Original Article

Relationship between some risk factors of pneumonia and hypoxaemia in hospitalised Nigerian children

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Abstract

There is a current body of knowledge linking various risk factors with the frequency of pneumonia and a fatal outcome. Despite this, there is a dearth of published data assessing the association between these risk factors of pneumonia and the occurrence of hypoxaemia. Thus, the current study was carried out to determine the relationship between the risk factors of pneumonia and hypoxaemia in hospitalised under-5 children at the University of Ilorin Teaching Hospital, Nigeria.

This is a descriptive study involving 200 children aged between 2 months and 5 years with pneumonia. Socio-demographic, anthropometric, clinical, and laboratory data were obtained. The pulse oximetry measurement was recorded after a stable reading for at least 1 minute while the child was breathing room air. Hypoxaemia was defined as an arterial oxygen saturation of less than 90%. Data were analysed using the SPSS 20.0 software package.

There were 119 males and 81 females. Bronchopneumonia was identified in 168 (84.0%) of the children while lobar pneumonia was diagnosed in 32 (16.0%) children. After a multivariate logistic regression, low social status of the child was significantly associated with hypoxaemia, p=0.023. There was a negative correlation between the socio-economic status of the child, maternal age (years), maternal literacy level, birth order of the child, and of immunisation status with the presence of hypoxaemia (r= -0.191, -0.151, -0.162, -0.154, -0.148; p=0.007, 0.032, 0.022, 0.030, and 0.036, respectively). The study concluded that socio-economic class of the child was a risk factor of pneumonia associated with the presence of hypoxaemia.

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Introduction

Pneumonia is a leading cause of morbidity and mortality among under 5 years old, children especially in developing countries.[1] Hypoxaemia constitutes a serious manifestation of severe respiratory illness and indeed, it is a strong risk factor of acute lower respiratory infection (ALRI)-related mortality, particularly pneumonia.[2–5] Pulse oximetry has been found to be a non-invasive, simple, reproducible, and reliable bedside tool for monitoring the level of hypoxaemia in clinical practice.[6]

Socio-demographic factors such as the age, sex, parental income, and level of parental education had earlier been identified as risk factors of pneumonia-related morbidity and mortality.[7–9] Also, domestic crowding, maternal age, exposure to indoor air pollutants especially firewood burning, and parental smoking had each been recognised as important domestic/household risk factors.[9–11] Other factors identified include attendance at day care facilities, breastfeeding practices, malnutrition, co-morbidities like diarrhoea, HIV/AIDS, micronutrient deficiency (especially vitamin A and zinc), and inter-current infections such as measles and pertussis.[9,12–16] Despite the current body of knowledge linking these risk factors with the frequency of pneumonia and a fatal outcome, there is still a dearth of published data assessing the association between these risk factors of pneumonia and the occurrence of hypoxaemia. The current study was done to determine the relationship between risk factors of pneumonia and the presence of hypoxaemia in hospitalised Nigerian children.

Materials and methods

The study was conducted in the Emergency Paediatric Unit (EPU) and the Paediatric Medical Ward of the University of Ilorin Teaching Hospital (UITH). The hospital is located in Ilorin, Kwara State, situated in the North Central geopolitical zone of Nigeria. The EPU, which constituted the principal recruitment site of the current study receives paediatric medical emergencies beyond the neonatal period and up to the age of 14 years. The yearly temperature in Ilorin ranges between 19.50 and 37.5°C, while the ambient humidity is usually between 42 and 45%.[17] The town is located at an altitude of 303 m above sea level. The majority of the inhabitants are predominantly artisans and Islamic clerics with low incomes.

The study was was a descriptive cross-sectional study in which the subjects were children aged between 2 months and up to 5 years diagnosed with pneumonia.

The sample size was calculated using Fisher formula,[18] and a prevalence of pneumonia estimated at 11.1% from a previous study;[19] the minimum sample size was 151, however, a total of 200 under-5 children were recruited for the study.

The subjects were children aged between 2 months and up to 5 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.[20] 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. Subjects were recruited until the desired sample size was achieved.

Exclusion criteria included: children with severe anaemia defined as a haematocrit value of ≤15%, children with clinical features of shock such as cold clammy extremities, weak thready pulse and other parameters of poor peripheral perfusion, sickle cell disease, bronchial asthma, and children that had previously been recruited for the study who represent to the unit with symptom recrudescence.

The study was approved by the Ethics and Research Committee of the hospital.

On presentation at the EPU, each child had a full clinical evaluation after obtaining 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.

Using the socio-economic classification scheme of Oyedeji (Table 1),[21] the socio-economic index score of each child was calculated based on the occupations and educational attainments of their parents/caregiver. The mean of four scores (two for the father and two for the mother) approximated to the nearest whole number was the social status assigned to the child.[21] For example, if the mother was a junior school teacher (score = 3) and father a senior teacher (score=2) and the educational attainment of the mother was primary six (score=4), and the father was a school certificate holder (score=2). The socio-economic index score for this child was: (3+2+4+2)/4 =2.75, which approximated to the nearest whole number was three. Socio-economic classes I and II were grouped as the upper socio-economic status, while socio economic classes III, IV and V were grouped as the lower socio-economic status.

Anthropometric measurements taken included the weight, height, and mid-arm circumference (MAC) in those aged 1-5 years. The weight was measured using a bassinet weighing scale (Surgifriend Medicals, London, UK) in infants, and a beam balance weighing scale (Marsdens weighing machine, London, UK) in children who were able to stand unsupported. Both scales have a degree of accuracy of 50 g, and were calibrated prior to use. The standing height was measured to an accuracy of 0.1 cm using a stadiometer. The MAC was measured to the nearest 0.1 cm using a non-flexible tape measure. The MAC was taken at the point mid-way between the olecranon process of the ulna and the acromion process of the scapula.

Haemoglobin oxygen saturation (SpO_2) was measured by attaching a Smartsigns® Lite plus CE 0088 pulse oximeter (Huntleigh Healthcare, Cardiff, UK) to a finger using an appropriately sized paediatric sensor. This was done as soon as possible after presentation before oxygen administration as required. The oxygen saturation was recorded after a stable reading was obtained for at least 1 minute while the child was breathing room air. For the purposes of the current study, hypoxaemia was defined as an arterial oxygen saturation of less than 90% as recorded by pulse oximetry.[22]

Chest radiographs were obtained in all subjects. 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. Also, the presence of radiographic features of effusion, or other intra-thoracic complications such as

Social status	Profession	Educational attainment
I	Professional, senior public servants, owners of large business concerns, senior military officers, large-scale contractors.	University graduates or equivalent
II	Non-academic professional, e.g. nurses, secondary school teachers, secretaries, owners of medium-sized businesses, intermediate-grade public servants.	School certificate holders and equivalent
III	Non-manual skilled workers including clerks, typist, telephone operators, junior school teachers, drivers.	Grade II teachers or equivalent
IV	Petty traders, labourers, messengers.	Primary certificate
V	Unemployed, full-time housewives, students, subsistence farmers.	No formal education

Table 1 Social classification scheme

Parameter	Frequency	Percentage	Cumulative per cent
Age group (months)			
2 to ≤6	70	35.0	35.0
>6 to <12	43	21.5	56.5
12 to <24	46	23.0	79.5
24 to <36	26	13.0	92.5
36 to <48	4	2.0	94.5
48 to <60	11	5.5	100.0
Social status of the child			
I	11	5.5	5.5
II	69	34.5	40.0
III	66	33.0	73.0
IV	46	23.0	96.0
V	8	4.0	100.0

Table 2 Age group and social class of the children with pneumonia

Parameter	Frequency	Percentage	Cumulative per cent
Family type			
Monogamous	169	84.5	84.5
Polygamous	31	15.5	100.0
Number of siblings			
≤3	126	63.0	63.0
>3	31	15.5	78.5
None	43	21.5	100.0
Birth interval			
None	43	21.5	21.5
<24 months	33	16.5	38.0
≥24 months	124	62.0	100.0
Smoking in the house			
Yes	19	9.5	9.5
No	181	90.5	100.0
Attendance at day care centre			
Yes	25	12.5	12.5
No	175	87.5	100.0
Indoor cooking			
Yes	153	76.5	76.5
No	47	34.5	100.0
Cooking with firewood			
Yes	21	10.5	10.5
No	179	89.5	100.0
Exclusive breastfeeding			
Yes	160	80	80.0
No	40	20	100.0

Table 3 Some risk factors of pneumonia in the study population

pneumothorax were identified. Using a combination of clinical and radiographic parameters, subjects were grouped as having either lobar or bronchopneumonia. All subjects were treated with the most appropriate medications according to the current institutional guidelines.

Data were analysed using the IBM® SPSS 20.0 (2011) software package. A nutritional anthropometry program, NutriStat of Epi-info version 3.5.1 (2008) was used to determine the percentage and z-score for age of each child based on the WHO Growth Reference data set.

Chi-square ($\chi 2$) and Student's t-tests were used to identify significant differences for categorical and continuous variables, respectively. A multivariate binomial logistic regression model by backward stepwise method was performed to ascertain the effects of the various risk factors of pneumonia on the likelihood that subjects have hypoxaemia. In determining the correlation between some risk factors of pneumonia and the SpO_2 levels, Spearman's rank correlation was used for categorical variables while Pearson's correlation test was used for quantitative variables. A p- value of <0.05 was considered significant.

Results

There were 119 (59.5%) male and 81 (40.5%) female patients; the male:female ratio was 1.5:1, and the mean (SD) age of the subjects was 14.3 (13.5) months. Table 2 shows that 113 (56.5%) of the children were infants, and 80 (40%) children were from social status I and II.

Thirteen (6.5%) of the children with pneumonia had never received any vaccination while 187 (93.5%) had received at least one or more types of vaccination. Seventeen (8.5%) of the children had concomitant measles infection, and three (1.5%) had pertussis as co-morbid illness with the pneumonia. Table 3 shows the frequency of some of the identified risk factors of pneumonia among the children recruited. The anthropometric parameters of the children with pneumonia are as shown in Table 4.

Bronchopneumonia accounted for

Anthropometry	Frequency	Percentage	Range	Mean (SD)
Weight (kg)	200	100.0	3.0–20.0	7.8 (3.1)
Height (cm)	200	100.0	50.0–114.5	71.2 (31.5)
Weight for age percentage, WAP (%)				
≤80	90	45.0	43.4–79.9	69.8 (8.2)
>80	110	55.0	80.6–140.6	99.4 (11.5)
Total	200	100.0	43.4–140.6	83.3 (15.9)
Height for age percentage, HAP (%)				
≤95	101	50.5	75.3–94.9	89.7 (4.4)
>95	99	49.5	95.1–128.3	101.5 (6.1)
Total	200	100.0	75.3–128.3	95.6 (7.9)
Weight for height percentage, WHP (%)				
≤90	90	45.0	38.9–88.9	77.4 (10.6)
>90	110	55.0	90.4–175.6	108.2 (16.7)
Total	200	100.0	38.9–175.6	94.3 (21.0)
Weight for age z-score, WAZ				
<−1	125	62.5	-5.7 to -1.1	-2.3 (0.9)
≥−1	75	37.5	-1.0 to 3.2	-0.1 (0.8)
Total	200	100.0	-5.7 to 3.2	-1.5 (1.4
Height for age z-score, HAZ				
<−1	109	54.5	-6.3 to -1.1	-2.5 (1.2)
≥−1	91	45.5	-1 to 7.0	0.5 (1.5)
Total	200	100.0	-6.3 to 7.0	-1.1 (2.0)
Weight for height z-score, WHZ				
<−1	93	46.5	-7.8 to 1.1	-2.5 (1.3)
≥−1	107	53.5	-1.0 to 5.6	0.7 (1.4)
Total	200	100.0	-7.8 to 5.6	-0.8 (2.1)
Mid- arm circumference (cm)				
<13.5	18	20.5	10.0–13.0	12.5 (0.8)
≥13.5	69	79.5	13.5–18.0	14.8 (0.9)
Total	87	100.0	10.0–18.0	14.3 (1.3)

Table 4 Anthropometric measurements of the subjects

the diagnosis in 168 (84.0%) of the children while lobar pneumonia was diagnosed in 32 (16.0%) of the children recruited. Overall, the mean (SD) SpO_2 level of all the children recruited was 90.4 (8.9) percent with a range of 47–100%. Eighty-three (41.5%) of the children with pneumonia had hypoxaemia.

Table 5 shows that 59 (49.2%) of the children of the low social status had hypoxaemia which was significantly higher compared with 24 (30.0%) of the children from a high social class, p=0.007. A significantly higher proportion of children with a high birth order had hypoxaemia compared with the corresponding proportion in those with a lower birth order, p=0.026. Also, hypoxaemia was significantly higher in children of mothers who had primary school education compared with the corresponding proportion of children whose mothers had at least secondary school education, p=0.022.

Table 6 shows that hypoxaemia was significantly higher among the unvaccinated children compared to those who were vaccinated, p=0.036.

The multivariate logistic regression model was statistically significant, $\chi 2= 24.549$, df (11) and p=0.011. The reduced model explained 15.5% (Nagelkerke R^2) of the variance in hypoxaemia and correctly classified 68.5% of cases. The only risk factor significant in the reduced model was low social status, p=0.023 as shown in Table 7. Children of low social status were 2.2 times more likely to exhibit hypoxaemia than those of high social status.

The social status of the child was identified to have a

Risk Factors 1	n	Hypoxaemia Yes (%)	Hypoxaemia No (%)	p-value*
Age group (months)				
2 to <12	113	52 (46.0)	61 (54.0)	0.140
12 to <60	87	31 (35.6)	56 (64.4)	
Gender				
Male	119	51 (42.9)	68 (57.1)	0.637
Female	81	32 (39.5)	49 (60.5)	
Socio-economic status of child				
High (I,II)	80	24 (30.0)	56 (70.0)	**0.007**
Low (III,IV,V)	120	59 (49.2)	61 (50.8)	
Maternal educational level				
≥Secondary	106	36 (34.0)	70 (66.0)	**0.022**
≤Primary	94	47 (50.0)	47 (50.0)	
Maternal age group (years)				
<35	158	61 (38.6)	97 (61.4)	0.107
≥35	44	22 (52.4)	20 (47.6)	
Family type				
Monogamous	168	69 (41.3)	99 (58.7)	0.778
Polygamous	32	14 (45.2)	18 (54.8)	
Number of siblings				
≤3	169	68 (40.2)	101 (59.8)	0.397
>3	31	15 (48.4)	16 (51.6)	
Birth order				
1st-4th child	174	67 (38.5)	107 (61.5)	**0.026**
≥ 5th child	26	16 (61.5)	10 (38.5)	
Exclusive breastfeeding				
Yes	160	66 (41.3)	94 (57.9)	0.886
No	40	17 (42.5)	23 (57.5)	

* = chi-squared test. Bold values are significant.

Table 5 Hypoxaemia and risk factors of pneumonia in the subjects

negative correlation with the presence of hypoxaemia. Also, factors such as the maternal age, maternal literacy level, the birth order of the child and absence of immunisation had a negative correlation with the presence of hypoxaemia (Table 8).

Discussion

Various risk factors earlier identified with the occurrence and severity of pneumonia were explored as possible clinical correlates of hypoxaemia in the current study. In this regard, hypoxaemia was found to be associated with a low socio-economic background of the child.

As is the case with most of the risk factors explored, the dearth of earlier published data on the association between risk factors of pneumonia and the presence of hypoxaemia would obviously preclude a robust comparison with previous data. However, the current association of low socio-economic background with hypoxaemia is putatively attributable to parental health-seeking behaviour; the more affluent, literate mothers are more likely to afford and seek health care early and hence their children's illness is more likely to be less severe, and the risk of hypoxaemia lower.[23]

Similarly, the need for appropriate and timely health care-seeking behaviour, as well as a clear understanding of the available preventive strategies, are less likely to be appreciated by the younger, illiterate mothers.[24] In such children with a poor parental socio-economic background, the (expected) inadequate family income would hardly support prompt and appropriate healthcare-seeking behaviour in the event of the occurrence of pneumonia.[23] One of the possible consequences of such belated presentations (at the relevant healthcare facilities) is the unfettered progression of the pneumonia with increasing risk of hypoxaemia. Also, children from higher socioeconomic status are more likely to be better nourished and thus protected from severe pneumonia and its severe complications. However, the current study did not find any association between poor nutritional status (as a risk factor of pneumonia) and the presence of hypoxaemia.

The finding of a higher proportion of hypoxaemia in children of high birth order compared with the corresponding observation in those with a low birth order in the current study (univariate analysis) is not surprising. Birth order has been reported to be a risk factor for pneumonia.[2] A high birth order suggests that there is an increased likelihood of a higher number of siblings/other children in the household sharing the meager household facilities and

Risk factors 2	n	Hypoxaemia		p-value*
		Yes (%)	No (%)	
Smoking in the house				
Present	19	11(57.9)	8(42.1)	0.127
Absent	181	72(39.8)	109(60.2)	
Indoor cooking				
Present	153	62(40.5)	91(59.5)	0.613
Absent	47	21(44.7)	26(55.3)	
Cooking with firewood				
Present	21	11(52.4)	10(47.6)	0.285
Absent	179	72(40.2)	107(59.8)	
Attendance at day-care				
Present	25	9(36.0)	16(64.0)	0.551
Absent	175	74(42.3)	101(57.7)	
Immunisation				
None	13	9(69.2)	4(30.8)	**0.036**
Yes	187	74(39.6)	113(60.4)	
Pertussis				
Present	3	1(33.3)	2(66.7)	0.999†
Absent	197	82(41.6)	115(58.4)	
Intercurrent measles				
Present	17	9(52.9)	8(47.1)	0.319
Absent	183	74(40.4)	109(59.6)	
Positive blood culture				
Present	67	33(49.3)	34(50.7)	0.140
Absent	133	50(38.3)	83(61.7)	

* = chi-squared test † = Fisher's exact test. Bold value is significant.

Table 6 Hypoxaemia and risk factors of pneumonia in the subjects

food, and the child is therefore exposed to a higher risk of overcrowding and malnutrition. This may be further aggravated by short birth intervals between the siblings in the household such that the maternal care is inadequate. The predisposition of the child of high birth order to severe pneumonia with resultant hypoxaemia may be a consequence of some or all of these aforementioned adverse household variables.

Measles and pertussis are vaccinepreventable comorbidities which had earlier been identified with pneumonia-related deaths.[14] The present study found that a poor immunisation status (as a co-morbidity of pneumonia) was associated with a higher risk of hypoxaemia. In addition, there was a negative correlation between immunisation status and the presence of hypoxaemia such that the children who were unvaccinated were at increased risk of having hypoxaemia. Appropriate immunisation in childhood has been shown to confer protection against pathogens that could cause severe pneumonia.[9,25] Therefore, unvaccinated children are more likely to have no protection against these pathogens, develop severe pneumonia and thus an increased risk of hypoxaemia.

The relevant correlation values of all the aforementioned risk factors of pneumonia with respect to hypoxaemia is however weak, and there is therefore a need for a larger series. Also noteworthy for its absence in the present study is the earlier reported association between age of the children with pneumonia and the occurrence of hypoxaemia. Earlier reports from India[26,27] had suggested that hypoxaemia was significantly more common in infants compared with older children.

Low socio-economic status of the child was the most significant risk factor of pneumonia associated with the presence of hypoxaemia. There was a significant negative correlation between the socio-economic status of the child, maternal age (years), maternal literacy level, birth order of the child and lack of immunisation with the presence of hypoxaemia

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Variable	B	SE	Wald	df	p	Exp (B)	95% CI	
							Lower	Upper
Sibling group	−1.620	1.182	1.879	1	0.170	0.198	0.020	2.007
Birth order group	2.048	1.219	2.822	1	0.093	7.751	0.711	84.535
Social class group	0.809	0.357	5.143	1	0.023	2.245	1.116	4.516
Smoking in house	0.618	0.555	1.239	1	0.266	1.855	0.625	5.509
Not vaccinated	0.840	0.726	1.339	1	0.247	2.317	0.558	9.617
Mother's age	−0.042	0.035	1.396	1	0.237	0.959	0.895	1.028
Indoor cooking	0.332	0.411	0.651	1	0.420	1.394	0.622	3.121
WAZ	−0.775	0.588	1.736	1	0.188	0.461	0.145	1.459
WHZ	−0.554	0.490	1.275	1	0.259	0.575	0.220	1.503
WHP	0.042	0.048	0.759	1	0.384	1.043	0.949	1.146
WAP	0.086	0.052	2.682	1	0.102	1.089	0.983	1.207
Constant	13.217	5.901	5.017	1	0.025	0.000		

Variable(s) entered on step 1: sex, age (months), family type, sibling group, birth order group, social class group, smoking in-house, attendance at daycare centre, not vaccinated, maternal literacy group, mother's age, non-exclusive breastfeeding, indoor cooking, fire cooking, HAZ, WAZ, WHZ, HAP, WHP, and WAP.

Table 7 Logistic regression model with variables in equation

Table 8 Correlation of the risk factors of pneumonia with the presence of hypoxaemia

Risk factor	Correlation (*r*)	p-value
Age (months)	0.087	0.221
Social status	−0.191	**0.007**
Maternal age (years)	−0.151	**0.032**
Maternal literacy	−0.162	**0.022**
Family type	0.013	0.853
Birth order	−0.154	**0.030**
Sibling group	0.064	0.365
Birth interval	−0.022	0.753
Smoking in the house	0.108	0.129
Attendance at daycare	−0.042	0.553
Immunisation status	−0.148	**0.036**
Pertussis	−0.020	0.774
Measles	0.071	0.319
Exclusive breastfeeding	−0.010	0.887
Duration of exclusive breastfeeding	−0.063	0.378
Indoor cooking	−0.036	0.615
Cooking with firewood	0.076	0.287
WAP	0.095	0.182
HAP	0.063	0.378
WHP	0.013	0.852
WAZ	0.107	0.130
WHZ	−0.012	0.865
HAZ	0.016	0.827

WAP (weight for age percentage), HAP (height for age percentage), WHP (weight for height percentage), WHZ (weight for height z-score), WAZ (weight for age z-score), and HAZ (height for age z-score). Bold values for significant.

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