months	89(67.4)	172(65.6)	0.124	0.725
≥12 months	43(32.6)	90(34.4)		
Sex				
Male	62(47.0)	182(69.5)	18.841	0.000
Femnale	70(53.0)	80(30.5)		
Residence				
Rural	39(29.5)	87(33.2)	3.329	0.189
Urban	46(34.8)	105(40.1)		
Semi-urban	47(35.6)	70(26.7)		

Table I shows that there was no statistically significant difference in age distribution between hypoxic and non-hypoxic subjects. However, more females were hypoxic than males. Both groups were homogeneous in terms of place of residence.

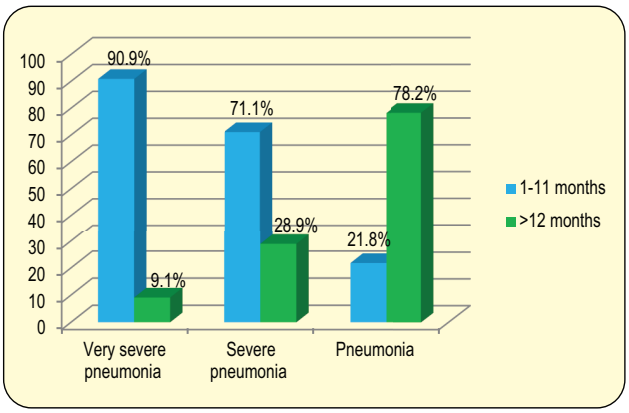

Figure 1: *Distribution of hypoxemia and non-hypoxemia among the cases.*

Among the 394 pneumonia cases, 132 (33.5%) had hypoxemia, while 262 (66.5%) did not (Figure 1).

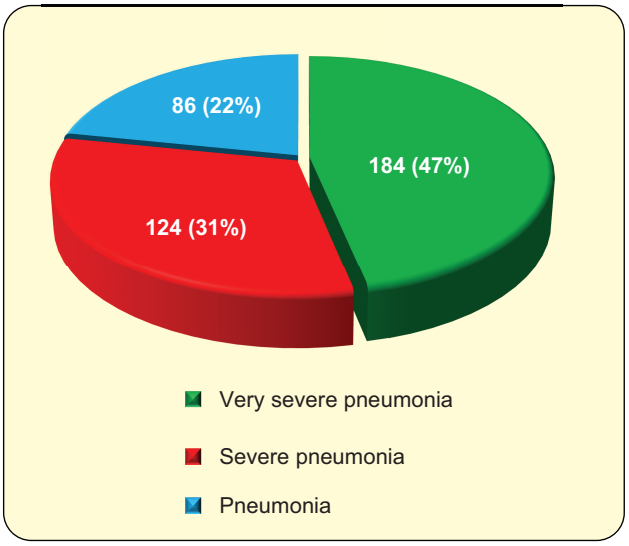

Figure 2: *Distribution of pneumonia cases according to severity.*

Figure 2 shows the distribution of pneumonia cases according to severity. Among the cases,very severe pneumnonia accounted for 46.7% (184 cases), severe pneumonia for 31.5% (124cases), and pneumonia for 21.8%(86 cases).

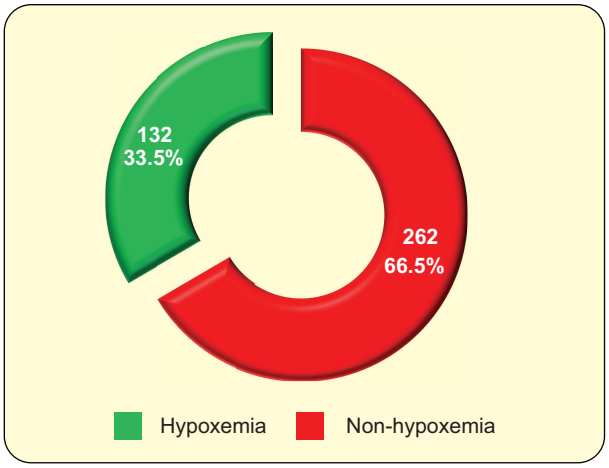

Figure 3: *Distribution of children by age and classification (N=394)*

Figure 3 shows the distribution of the study subjects by age and classification. Among the subjects with very severe pneumonia, 91% were less than 1 year of age. In children with severe pneumonia, 71.1% were less than 1 year old. In children with pneumonia, most (78.2%) were aged 12 months or older.

Table II

Comparison of sympto ms reported between hypoxic and non-hypoxic subjects

Characteristics	Hypoxemic (n = 132) n(%)	Non-hypoxemic (n = 262) (%)	X2	p-value
Cough		258(98.5)	2.036	0.154
Breathing difficulty		197(75.2)	2.205	0.138
Vomit everything		46(17.6)	10.291	0.001
Fast breathing		197(75.2)	4.075	0.044
Fever	132(100)	170(64.9)	0.154	0.695
Excess cry	108(81.8)	101(38.5)	2.129	0.145
	42(31.8)			
	111(84.1)			
	83(62.9)			
	61(46.2)			
	57(43.2)			
	60(45.5)			
	63(47.7)			
	33(25.0)			
Reduce feed		94(35.9)	1.681	0.159
Inability to drink		74(28.2)	11.584	0.001
Irritability		121(46.2)	0.084	0.772
Unusually sleepy		9(3.4)	42.862	0.000

Table II presents the univariate analysis of symptoms reported by informants. Symptoms such as vomiting everything(p=0.001),fast breathing(p=0044),inability to drink(p=0.001),and unusual sleepiness(p<0.001) were significantly associated with the hypoxic status of children.

Table III

Comparison of signs revealed on general examination among subjects with or without hypoxia

Characteristics	Hypoxemic (n = 132) n(%)	Non-hypoxemic (n = 262) (%)	X2	p-value
Unconscious/ Lethargic	60(45.5)	50(19.1)	30.332	0.000
Movement on examination	98(74.2)	258(98.5)	59.139	0.000
Abnormally sleepy	39(29.5)	4(1.5)	70.875	0.000
Ability to cry	112(74.2)	232(88.5)	1.085	0.298
Restless/ Irritable	79(59.8)	132(50.4)	3.163	0.075
Stridor in calm child	15(11.4)	25(9.5)	0.319	0.572
Pallor of palm	106(80.3)	179(68.3)	6.298	0.012
Temperature	50(37.9)	112(42.7)	0.86	0.354

Table III presents a comparison of signs revealed during the general examination of subjects with or without hypoxia. Univariate analysis indicates a significant association of the signs-unconsciousness or lethargy (p<0.001), absent movement during examination (p<0.001),abnormal sleepiness (p<0.001), and pallor of the palm (p=0.012)with hypoxic status.

Table IV presents a comparison of respiratory signs between subjects with and without hypoxia.Univariate analysis shows that nasal flaring (p=0.016), lower chest indrawing (p=0.005), head nodding (p<0.001), continuous grunting(p<0.001), and diminished breath sounds (p=0.04are significantly associated with hypoxic status.

Table V shows the distribution of study subjects by hypoxia status and respiratory rate across different age groups. In children aged 2-11 months, fast breathing was significantly morecommon in hypoxic subjects compared to non-hypoxic subjects(p<0.001). Similarly, in children aged 12-59 months, fast breathing was also significantly more frequent in hypoxic subjects than in non-hypoxic subjects (p=0.009).

Table IV

Comparison of respiratory signs between subjects with or without hypoxia

Characteristics	Hypoxemic (n = 132) n(%)	Non-hypoxemic (n = 262) (%)	X2	p-value
Nasal flaring	43(32.6)	56(21.4)	5.854	0.016
Lower chest in drawing	105(79.5)	173(66.0)	7.718	0.005
Head nodding		20(7.6)	31.29	0.000
Continued grunt		31(11.8)	20.272	0.000
Crepitating	39(28.8)	221(84.4)	1.881	0.170
Wheeze	40(30.3)	31(11.8)	1.274	0.259
	104(78.8)			
	21(15.9)			
	34(25.8)			
	54(40.9)			
Rhonchi		68(26.0)	0.002	0.966
Diminish breath sound		80.(30.5)	4.210	0.040
Bronchial breath sound	32(24.2)	57(21.8)	0.310	0.577
Stridor in calm child	15(11.4)	25(9.5)	0.319	0.572

Table V

Comparison of the presence or absence of fast breathing between subjects with or without hypoxemia

Characteristics	Hypoxemic (n=132)	Non-hypoxemic (n=262)	X2	p-value
Age:2-11 months				
<50/min	21(23.6)	82(47.7)	14.20	0.000
≥50/min	68(76.4)	90(52.3)		
Age:≥12 months				
<40/min	19(44.2)	61(67.8)	6.76	0.009
≥40/min	24(55.8)	29(32.2)		

Table VI

Comparison of non-respiratory physical signs in children with or without hypoxia

Characteristics	Hypoxemic (n=132)	Non-hypoxemic (n=262)	X2	p-value
Heart rate				
≥100	124(93.9)	262(100)	16.208	0.000
<100	8(6.1)	0(0.0)		
Capillary refill time				
<3 second	117(88.6)	240(91.6)	0.908	0.341
≥3 second	15(11.4)	22(8.4)		
Hepatomegaly				
<2cm	104(78.8)	199(76.0)	0.397	0.529
≥2cm	28(21.1)	63(24.0)		

Table VI presents a comparison of physical signs in children with and without hypoxia. The analysis indicates that hypoxic status is significantly associated only with heart rate(P<0001)

Table VII

Sensitivity, specificity, and predictive values found to have a significant association with hypoxia

Clinical predictors	Sensitivity %	Specificity	Predictive value Positive	Negative
Symptoms				
Vomit everything	31.8	82.4	47.7	70.6
Fast breathing	82.4	24.8	36.3	75.6
Inability to drink	45.5	71.8	44.8	72.3
General sign				
Lethargy	45.5	80.9	54.5	74.6
Movement	74.2	1.5	27.5	10.5
Unusually sleepy	29.5	98.5	90.7	73.5
Pallor of palm	80.3	31.7	37.2	76.2
Heart rate	93.9	0.0	35.4	0.0
Respiratory sign				
Nasal flaring	35.6	78.6	43.4	69.8
Chest indrawing	79.5	33.9	37.8	76.7
Head nodding	28.8	92.3	65.5	72.0
Continued grunting	30.3	88.2	56.3	71.5

Table VII analyzes the predictive capacity of clinical signs and symptoms in terms of sensitivity, specificity, and predictive values for hypoxemic and non-hypoxemic children. Sensitivity was higher for heart rate, fast breathing, pallor of the palm, and lower chest indrawing, while specificity was higher for symptoms like vomiting everything, lethargy/unconsciousness, unusual sleepiness , head nodding, grunting, and nasal flaring. No single characteristic excelled in both sensitivity and specificity.

Discussion:

In this study, 394 pneumonia cases were examined, and hypoxemia was confirmed in 132 cases (33.5%). This prevalence aligns well withBasnet et al.'s[16] finding of a 38%prevalence of hypoxemia. Very severe pneumonia was more frequent in the 2-11 months age group than in children aged 12 months or older, consistent with findings from other studies.[16,17] Additionally,this study showed that hypoxemia was more prevalent among young children aged less than 12 months, similar to another previous study[2], which also found a higher frequency of hypoxemia in infants compared to children aged 12 months or older. In the present study, symptoms reported by informants that showed a significant association with hypoxemia included persistent vomiting, fast breathing, and inability to drink, aligning with observations by Odeyemi et al.[18] Among these symptoms, the inability to drink had the highest sensitivity (45.5%) and specificity (71.8%) in this study. Among the general signs considered, lethargy, absent movement during examination, unusual sleepiness, pallor of the palm, and altered heart rate showed significant associations with hypoxemia. These findings are consistent with those of Basnet et al.[16], who also reported significant associations with lethargy and unresponsiveness. In the present study, lethargy exhibited a sensitivity of 45.5% and a specificity of 80.9%, making it a better predictor of hypoxemia in children with pneumonia than other general signs. This aligns with Usen et al.[19], who reported a sensitivity and specificity of 49% and 77%, respectively. Respiratory signs significantly associated with hypoxemia in the present study included nasal flaring, lower chest indrawing, head nodding,diminished breath sounds, tachypnea, and grunting. Similarly, Basnet et al.[16] identified nasal flaring, lower chest indrawing, cyanosis, tachypnea, crepitation, and grunting as significant predictors. In the present study, nasal flaring had a sensitivity of 35.6% and a specificity of 78.6%, comparable to Dyke et al.[20], who reported a sensitivity and specificity of 56% and 84%, respectively. In the present study, although the sensitivity of nasal flaring was low, its specificity was comparable to other studies. Lower chest indrawing demonstrated better sensitivity (79.5%) and specificity (33.9%) in our findings. Lozano et al.[17] reported similar results with a sensitivity of 83% and specificity of 40%. Only two cases of cyanosis were identified in this study. Consequently, the significant clinical predictors of hypoxemia were inability to drink, lethargy, nasal flaring, and lower chest indrawing. Among these, lethargy emerged as the best clinical predictor of hypoxemia in children with pneumonia aged 2-59months, with a sensitivity

of 45.5% and specificity of 80.9%. Clinical signs that predict hypoxemia can help identify children who need supplemental oxygen and should be referred to larger hospitals, thereby reducing morbidity. In centers where hypoxemic children are screened using physical signs for referral to higher facilities, these predictor signs can facilitate quicker and more accurate referrals.

Limitation of the study:

The study faced several limitations: not all patients could be recruited during emergency admissions, which could have enhanced the results. It was conducted at a single center and had a short duration due to time constraints, limiting its generalize ability. Additionally, confounding factors such as bronchiolitis, asthma, and other related conditions were inadequately addressed.

Conclusion:

Among children with pneumonia, nearly one-third may experience hypoxia, with a higher frequency observed in females. Predictors of hypoxemia show better sensitivity in the presence of fast breathing, pallor of the palms,lower chest indrawing, and increased heart rate.In contrast, specificity for hypoxemia is higher when symptoms such as persistent vomiting, lethargy, unusual sleepiness, head nodding, grunting, and nasal flaring are present.

Recommendations:

Inability to drink, lethargy, nasal flaring, and lower chest indrawing are clinical predictors of hypoxemia in pneumonia, though their sensitivity and specificity do not meet optimal expectations. Further studies with greater methodological rigor and consideration of all limitations are recommended to provide more conclusive evidence regarding hypoxemia in pneumonia. This can help improve diagnosis and treatment protocols, enhancing patient care in resource constrained settings

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Conflict of Interest:

No author has any conflict of interest to disclose for this manuscript. The authors themselves are responsible for their ideas and views expressed in this article, which do not necessarily represent the views, decisions or policies of the institutions with which they are affiliated.

Ethical Approval:

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Institutional Review Board of the Sir Salimullah Medical College. Written informed consent was taken from all the patients before taking part of the study.

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