



Hypoxaemia in Hospitalised Under-Five Nigerian Children with Pneumonia

L'Hypoxémie Chez les Enfants de Moins de Cinq ans Hospitalisés au Nigeria avec une Pneumonie

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ABSTRACT

BACKGROUND: Hypoxaemia constitutes a possible complication of severe respiratory illness which is often under-reported in developing countries. Therefore, the current study was carried out to determine the prevalence and clinical predictors of hypoxaemia in hospitalized under-five children with pneumonia in Ilorin, Nigeria.

METHODS: This is a descriptive cross-sectional study of 200 children aged between two months and five years with pneumonia recruited consecutively. Socio-demographic, clinical and laboratory data were obtained. The pulse oximetry measurement was recorded after a stable reading for at least one minute while the child was breathing room air. Hypoxaemia was defined as an arterial oxygen saturation of less than 90%. Data was analyzed using the SPSS 20.0 software.

RESULTS: The male/female ratio was 1.5:1. The prevalence of hypoxaemia in the children with pneumonia was 41.5%. Using a linear regression analysis, the clinical features that were significantly associated with hypoxaemia were restlessness, lower chest wall indrawing, bronchial breath sounds and tender hepatomegaly ($p < 0.05$ each). Restlessness had a sensitivity of 22.9%, specificity of 91.5%, while chest wall indrawing had a sensitivity of 86.7% and specificity of 53.3%. Bronchial breath sound had a sensitivity of 16.9%, a specificity of 95.7% whereas tender hepatomegaly had a sensitivity of 48.2% and specificity of 82.9%.

CONCLUSION: There is a high local burden of pneumonia-associated hypoxaemia. Restlessness, chest wall indrawing, bronchial breath sounds and tender hepatomegaly could be useful in detecting pneumonia-related hypoxemia in poorly equipped health facilities. *WAJM* 2014; 33(1): 37-43.

Keywords: Hypoxaemia, Children, Pneumonia.

ReSUMe

CONTEXTE: L'hypoxémie constitue une complication possible des maladies respiratoires grave qui sont souvent sous-estimées dans les pays en développement. Par conséquent, la présente étude a été menée afin de déterminer la prévalence et les indicateurs cliniques de l'hypoxémie chez les enfants hospitalisés de moins de cinq ans atteints de pneumonie à Ilorin, Nigeria.

Méthodes: Il s'agit d'une étude transversale descriptive de 200 enfants âgés de deux mois et cinq ans souffrant de pneumonie recrutés consécutivement. Les données socio-démographiques, cliniques et de laboratoire ont été obtenues. La mesure de l'oxymétrie a été enregistrée après une lecture stable pendant au moins une minute pendant que l'enfant respirait l'air ambiant. L'hypoxémie a été définie comme une saturation artérielle en oxygène inférieure à 90%. Les données ont été analysées à l'aide du logiciel SPSS 20.0.

Résultats: Le ratio hommes/femmes était 1.5:1. La prévalence de l'hypoxémie chez les enfants atteints de pneumonie était de 41,5%. Utilisant une analyse de régression linéaire, les caractéristiques cliniques qui étaient significativement associées à l'hypoxémie étaient : l'agitation, l'excavation thoracique, les souffles bronchiques et une hépatomégalie douloureuse ($p < 0,05$ chaque). L'agitation a une sensibilité de 22,9%, et une spécificité de 91,5%, tandis que le tirage paroi thoracique a une sensibilité de 86,7% et une spécificité de 53,3%. Le souffle bronchique a une sensibilité de 16,9%, et une spécificité de 95,7% alors que l'hépatomégalie a une sensibilité de 48,2% et une spécificité de 82,9%.

Conclusion: Il y a un fardeau local élevé de l'hypoxémie associée à la pneumonie.

L'agitation, les tirages de la paroi thoracique, le souffle bronchique et une hépatomégalie douloureuse pourraient être utiles dans la détection de l'hypoxémie liée à la pneumonie dans les établissements de santé mal équipés. *WAJM* 2014; 33(1): 37-43.

Mots-clés: Hypoxémie, les enfants, la pneumonie.

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Abbreviations: CAP, Community Acquired Pneumonia; BBS, Bronchial Breath Sounds; EPU, Emergency Paediatric Unit; UIH, University of Ilorin Teaching Hospital.

INTRODUCTION

Globally, pneumonia remains a leading cause of death among under-five children, with pneumonia accounting for over 90% of acute lower respiratory infection related deaths.¹ In Nigeria, pneumonia-related deaths account for 20±25% of childhood mortality; the estimated median incidence of pneumonia is 34 per 100 child years, with approximately 6.1 million new cases annually.^{1,2} These pneumonia-related deaths may be ascribed to one or more of dissemination of the causative pathogens, or ventilation-perfusion mismatch with resultant hypoxaemia and subsequent respiratory failure.³ Also, hypoxaemia is reportedly the best indicator of a severe and potentially fatal pneumonia.⁴

Traditionally, the levels of arterial blood gases are used for monitoring hypoxaemia in patients with pneumonia, but more recently the use of pulse oximeters has been gaining ground in many health facilities. As a non-invasive, simple and reproducible method of measuring the arterial haemoglobin oxygen saturation (SpO₂), pulse oximetry remains a reliable bedside tool for monitoring the level of hypoxaemia in clinical practice.⁵ In a 2009 systematic review, the median prevalence of hypoxaemia in ill children using WHO-defined pneumonia was 13.0% in developing countries, varying with a prevalence rate of 3.0±10.0% in Africa and 9.0±39.0% in Asia.⁶ Despite the morbidity burden of pneumonia in the African sub-region, the limited data on ALRI-related hypoxaemia have emanated from a few countries.^{4, 7±10} There is a clear paucity of accessible data on pneumonia-related hypoxaemia in Nigerian children.

Various clinical symptoms and signs have been studied for their ability to predict hypoxemia in children with pneumonia.^{11±14} The major symptoms and physical signs associated with hypoxaemia include central cyanosis, altered mental state, tachypnoea, chest wall retractions and the use of accessory muscles of respiration. Although the reported sensitivity and specificity of these signs varied widely in some earlier studies, the presence of respiratory rates above age specific cut-

off values and lower chest indrawing were reported as highly specific and sensitive. Hence, these clinical parameters were considered useful for identifying hypoxaemia.^{14±15} The current study was therefore aimed at determining the prevalence of hypoxaemia and the ability of clinical symptoms and signs to predict hypoxaemia in children with pneumonia in Ilorin, North Central Nigeria.

SUBJECTS, MATERIALS AND METHODS

Study Site: The study was conducted in the Emergency Paediatric Unit (EPU) and the Paediatric Medical Ward of University of Ilorin Teaching Hospital (UITH). The hospital is located in Ilorin, the capital city of Kwara State, situated in the North Central region of Nigeria. The yearly temperature in Ilorin ranges between 19.5⁰ to 37.5⁰C, while the ambient humidity is usually between 42 and 45%.¹⁶ The town is located at an altitude of 303 metres above sea level.

Study Design: This was a descriptive cross-sectional study in which the subjects were children aged between two months and up to five years diagnosed with pneumonia.

The sample size was calculated using the Andrew Fisher formula,¹⁷ and a prevalence of pneumonia estimated at 11.1% from a previous study,¹⁸ the minimum sample size was 151, however, a total of 200 under-five children were recruited for the study.

The subjects were children aged between two months and up to five years presenting at the EPU of UITH with clinical features comprising cough of less than 28 days duration, fever, difficult breathing, tachypnoea, and auscultatory findings of one or more of reduced breath sound intensity, bronchial breath sounds, or crepitations.¹⁹ Subject recruitment was done at the initial presentation in EPU. All consecutive admissions into the EPU with a diagnosis of pneumonia that fulfilled the inclusion criteria were enrolled.

Exclusion Criteria: Children with severe anaemia defined as a haematocrit value

of < 15%, children with clinical features of shock like cold clammy extremities, weak thready pulse and other parameters of poor peripheral perfusion, underlying congenital heart disease, sickle cell disease, bronchial asthma, and children that had previously been recruited for the study who re-present to the unit with symptom recrudescence.

Approval was obtained from the Ethics and Research Committee of UITH. After obtaining an informed consent from the parent, a semi-structured questionnaire was administered to obtain the clinical and socio-demographic data from each subject's parent/guardian.

The informant was asked about the presence of symptoms such as cough, fever, inability to feed/drink, rapid/difficult breathing, abnormal sleepiness or irritability. The presence of relevant clinical signs like tachypnoea, nasal flaring, wheeze, central cyanosis and chest indrawing were also noted. Respiratory rate was counted by visual inspection of upward movement of the abdominal and/or chest wall while the child was calm for one minute. The presence/absence of fast breathing in the individual subject was determined using the age-related cut-off values of >50 breaths/minute for infants aged between two months to less than 12 months, and >40 breaths/minute for children aged 12±59 months. The child's clothing was removed to enable visualization of the lower chest wall. Chest wall indrawing was identified as inward movement of the lower chest wall on breathing in, with the child placed on either the mother's lap or the examination couch. Central cyanosis was determined by bluish discoloration of the tongue and/or buccal mucosa. Auscultatory signs such as reduction in the intensity of breath sounds, presence of crepitations, rhonchi or bronchial breath sounds were recorded.

Haemoglobin oxygen saturation (SpO₂) level was measured by attaching a SmartSigns Liteplus CE 0088 pulse oximeter (Huntleigh Healthcare, Cardiff, United Kingdom) to a finger using an appropriately-sized sensor. This was done as soon as possible after presentation before oxygen administration as required. The SpO₂ level was

recorded after a stable reading was obtained for at least one minute while the child was breathing room air. Measurement of the SpO₂ level of the researcher was taken at the beginning of each day of data collection to serve as a control and confirm that the oximeter was functioning appropriately. For the purpose of the current study, hypoxaemia was defined as an arterial oxygen saturation of less than 90% as recorded by pulse oximetry.²⁰

The severity of pneumonia in each subject was graded using the British Thoracic Society guidelines on the management of community acquired pneumonia (CAP) in children.²¹ Chest radiographs were obtained in all subjects within 24 hours of presentation. Radiographic features were recorded as either normal, presence of patchy opacities in one or more lobes, or lobar/segmental consolidation with or without an air bronchogram. Using a combination of clinical and radiographic parameters, subjects were grouped as having either lobar or bronchopneumonia. All subjects had blood specimen obtained for total blood counts. The subjects were treated with the most appropriate medication according to the current institutional guidelines.

Data Analysis: Data was analyzed using the IBM SPSS version 20.0 (IBM corporation, Virginia, U.S.A.) 2011 for windows software package. After the generation of frequency tables and simple proportions, discrete clinical signs between hypoxaemic and non-hypoxaemic children were compared using the chi-square (χ^2) test or the Fisher's exact test for cells with small numbers (<5). The sensitivity, specificity, positive and negative predictive values were determined for the symptoms and signs. Also, a linear regression analysis was done to determine the best independent combinations of clinical features for predicting hypoxaemia. A p -value of <0.05 was considered significant.

RESULTS

One hundred and thirteen (56.5%) of the children were infants and the male:female (M:F) ratio was 1.5:1. (Table 1).

All the children presented with cough and fever. Other common respiratory symptoms were difficult breathing 182(91.0%), nasal discharge 87(43.5%), fast breathing 77(38.5%) and noisy breathing 21(10.5%). The non-respiratory symptoms were inability to feed 51(25.5%), vomiting 48(24.0%), poor drinking 39(19.5%), lethargy 35 (17.5%), restlessness 29(14.5%), diarrhoea 16(8.0%), and convulsion in six (3.0%) children. The physical findings are shown in Table 2. Bronchopneumonia accounted for the diagnosis in 168(84.0%) of the

Table 1: Age and Gender of the Children with Pneumonia

Age Group (months)	Male n(%)	Female n(%)	Total n(%)
2 $\pm$ <12	64(32.0)	49(24.5)	113(56.5)
12 $\pm$ <24	32(16.0)	14(7.0)	46(23.0)
24 $\pm$ <36	16(8.0)	10(5.0)	26(13.0)
36 $\pm$ <48	1(0.5)	3(1.5)	4(2.0)
48 $\pm$ <60	6(3.0)	5(2.5)	11(5.5)
Total	119(59.5)	81(40.5)	200(100.0)

Table 2: The Examination Findings in Children with Pneumonia

Examination findings	Frequency	Percentage
Age-related tachypnoea	191	95.5
Nasal flaring	181	90.5
Reduced breath sounds(BS)	176	88.0
Crepitations	162	81.0
Febrile $\geq 37.5^\circ\text{C}$	145	72.5
Lower chest wall in-drawing	127	63.5
Hepatomegaly	127	63.5
Intercostal recession	91	45.5
Pallor	64	32.0
Tender hepatomegaly	61	30.5
Grunting	59	29.5
Rhinorrhoea	53	26.6
Dehydration	50	25.0
Abnormal percussion findings	46	23.0
Splenomegaly	22	11.0
Snuffle	21	10.5
Bronchial breath sounds	19	9.5
Unconsciousness	8	4.0
Central cyanosis	6	3.0
Head nodding	4	2.0

children while lobar pneumonia was diagnosed in 32(16.0%) of the children. Twelve (6.0%) of the children were classified with moderate pneumonia while 188(94.0%) had severe pneumonia.

Figure 1 shows that 83(41.5%) of the children recruited had hypoxaemia. The overall mean (SD) SpO₂ level of the 200 children recruited was 90.4(8.9)% while the mean(SD) SpO₂ of the 83 children with hypoxaemia was 82.3(8.1)%. Eighty-two (41%) children had SpO₂ levels $>95\%$ with a mean(SD) of 97.7(1.6)%; 35(17.5%) children had SpO₂ levels between 90-94% [mean(SD) $\pm 92.5(0.9)\%$]; 34(17.0%) had SpO₂ levels between 86-89% [mean(SD) $\pm 88.1(1.0)\%$], and 49(24.5%) children had SpO₂ $<85\%$ [mean(SD) 78.2(8.5)%].

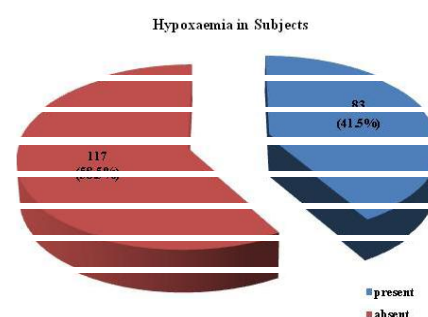


Fig. 1: Hypoxaemia in the Children with Pneumonia

Out of 188 children with severe pneumonia, 83 had hypoxaemia while neither of the children with moderate pneumonia had hypoxaemia (Fisher exact test, $p=0.003$). Also, 20(62.5%) of the 32 children with lobar pneumonia had hypoxaemia while 63(37.5%) of the 168 children with bronchopneumonia had hypoxaemia (chi-square = 6.92, degree of freedom = 1, $p=0.009$).

Poor drinking, restlessness, lethargy and difficult breathing were identified as the significant symptoms that predicted the presence of hypoxaemia in the subjects, $p<0.05$ each. Also, Table 3 shows that pallor, central cyanosis, grunting, intercostal recession, lower chest indrawing, abnormal percussion notes, bronchial breath sounds and tender hepatomegaly were significant examination findings ($p<0.05$ each).

The clinical features that remained significant after a subsequent linear regression analysis were restlessness, lower chest wall indrawing, bronchial

Table 3: Clinical Features as Predictors of Hypoxaemia in the Subjects

Clinical Feature	Hypoxaemia		p-value*	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
	Present n=83	Absent n=117					
Poor drinking	23	16	0.014	27.7	86.3	59.0	62.7
Restlessness	19	10	0.005	22.9	91.5	65.5	62.6
Lethargy	34	28	0.010	41.0	76.1	54.8	64.5
Nasal discharge	30	57	0.077	36.1	51.3	34.5	53.1
Difficult breathing	82	100	0.001	98.8	14.5	45.1	94.4
Febrile $\geq 37.5^{\circ}\text{C}$	61	84	0.791	73.5	28.2	42.1	60.0
Pallor	38	26	0.001	45.8	77.8	59.4	66.9
Tachypnoea	77	114	0.112 [#]	92.8	2.6	40.3	33.3
Central cyanosis	6	0	0.005[#]	7.2	100.0	100.0	60.3
Grunting	37	22	0.001	44.6	81.2	62.7	67.4
Rhinorrhoea	17	37	0.097	20.5	69.0	32.1	54.8
Nasal flaring	79	102	0.057	95.8	12.8	43.6	78.9
Intercostal recession	83	99	0.001	100.0	15.4	45.6	100.0
Lower chest indrawing	72	55	0.001	86.7	53.3	56.7	84.9
Head nodding	3	1	0.195 [#]	3.6	99.1	75.0	59.2
Abnormal percussion note	31	15	0.001	37.3	87.2	67.4	66.2
Reduced BS intensity	77	98	0.058	92.8	16.2	44.0	75.0
Crepitations	71	91	0.168	85.5	22.2	43.8	68.4
Bronchial BS	14	5	0.003	16.9	95.7	73.7	61.9
Tender hepatomegaly	40	21	0.001	48.2	82.1	65.6	69.1
Unconsciousness	6	2	0.056 [#]	7.2	98.3	75.0	59.9

* = chi-square test derived; # = Fisher's exact test derived; PPV=positive predictive value; NPV=negative predictive value

breath sounds and tender hepatomegaly, $p < 0.05$ each (Table 4). The goodness-of-fit model gave an F-value of 16.851; $df=4$, $p = 0.001$ and the effect was 44.8% for the clinical features in the presence of hypoxaemia.

Seventeen of the children with pneumonia died giving a case fatality of 8.5%. Six (18.7%) of the 32 children with lobar pneumonia had a fatal outcome while 11 (6.5%) of the 168 children with bronchopneumonia died. All the children who died had hypoxaemia while none of the children without hypoxaemia died, (Fisher exact test, $p=0.001$).

DISCUSSION

The prevalence of hypoxaemia among hospitalized children with pneumonia was estimated to be 41.5% in the current study which is in accord with the range of 31±43% found in a systematic review of hypoxaemia among children with clinical pneumonia by Lozano *et al.*²² The present value is however lower than the prevalence of

Table 4: Linear Regression Model of the Clinical Features and Hypoxaemia in Subjects

Clinical feature	Beta Co-efficient	t	p-value
Restlessness	0.181	2.165	0.033
Nasal discharge	0.059	0.709	0.480
Difficult breathing	0.053	0.615	0.540
Age-related tachypnoea	± 0.057	± 0.685	0.496
Pallor	0.113	1.137	0.259
Central cyanosis	0.102	1.194	0.236
Grunting	0.025	0.262	0.794
Nasal flaring	± 0.030	± 0.350	0.727
Intercostal recession	0.012	0.132	0.895
Lower chest indrawing	0.354	4.250	0.001
Head nodding	0.002	0.020	0.984
Abnormal percussion notes	0.075	0.704	0.483
Abnormal breath sound intensity	± 0.024	± 0.280	0.780
Crepitations	0.039	0.466	0.642
Bronchial breath sound	0.271	3.168	0.002
Tender hepatomegaly	0.284	3.253	0.002

59%, and 63% reported from Kenya and Colombia.^{4, 23} These earlier studies with higher prevalence values were carried out

at high altitudes compared to the location of the present study which is at near sea level of 303 metres.¹⁶ Hypoxemia may be

more frequent and more severe in children who live at high altitude because of the reduced pressure of the atmospheric oxygen.²⁴ Some physiological responses to hypoxemia at high altitude such as increase in the cardiac output and increase in the depth and rate of ventilation with a resultant ventilation perfusion mismatch may further worsen the severity of hypoxemia.²⁴ Also, the age group recruited in the studies from Kenya and Colombia^{4, 23} comprised of a younger age (7 days $\pm$ 36 months) compared to that of 2 $\pm$ 59 months in the present study. A stepwise decrease in the age-specific disease burden of pneumonia with increasing age has been reported.^{18, 25 $\pm$ 26} The fact that these studies included mainly infants and toddlers with a high susceptibility to pneumonia may have contributed to the higher prevalence.

The high prevalence of 41.5% recorded among children with severe pneumonia is considerably higher when compared with the corresponding value of 13.3% (inter-quartile range 7.5 $\pm$ 18.5%) reported in children hospitalized with 'severe' and 'very severe pneumonia' in a recent systematic review.⁶ However, the severity assessment tool of the studies in this recent systematic review was the WHO clinical classification as against the BTS guidelines used in the present study. In areas where facilities for investigations are limited and there is a paucity of clinicians, health care workers (who may not be doctors) are the first contact of the patient. Furthermore, these health care workers are trained to identify children with pneumonia using the WHO criteria for ALRI which does not differentiate between the various types of ALRI. There is therefore the possibility of misdiagnosis by these health personnel who may misdiagnose some ALRI syndrome as pneumonia with a resultant over-diagnosis of the disease. On the other hand, it is also possible to underestimate the prevalence of severe pneumonia in the poorly organized health services of many developing countries.²⁶ The implication of this inadequacy in health service delivery is that many children with severe CAP are not admitted to the hospital, and are therefore more likely to die at home.²⁶

In the current study, children with lobar pneumonia were found to have a higher prevalence of hypoxaemia compared to those with bronchopneumonia. However, a valid comparison of the present data is precluded by the paucity of published studies comparing hypoxaemia in children with lobar and bronchopneumonia. Lobar pneumonia is associated with more extensive consolidation of the lungs and hence, a more severe compromise of alveolar gaseous exchange compared to bronchopneumonia. In lobar pneumonia, there is a reduction in lung compliance, with extensive loss of functioning lung tissue. The latter may be attributable to the involvement of one of either a segment or the entire lobe in the consolidation process and hence, the resultant alveolar hypoventilation and hypoxaemia.³

Prompt recognition of hypoxaemia and use of supplemental oxygen therapy improves the outcome in severe pneumonia.²⁷ The current study examined the association between some clinical features of children with pneumonia and the SpO₂ levels with the aim of identifying their usefulness as early predictors of hypoxaemia. Restlessness, inability to drink, lethargy, difficult breathing, cyanosis, pallor, grunting, intercostal recession, lower chest wall indrawing, bronchial breath sounds (BBS) and tender hepatomegaly were significantly associated with hypoxaemia in the present study. With the exception of pallor and BBS, previous studies had also identified these clinical findings as significant predictors of hypoxaemia.^{9, 11 $\pm$ 12, 14, 28 $\pm$ 29} However, in the present study some of these clinical features with high sensitivity had poor specificity and vice versa. This observation is in accord with the findings in earlier studies.^{9, 11 $\pm$ 12, 14, 28 $\pm$ 29} The wide variability in the sensitivity and specificity of the symptoms and signs reported in predicting the presence of hypoxaemia could be due to differences in definitions of hypoxaemia used, even among studies conducted at similar altitudes. While Onyango *et al*⁴ defined hypoxaemia as SpO₂ < 91%, Dyke *et al*³⁰ defined same as SpO₂ < 86% while a SpO₂ < 88% was used by Duke *et al*.³¹

The best clinical predictors for

detecting hypoxaemia in the current study are the presence of restlessness, lower chest wall indrawing, bronchial breath sounds and tender hepatomegaly. Restlessness, as a significant finding in the present study differs from the findings of Usen *et al*⁸ but is similar to the findings in an earlier report from the Gambia.⁷ Restlessness, as a manifestation of impaired mental state, has been shown to have a very close correlation with oxygen saturation, and the degree of restlessness tends to increase with increasing hypoxaemia.⁹ Thus, its presence should arouse the suspicion of both the clinician and the health worker of the presence of hypoxaemia.⁴

Chest indrawing was highly sensitive but poorly specific in the present study which is an observation in accord with the finding of Onyango *et al*.⁴ On the other hand, other workers have reported variable sensitivity (35.0 $\pm$ 78.5%) with a moderate to high specificity (60.0 $\pm$ 94.0%) respectively.^{7, 12, 14, 28} Also, the present study found chest indrawing to be the best independent predictor of hypoxaemia and this appears to be consistent with the findings from some earlier studies.^{4, 14} Chest indrawing is an evidence of severe respiratory distress, with increased respiratory muscle effort and increased work of breathing, in an attempt to breathe against a poorly compliant lung parenchyma. The clinical implication of the current finding is that the absence of this sign is only likely to miss a small percentage of patients with pneumonia who are hypoxemic.

Several studies have found the association of auscultatory signs such as crepitations or rhonchi to be associated with hypoxaemia,^{8, 23, 30} while others did not find a consistent association between these auscultatory signs and hypoxaemia.^{7, 28} The finding in the present study of a significant association between bronchial breath sound (BBS) and hypoxaemia with a high specificity and poor sensitivity is noteworthy. However, a valid comparison with previous work is precluded by the paucity of comparable reports on the study. The fact that BBS is associated with hypoxaemia is not surprising as BBS is usually heard over consolidated area(s)

of the lung. This pathologic change is more likely to be accompanied by ventilation-perfusion mismatch, alveolar hypoventilation and a resultant severe hypoxaemia.

The current study found that tender hepatomegaly had a fair sensitivity but a moderate specificity. The presence of tender hepatomegaly, tachypnoea and tachycardia in a child with pneumonia remains a valid clinical indicator of heart failure.²⁵ The predominance of heart failure as a complication of childhood pneumonia in the current study is consistent with the findings of earlier Nigerian hospital-based reports.^{18,25,32} The inflammation-driven reduction in the lung compliance associated with pneumonia causes a right ventricular strain and consequently heart failure.²⁵ A prompt identification and treatment of co-morbid heart failure remains a crucial aspect of the management of childhood pneumonia. In this regard, identification of heart failure as a predictor of hypoxaemia should hardly pose a problem for the clinician in view of the ease of identifying the clinical parameter of liver tenderness.

Oxygen administration remains the key therapeutic measure in children with hypoxaemia. A judicious deployment of this important 'medication' by administering the agent to patients who need it remains a desirable cost-saving measure in health care service delivery. Against this background, the implication of the low sensitivity of various signs of hypoxemia in a clinical setting is that some children with severe pneumonia who need oxygen will not receive it if the administration is based on clinical evaluation alone.³³ However, therapy based on clinical signs with high sensitivity but at the same time low sensitivity is likely to encourage the hardly cost-effective and inappropriate administration of oxygen. This resource is often expensive and in limited supply in low income countries.³³ Clearly, it is this logic that underscores the value of pulse oximetry as a cost-effective intervention in small and moderate sized hospitals in developing countries.³⁴

CONCLUSION

The identified prevalence of pneumonia-associated hypoxaemia is

high in the study population. It has also been identified that the best independent clinical correlates of hypoxaemia are restlessness, lower chest wall indrawing, bronchial breath sounds and tender hepatomegaly. For clinicians working at the higher tiers of health care delivery, chest wall indrawing, lobar consolidation and clinical evidence of heart failure should arouse a high index of suspicion for hypoxaemia in the patient. On the other hand, for the health care workers at the primary health care facility, lower chest wall indrawing remains perhaps the single most reliable clinical predictor of hypoxaemia that should suggest a need for immediate referral to centres where oxygen therapy is available.

Limitation: The SpO₂ levels in the subjects were taken only at presentation. Continuous pulse oximeter monitoring would have been the ideal for the present study as we would have been able to monitor the changes in the SpO₂ level after commencing therapy.

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Conflict of Interest: None

CONTRIBUTIONS

RMI conceptualized the study, collected and interpreted the data, WBRJ and AAA refined the study protocol and contributed to data interpretation. All the authors contributed to drafting the paper while the correspondence author did the final draft of this paper.

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