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Prevalence and risk factors of bacteraemic community-acquired pneumonia in under-fives in Akwa Ibom State, Nigeria

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Abstract

Background: Community-acquired pneumonia (CAP) is an important contributor to under-five mortality worldwide. Low- and middle-income countries (LMICs) like Nigeria have a high disease burden, with most children presenting with severe disease. Therefore, there is a need for a microbiologic diagnosis at presentation. This study aimed at determining the prevalence and risk factors of bacteraemia in radiologically confirmed CAP among under-fives in Akwa Ibom State, Nigeria.
Methodology: The study was cross-sectional and under-five children admitted into the Paediatric emergency unit of the University of Uyo Teaching Hospital, Uyo, South-south Nigeria, with clinical pneumonia were recruited consecutively until the sample size of 372 was achieved. Sociodemographic and clinical information were obtained using an interviewer-administered questionnaire. Chest radiographs were done for all participants, while blood culture was performed in those who had radiologically confirmed pneumonia.
Results: The prevalence of bacteraemia in radiologically confirmed CAP was 28.7%. The risk factors associated with bacteramia in these children included younger age ($p=0.001$), lack of exclusive breastfeeding ($p=0.015$), incomplete immunization status ($p=0.009$), duration from onset of symptom to presentation greater than five days ($p=0.030$) and neutrophilia ($p=0.003$).
Conclusion: The high prevalence of bacteraemia in this study underscores the need to have blood culture done for patients with radiologically confirmed pneumonia. This will ensure early identification of bacterial agents for culture-directed antibiotic administration, and reduce antimicrobial resistance.

Keywords: Community-acquired pneumonia, bacteraemia, prevalence, radiologic confirmation

Introduction

Community-acquired pneumonia (CAP) remains a leading cause of morbidity and mortality worldwide,[1] and it accounts for 15% of all deaths of children under five.[2] More than 95% of these deaths occur in low- and middle-income countries (LMIC), predominantly South Asia and sub-Saharan Africa.[3] In Nigeria, pneumonia constituted 19% of child deaths in 2018.[4] The 'gold standard' for the diagnosis of CAP is chest radiography.[5,6] Radiographic evidence of pneumonia is the presence of consolidation, other infiltrate, or pleural effusion,[7,8] and has been reported in 78.1% of children with clinical pneumonia.[9] However, chest X-ray is not recommended routinely for the diagnosis of pneumonia[10] and is generally unhelpful in differentiating aetiologies.[11]

The prevalence of bacteraemia in children with CAP has been reported to be between 1.5% to 3.2% in the USA.[12-14] A prevalence of 5.6%, 5% and 27.5% was reported in Ethiopia,[1] Mali[15] Ilorin, Nigeria[16] respectively. Among under-five children with CAP, the prevalence of bacteraemia has been reported as

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31% in Congo[17] and 8.1% to 31.2% in Nigeria.[18,19] In the study by Oloyede *et al*, 89.5% of children admitted for CAP were under the age of five years.[20] There is a paucity of studies in Nigeria on the prevalence of bacteraemia in paediatric patients with radiologically diagnosed CAP.

Common risk factors for the increased incidence of childhood CAP in LMICs countries include malnutrition, low birth weight, non-exclusive breastfeeding, lack of measles immunization, indoor air pollution, and overcrowding.[1] Risk factors for mortality in CAP include severe pneumonia, low weight-for-age Z score (WAZ), age younger than 12 months, male sex, Pneumocystis carinii infection, HIV infection, young maternal age, low maternal education, low socioeconomic status, second-hand cigarette smoke exposure, indoor air pollution, and incomplete childhood immunization status.[21,22]

Although viruses such as Respiratory Syncytial virus are the commonest cause of radiologically confirmed CAP, bacterial agents such as *Streptococcus pneumoniae, Staphylococcus aureus and Haemophilus influenzae* – type B have been reported. These bacterial agents are known to cause severe infections, leading to significant morbidity and mortality.[15,23]

In view of the paucity of studies on the prevalence of bacteraemia in radiologically confirmed CAP among paediatric patients in the South-south geopolitical zone, this study aimed to determine the prevalence and risk factors of bacteraemia in radiologically confirmed CAP among under-fives in Southern Nigeria.

Materials and methods

Study design, setting, participants, and data sources.

This cross-sectional study was conducted over six months (July to December 2023). Clinical and laboratory data were obtained from children aged 2 to 59 months, admitted to the Children's Emergency Unit (CHEU) of the University of Uyo Teaching Hospital (UUTH) with clinical pneumonia (cough or difficulty in breathing and fast breathing). All children aged 2-59 months with a clinical diagnosis of pneumonia and symptoms appearing within the preceding two weeks were recruited. Children with congenital heart disease, known history or evidence of HIV infection, tuberculosis, and other immunosuppressive illnesses or conditions were excluded. Ethical clearance to conduct the study was obtained from the Health Research Ethical Committee of the University of Uyo Teaching Hospital (UUTH/AD/S/96/VOL.XXI/725). Written informed consent was obtained from the parents/caregivers of the study participants.

Based on the 27.5% prevalence of bacteraemia in children with CAP in a previous study in Ilorin, Nigeria[16], the calculated minimum sample size, including a 20% non-response rate, was 370, using the formula: $n = Z\alpha^2 pq / d^2$

Study Questionnaire: A semi-structured interviewer-administered questionnaire was used to obtain sociodemographic and other relevant clinical data. Immunization status was confirmed using immunization cards; where cards were not available, questions were asked to ascertain immunization status. Parents' socioeconomic status was determined using the revised classification of social status by Oyedeji.[24]

Chest radiographs were performed for all the study participants. Two views (anteroposterior and lateral) of the chest radiograph were obtained. Chest radiographs were interpreted by two independent radiologists with the investigator present, following a WHO protocol for interpreting chest radiographs.[25] Where there were discordant conclusions, a panel of two senior radiologists gave a consensus reading, which was taken as the conclusion.[25]

Full blood count: The full blood count was performed on all study participants. Two milliliters of blood from each participant was analysed using a fully automated haematology analyzer (Mindray BC 3200) with the assistance of a laboratory scientist/hematologist in the Haematology department of the hospital. The normal values for the parameters were defined as: Haemoglobin concentration: 12.5 – 14.0g/dl and 10.5 – 14.0g/dl in infants and those aged 12 – 59 months respectively; packed cell volume: 33 – 41% and 31 - 44% in infants and 12 – 59 months old respectively; total white blood cell count: 4.0 -10.0 x 109/L and 6.5 – 13.2 x 109/L for infants and children aged 12 – 59 months respectively; Neutrophil count: 24 – 60% and 29 – 57% for infants and children aged 12 – 59 months respectively,; and Lymphocyte count: 50 – 80% and 48 – 68% for infants and children aged 12 – 59 months respectively.[26]

Blood culture: was obtained only in children with radiologically confirmed CAP using BacT/ALERT blood culture bottles.

Statistical analysis

This was done using Stata version 15.0. All categorical data were summarised as frequencies and percentages.

Normally distributed continuous data were summarised as mean and standard deviation, while skewed data were summarized as median and interquartile range. The proportion of children with radiologically confirmed pneumonia was determined by using the total number of children clinically diagnosed as the denominator and those with radiologic evidence as the numerator X 100. Chi-square or Fisher's exact test was used to determine the association between sociodemographic variables and clinical categorical variables and the occurrence of radiologic confirmation/ positive blood culture.

Univariate logistic regression models were used to find associations between sociodemographic, clinical variables, and blood culture results. Multivariate logistic regression was applied to find independent predictors of positive blood cultures. A p-value of <0.05 was taken as statistically significant. The multivariate models were used to adjust for possible confounders. Results are presented as tables and charts.

Results

A total of 372 children were recruited and used in the analysis based on the calculated minimum sample size.

Table 1 shows the sociodemographic and clinical characteristics of the study participants. More than half (56.2%) of the study participants were in the 2-11 months age range. The median and interquartile range (IQR) age of the children in months was 10 (6-16). There were more males (57.8%) than females (42.2%), corresponding to a male-to-female ratio of 1.4:1. The majority (96.0%) of the parents were Christians. The largest proportion (47.6%) of parents belonged to the Ibibio tribe, and 33.1% belonged to social class 1. The mean ± SD age of mothers was 31.9 ± 4.48 years, while that of fathers was 36.5 ± 5.56 years.

The proportion of children with radiologically confirmed pneumonia was 73.9% (275/372). (Figure 1A). Among the children with radiologically confirmed pneumonia, 28.7% (79/275) had a positive blood culture. (Figure 1B)

The majority (87.9%) of the study participants received pneumococcal and pentavalent vaccines, respectively, while 86.9% received the measles vaccine. Most (85.8%) children had appropriate immunisation for their age. The majority (85.5%) of the children did not attend daycare or preschool, and 48.7% of the children had three or more people staying

Table 1: Sociodemographic and clinical characteristics of the study participants and their parents

Variable	Frequency (n=372)	Percent
Study participants		
Age of children (in Months)		
2-11	209	56.2
12-23	130	34.9
24-35	23	6.2
36-59	10	2.7
Sex		
Male	215	57.8
Female	157	42.2
Preterm		
Yes	18	4.8
No	354	95.2
Birth Weight (in Kg)		
< 2.5	24	6.5
>/= 2.5	348	93.5
Parents of study participants		
Religion		
Christianity	357	96.0
Islam	15	4.0
Tribe		
Ibibio	177	47.6
Annang	61	16.4
Oron	34	9.1
Igbo	57	15.3
Hausa	12	3.2
Yoruba	11	3.0
Others	20	5.4
Mothers' Age (in years)		
< 32	182	48.9
32 years and above	190	51.1
Fathers' Age (in years)		
< 37	211	56.7
37 and above	161	43.3
Estimated Monthly Income		
(in Naira)	12	3.2
< N5000	81	21.8
N5000-N49,000	100	26.9
N50,000-N99,000	179	48.1
>/= N100,000		
Social Class		
1	123	33.1
2	98	26.3
3	76	20.4
4	58	15.6
5	17	4.6

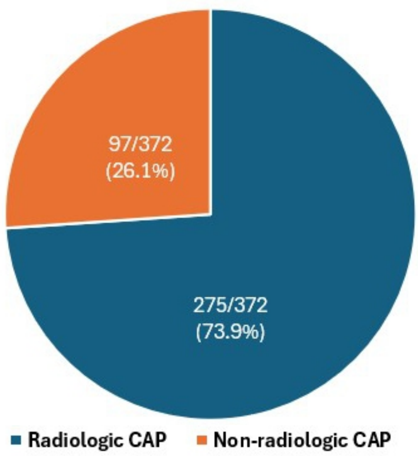

Figure IA: The prevalence of radiologically confirmed CAP among under-five children with clinical pneumonia in Akwa Ibom State.

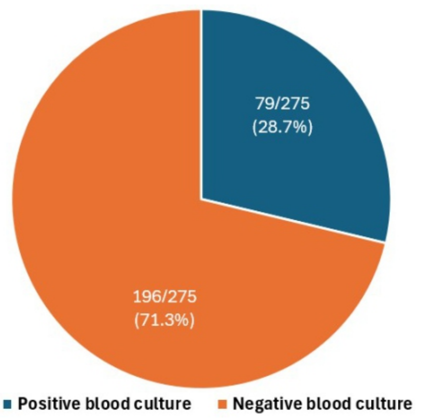

Figure IB: The proportion of bacteriaemia among under-five children with radiologically confirmed CAP in Akwa Ibom State.

Table 2: Immunisation and Environmental factors of study participants

Variables	Frequency (n=372)	Percent
Immunisation History		
Pneumococcal Vaccine		
Vaccinated	327	87.9
Not vaccinated	45	12.1
Pentavalent Vaccine		
Vaccinated	327	87.9
Not Vaccinated	45	12.1
Measles Vaccine (n=229)		
Vaccinated	199	86.9
Not Vaccinated	30	13.1
Complete Immunisation for Age		
Yes	319	85.8
No	53	14.2
Household size		
≤ 3	63	16.9
4 to 6	275	73.9
≥ 7	34	9.2
Number of Rooms in the house		
≤ 2	217	58.3
≥ 3	155	41.7
Number of people in the same		
room as the child	13	3.5
1	178	47.8
2	181	48.7
≥ 3		
Number of windows in the		
Child's room	71	19.1
1	270	72.6
2	31	8.3
>2		
Daycare/Preschool attendance		
Yes	54	14.5
No	318	85.5
Parental smoking status		
Yes	35	9.4
No	337	90.6
Type of cooking Fuel used at		
home*	279	75.0
Gas cooker	62	16.7
Kerosene stove	54	14.5
Firewood		
Household water source		
Borehole	361	97.0
Stream	7	1.9
Tap water	4	1.1

***Multiple responses allowed.**

in the same room as them. Most (72.6%) of the children slept in rooms with two windows, and 9.4% had parents who smoked at home. (Table 2)

Table 3 shows the factors associated with positive blood culture in study participants with radiologically confirmed pneumonia. Children with a positive blood culture were significantly younger than those with a negative blood culture. (Mean (±SD): 8.01± 6.47 vs 13.10 ± 7.83; p <0.001). Younger age (p<0.001), lack of exclusive breastfeeding (p<0.001), incomplete immunisation (p<0.001), lower socioeconomic class (p<0.001), duration of symptoms > 5 days before presentation (p<0.001), anaemia (p<0.001), leukocytosis (p<0.001), lymphopenia (p<0.001) and neutrophilia (p<0.001) were significantly associated with a positive blood culture among children with radiologically diagnosed CAP.

Table 3: Factors associated with Bacteraemia in study

Table 3: Factors associated with Bacteraemia in study participants with Radiologically confirmed Pneumonia (n=275)

Variables	Blood Culture Negative n=196(%)	Positive n=79(%)	Total n=275(%)	Statistical test and P value
Age group (in				
months)	100 (51.0)	61 (77.2)	161 (58.5)	
2-11	76 (38.8)	15 (19.0)	91 (33.1)	
12-23	15 (7.7)	2 (2.5)	17 (6.2)	**P=0.001*+**
24-35	5 (2.5)	1 (1.3)	6 (2.2)	
36-59				
Sex				
Female	114(58.2)	51 (64.6)	165 (60.0)	χ^2=95.91
Male	82 (41.8)	28 (35.4)	110 (40.0)	P=0.327
Exclusive BF				
Yes	105 (53.6)	9 (11.4)	114 (41.5)	χ^2=41.274
No	91 (46.4)	70 (88.6)	161 (58.5)	**P<0.001***
Immunization				
status	182 (92.9)	41 (51.9)	223 (81.1)	χ^2=61.602
Complete	14 (7.1)	38 (48.1)	52 (18.9)	**P<0.001***
Incomplete				
Social class				
Upper	127 (64.8)	18 (22.8)	145 (52.7)	
Middle	35 (17.9)	22 (27.8)	57 (20.7)	χ^2=43.306
Lower	34 (17.3)	39 (49.4)	73 (26.6)	**P<0.001***
Duration of first				
symptom (days)				
<2	3 (1.5)	0 (0.0)	3 (1.1)	**P<0.001*+**
2 to 5	164 (83.7)	30 (38.0)	194 (70.5)	
>5	29 (14.8)	49 (62.0)	78(28.4)	
Haemoglobin level				
Normal	41 (20.9)	3 (3.8)	44 (16.0)	
Low (anaemia)	155 (79.1)	76 (96.2)	231 (84.0)	**P<0.001*+**
TWBC				
Normal	155 (79.1)	29 (36.7)	184 (66.9)	
Leucopenia	7 (3.6)	0 (0.0)	7 (2.5)	**P<0.001*+**
Leukocytosis	34 (17.3)	50 (63.3)	84 (30.6)	
Lymphocyte				
Normal	100 (51.0)	14 (17.7)	114 (41.5)	
Lymphopenia	94 (48.0)	65 (82.3)	159 (57.8)	**P<0.001*+**
Lymphocytosis	2 (1.0)	0 (0.0)	2 (0.7)	
Neutrophil				
Normal	149 (76.0)	25 (31.7)	174 (63.3)	
Neutropenia	5 (2.6)	2 (2.5)	7 (2.5)	**P<0.001*+**
Neutrophilia	42 (21.4)	52 (65.8)	94 (34.2)	

*** significant p value; + Fisher's Exact p value; Chi-square test was used for categorical variables**

participants with Radiologically confirmed Pneumonia (n=275)Figure II illustrates the association between sociodemographic and haematological indices with bacteriaemia among children with radiologically confirmed pneumonia. =

In the univariate analysis (Figure IIA), younger age (p<0.001), lack of exclusive breastfeeding (p<0.001), middle and lower social class (p<0.001, respectively), duration of first symptom >5 days (p<0.001), anaemia (p=0.002), leukocytosis (p<0.001) and neutrophilia (p<0.001) significantly increased the odds of having a positive blood culture among children with radiologically confirmed CAP.

In the multivariate analysis (Figure IIB), lack of exclusive breastfeeding (Adjusted OR (AOR)=3.32; 95%CI=1.26-8.80, P=0.015), incomplete immunisation (AOR=3.84; 95%CI=1.40-10.49, P=0.009), Duration of the first symptom of more than 5 days (AOR=2.61, 95%CI=1.10-6.20 P=0.030) and neutrophilia (AOR=3.70; 95%CI=1.58-8.66, P=0.003) significantly increased the odds of having a positive blood culture among children with radiologically confirmed CAP. However, increasing age significantly reduced the odds of having a positive blood culture result among children with radiologically confirmed pneumonia (AOR = 0.87, 95% CI = 0.80-0.94; p = 0.001)

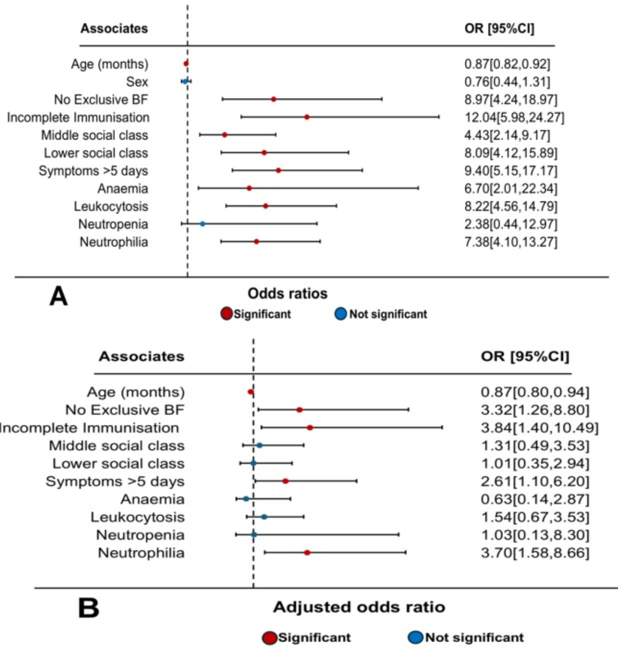

Figure II: Forest plots showing the association between sociodemographic and haematological indices with bacteriaemia among children with radiologically confirmed pneumonia. A. Univariate analysis. B. Multivariate analysis. Significant p-value <0.05

Discussion

The prevalence of bacteraemia in children with radiologically confirmed pneumonia in our study was 28.7%. This was comparable to the prevalence of 27.5% and 31.2% reported in previous studies by Abdulkarim *et al*[16] and Amai *et al*[19] in Ilorin and Makurdi, respectively. This high prevalence may be because more than half (56.2%) of the participants in our study were infants, aged 2 to 11 months. This group of children are more predisposed to infections due to the immaturity of their immune system. In contrast, Akinrinoye *et al*[18] in Ibadan, reported a prevalence of 8.14%, Negash *et al*[1] reported 5.6% in Ethiopia, Tapia *et al*[15] reported 5.0% in Mali, Asih *et al*[27] reported 8.2% in Indonesia. The contrasting difference may have been due to the study design employed in the Ibadan study, which was a retrospective study where data were obtained from patients' records previously managed in the facility, with a possibility of missed data. On the other hand, the study in Ethiopia comprised children aged 0 to 14 years. The older children's population may have contributed to the low prevalence, as they have a lower predisposition to infections. Furthermore, lower prevalences of 3.3%,[28] 3.2%,[13] and 1.4%,[29] reported in studies in developed countries may be because most cases of pneumonia in developed countries are viral in origin, hence the low prevalence of bacteraemia.

Younger age, lack of exclusive breastfeeding, incomplete immunisation status, duration from onset of symptom to presentation greater than five days, and neutrophilia were reported as independent predictors of bacteraemia in children with radiologically confirmed pneumonia. Younger age was reported as an independent predictor of bacteraemia in this study. This is consistent with findings from a previous study in Indonesia[27]. The plausible reason may be due to the immaturity of their immune system, which predisposes them to infections when compared to older children. Additionally, our study identified that the duration from onset of symptoms to presentation greater than five days was an independent predictor of bacteraemia in children with radiologically confirmed pneumonia. This finding was in keeping with earlier studies by Asih *et al.*[27] A plausible reason for this finding may be that delayed presentation to a health facility for proper medical treatment is known to cause increased morbidity and mortality in children, especially under-fives. During this period of delay, there is a tendency to resort to unorthodox care with increased chances of misdiagnosis and harmful interventions. Furthermore, Neutophilia was also shown to be an independent predictor of bacteraemia in this study. This can be explained by the significant involvement of large numbers of neutrophils in bacterial infections, including those affecting the lungs.[30] Similarly, this study identified leukocytosis as a significant factor in bacteraemia in children with radiologically confirmed pneumonia. This finding corroborated previous studies in Thailand,[31] Japan,[29] Indonesia,[27], and the United States.[28] The possible explanation for this is that leukocytosis is the body's immune response to infections.

Conclusion

The prevalence of bacteraemia in children with radiologically confirmed pneumonia was high. The independent predictors of bacteraemia in these children included younger age, lack of exclusive breastfeeding, incomplete immunization status, duration from onset of symptom to presentation greater than five days and neutrophilia. Blood culture should be done in all patients with community-acquired pneumonia at presentation. This will ensure early identification of bacterial agents for culture-directed antibiotic administration and reduce antimicrobial resistance.

Conflicts of Interest

The authors have declared that they have no competing interests.

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