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# Microbiological Profile, Antibiotic Susceptibility Pattern of Isolates and Clinical Outcome of Paediatric Parapneumonic Effusion in Nigerian Children

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**Abstract**

**Background:**
Parapneumonic effusion (PPE) remains a significant cause of morbidity among children with pneumonia, especially in low- and middle-income countries where diagnostic limitations and antibiotic resistance complicate management.

**Objective:** To determine the incidence, diagnostic modalities, bacteriological profile, antimicrobial susceptibility patterns, and outcomes of pediatric PPE in a tertiary hospital in Nigeria.

**Methods:** A five-year retrospective study was conducted among children aged 0–15 years diagnosed with PPE. Relevant data on socio-clinical characteristics, diagnostic findings, complications, comorbidities, and outcomes were extracted from patient records.

**Results:** Forty-two PPE cases were identified, giving an incidence rate of 1.1 per 1,000 pneumonia admissions. The mean age was 7.9 ± 3.8 years, with a male predominance (66.7%). Most had received prior antibiotics (88.1%) and were underweight (69.1%). Mycobacterium tuberculosis was detected in 14.3% of cases. Bacterial culture was positive in 28.6% of cases, with *Streptococcus pneumoniae*, *Staphylococcus aureus* (including MRSA), *Streptococcus agalactiae*, and *Escherichia coli* as the leading isolates. Gram-positive isolates were sensitive to cefuroxime, ceftriaxone, and gentamicin, while MRSA and MDR *E. coli* were sensitive to ciprofloxacin. Major complications included hypoxaemia and sepsis.

**Conclusion:** PPE is a significant pediatric respiratory complication. Strengthening pneumococcal vaccination, improving diagnostics, and implementing antimicrobial stewardship are crucial for better outcomes.

***Keywords: Antibiotic susceptibility, Childhood pneumonia, Effusion, Mycobacterium tuberculosis, Streptococcus pneumoniae.***

## Introduction

Parapneumonic effusion (PPE) is the abnormal accumulation of fluid in the pleural cavity

secondary to pneumonia. It represents an extension of lung infection into the pleural space and is associated with increased morbidity, prolonged hospitalisation, and higher treatment costs. [1, 2] Both bacterial and viral pathogens can cause PPE, but bacteria account for the majority of cases. [3, 4] Globally, PPE complicates up to 50–70% of severe or complicated pneumonia, and comorbidities, inappropriate antibiotic use, antimicrobial resistance, and delayed presentation amplify the risk. [5, 6]

PPE may present as uncomplicated or complicated effusions. Uncomplicated PPE is usually sterile, with normal glucose and pH levels, and often responds to antibiotics alone. In contrast, complicated PPE and empyema result from bacterial invasion of the pleura, usually requiring drainage and are associated with poorer outcomes. [1, 7] The incidence of PPE has been increasing worldwide despite advances in vaccination and management. [8, 9] Male children are disproportionately affected, and in tuberculosis-endemic regions, *Mycobacterium tuberculosis* accounts for 10–14% of cases. [10, 11]

The microbiological profile of paediatric PPE varies by region. In most studies, *Streptococcus pneumoniae* and *Staphylococcus aureus* are the leading pathogens, responsible for up to 70% of positive Gram-positive cultures. [12, 13] Among Gram-negative organisms, *Klebsiella*, *Pseudomonas*, and *Haemophilus* species are often implicated. [14, 15] However, culture yield remains low, with nearly 60% of cases showing no growth, often due to prior antibiotic use. [16, 17] In resource-limited settings, diagnosis of TB-related PPE is further complicated by the poor sensitivity of GeneXpert, leading to reliance on empirical treatment. [18, 19] Antimicrobial resistances further complicate management, with multidrug-resistant organisms increasingly reported. [20, 21]

The mainstay of PPE management remains prompt initiation of antibiotics combined with drainage when indicated. International guidelines recommend a multimodal approach, including imaging, antimicrobials, and drainage procedures, with adjunctive fibrinolytics and minimally invasive surgery in well-resourced settings. [2, 22] In contrast, low- and middle-income countries often rely on chest tube drainage alone, contributing to higher complication rates and prolonged hospital stays. [23, 24] Given these challenges, there is a pressing need for local epidemiological data to guide empirical therapy. This study, therefore, aimed to determine the incidence, diagnostic modalities, microbiological profile, antimicrobial susceptibility patterns, complications, comorbidities, and outcomes of paediatric PPE in a tertiary hospital in Northwestern Nigeria.

## Methods

*Study design and site*

This was a retrospective observational study with secondary data collection conducted between 1st January 2017 and 31st December 2021, at the Department of Paediatrics of Usmanu Danfodiyo University Teaching Hospital, Sokoto, northwest Nigeria.

*Sampling technique and sample size determination*

All the available records were retrieved for data extraction. All children who met the inclusion criteria within the study period were included.

*Study population and case identification*

The records of all children aged 1 month to 15 years admitted with a diagnosis of PPE during the study period were retrieved from admission registers and case folders. Additional information, including complications, comorbid illnesses, and treatment outcomes, were extracted from the case records. The annual total

admissions and the number of children admitted with pneumonia were also recorded.

The diagnosis of PPE was based on clinical evaluation, thoracocentesis, and supportive investigations, including chest radiography, chest ultrasonography, Mantoux test, blood/pleural fluid/sputum cultures, Gram staining, GeneXpert MTB/RIF assay, full blood count, erythrocyte sedimentation rate (ESR), and retroviral screening. Both haematological, biochemical, cytological, microbiological, and radiological assessments were considered in making the diagnosis.

*Socioeconomic and nutritional status assessment*

Socioeconomic status was determined using the scheme of Ibadin *et al.* for Nigerian children, [25] which classifies children into upper, middle, and lower classes. Nutritional status was assessed using two approaches: for children aged 2–15 years, body mass index (BMI) was calculated as weight/height² (kg/m²) and interpreted using CDC growth charts. [26] For children under 2 years, the WHO Anthro v3.2.2 software was used, applying Z-scores for weight-for-age, length/height-for-age, and weight-for-length/height. [27] Mid-upper arm circumference (MUAC) was also used for children with suspected acute malnutrition.

*Operational Definitions*

*Multidrug resistance (MDR):* Resistance to at least one antimicrobial in three or more antibiotic classes.

*TB contact:* Child with documented close exposure to an adult with tuberculosis within the preceding 3 months.

*High ESR:* Erythrocyte sedimentation rate >20 mm/hour.

*Hypoxaemia:* Oxygen saturation <92% on room air.

*Immunisation status: Fully immunised for age:* Completion of routine national immunisation schedule appropriate for the child's age. *Not immunised for age:* Incomplete or undocumented routine vaccinations.

*Classification of PPE:* Tuberculous *PPE:* Pleural effusion that improves with anti-TB therapy, supported by microbiological confirmation (GeneXpert or culture) **or** clinical–radiological features consistent with TB. *Bacterial PPE:* Pleural effusion resolving with appropriate antibiotic therapy and exclusion of non-infective causes. [28, 29]

*Inclusion and exclusion criteria*

*Inclusion criteria*

Children aged 1 month–15 years admitted with radiologically confirmed pleural effusion and thoracocentesis yielding adequate pleural fluid for microscopy, culture, and sensitivity (MCS).

*Exclusion criteria*

Children without radiological confirmation of pleural effusion; cases where pleural fluid aspiration was unsuccessful; pleural effusion due to non-infective causes (cardiac, renal, hepatic disease, malignancy, trauma, post-surgical complications); records with >20% missing data.

*Missing data handling*

Records with substantial missing data (>20%) were excluded. For variables with minimal missing data, available-case analysis was applied. The potential impact of missing data is addressed in the limitations.

Children presenting with suspected pneumonia had initial clinical assessment and imaging, including chest radiography and, where available, chest ultrasound. If effusion was absent, patients were managed as if they had pneumonia. If pleural effusion was detected, pleural aspiration was performed, followed by laboratory evaluation including full blood count (FBC), erythrocyte sedimentation rate (ESR), HIV screening, Mantoux test, pleural Gram stain and culture, and GeneXpert MTB/RIF assay. Effusions were then classified as bacterial PPE or tuberculosis (TB) PPE, guiding appropriate

management with antibiotics, tube thoracostomy, anti-TB therapy, and supportive care. Patients were subsequently monitored for complications such as hypoxaemia, congestive heart failure (CHF), and sepsis.

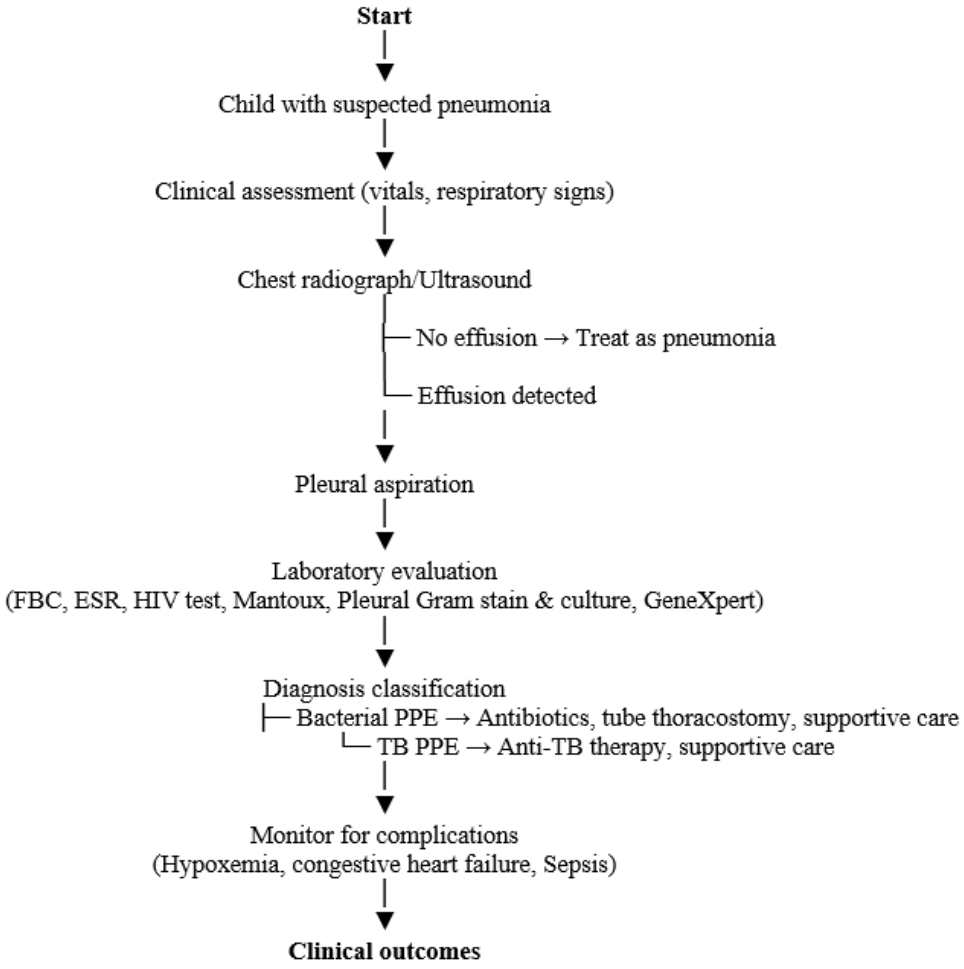


**Figure 1: Diagnostic pathway for paediatric parapneumonic effusion (PPE)**

*Data analysis*

Data were analysed using SPSS Version 20 (IBM, Armonk, NY). Continuous variables were summarised using means and standard deviations, and categorical variables using frequencies and percentages. Incidence rates were computed using descriptive weighted incidence formulas. Associations between socio-demographic variables and outcomes were assessed using the Chi-square or Fisher's Exact test, as appropriate. A p-value ≤0.05 was considered statistically significant.

*Ethical considerations*

Ethical approval for the study was obtained from the Institutional Health Research Ethics Committee with approval number: HREC/2022/1195/V1. As this study involved retrospective review of existing records, the requirement for informed consent was waived by the ethics committee.

## Results

The mean age of the 42 children with PPE was 7.9±3.8 years, with the 6–10 years age group most affected (45.2%). Infants and preschool children (0–5 years) accounted for 31.0%, while adolescents (11–15 years) made up 23.8%. Males predominated (66.7%) with a male-to-female ratio of 2.5:1 (Table I).

**Table I: Socio-demographic and clinical characteristics (n = 42)**

| Variable | Category | n (%) |
|---|---|---|
| Age (years) | 0–5 | 13 (31.0) |
| | 6–10 | 19 (45.2) |
| | 11–15 | 10 (23.8) |
| Sex | Male | 28 (66.7) |
| | Female | 14 (33.3) |
| Residence | Urban | 35 (83.3) |
| | Rural | 7 (16.7) |
| Socioeconomic status | Low | 30 (71.5) |
| | Middle | 9 (21.4) |
| | High | 0 (0.0) |
| | Not recorded | 3 (7.1) |
| Immunisation status | Fully immunised | 6 (14.3) |
| | Not immunised | 31 (73.8) |
| | Not recorded | 5 (11.9) |
| History of TB contact | Yes | 2 (4.8) |
| | No | 10 (23.8) |
| | Not recorded | 30 (71.4) |
| History of overcrowding | Yes | 4 (9.5) |
| | No | 8 (19.1) |
| | Not recorded | 30 (71.4) |
| Nutritional status | Normal weight | 2 (4.8) |
| | Underweight | 29 (69.0) |
| | Not recorded | 11 (26.2) |
| Prior antibiotic use | Yes | 37 (88.1) |
| | No / not recorded | 5 (11.9) |
| Referral source | Peripheral hospital | 35 (83.3) |
| | Direct admission | 7 (16.7) |

The majority were from urban areas (83.3%), and nearly 71.5% were from the low socioeconomic backgrounds. Immunisation status was generally poor—almost three-quarters (73.8%) were not immunised for their age, and information was missing in 11.9% of cases. Nutritional assessment showed that two-thirds (69.0%) were underweight, while only 4.8% had normal BMI for age. No child was overweight or obese. Most children (88.1%) had received prior antibiotics before referral, and over four-fifths (83.3%) were referred from peripheral hospitals. Information on household overcrowding and tuberculosis contact was missing in more than 70% of cases, though among those with available data, 9.5% reported overcrowding and 4.8% reported TB contact.

During the five-year study period, 42 cases of PPE were identified among 3,794 pneumonia admissions. This corresponds to a hospital-based proportion of 1.1% (11.1 per 1,000 pneumonia admissions; 95% CI: 0.93–1.29) (Table II). The annual proportion of PPE among pneumonia admissions ranged from 0.9% to 1.3% and showed no statistically significant variation across study years (p = 0.13).

All 42 children had chest radiographs, pleural fluid aspiration for microscopy/culture/sensitivity, full blood count, erythrocyte sedimentation rate, GeneXpert MTB/RIF, and retroviral screening performed (Table III). Radiographs consistently showed features of effusion, consolidation, or atelectasis. Pleural fluid aspiration was performed in all cases, but only 26.2% yielded bacterial growth, while 73.8% were culture-negative. Blood cultures were performed in five patients, with only one positive result. Pleural fluid for AAFB and gastric washout showed no organisms in the majority of cases, while sputum AAFB was uniformly negative.

GeneXpert MTB/RIF detected Mycobacterium tuberculosis in 9.5% of cases, while Mantoux testing was done in 64.3% of patients, with 11.1% showing significant induration. All patients had elevated ESR values. Haematological findings revealed leucocytosis in 64.3% of cases and anaemia in 45.2%. Chest ultrasound was the least

utilised diagnostic tool, performed in only one patient (2.4%), who demonstrated pleural thickening, loculation, and atelectasis.

Figure 2 demonstrates relatively stable rates across the study period with a modest downward trend towards the later years; the trend was not statistically significant ($\chi^2 = 16.4$, p = 0.13).

**Table II: Annual incidence of parapneumonic effusion**

| Study years | Parapneumonic cases enrolled | Total Pneumonia cases admitted | Incidence per 1000 Pneumonia admissions per year | Test statistical & *p*-value |
|---|---|---|---|---|
| **2017** | 9 | 752 | 1.20 | $\chi^2$ =16.4 |
| **2018** | 10 | 750 | 1.33 | *p* = 0.13 |
| **2019** | 9 | 760 | 1.18 | |
| **2020** | 8 | 777 | 1.03 | |
| **2021** | 6 | 755 | 0.79 | |
| **Total** | 42 | 3794 | 1.11 | |

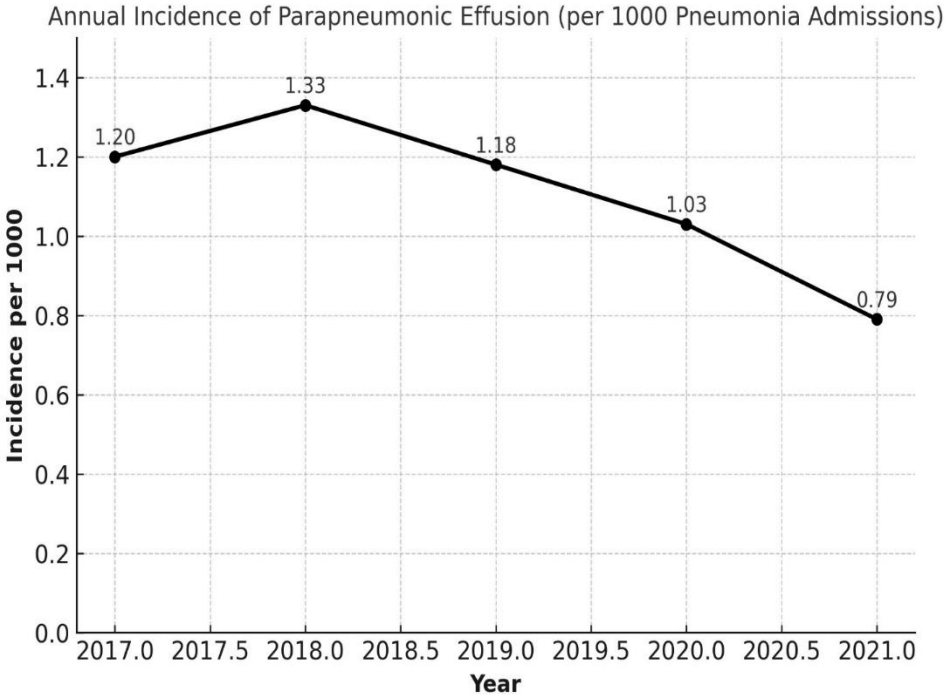


**Figure 2: Temporal distribution of incidence of parapneumonic effusion (2017–2021).**

Out of the 42 children with PPE, culture positivity was recorded in 28.6%, while 71.4% had negative cultures (Table IV). The majority of isolates (91.7%) were obtained from pleural fluid aspirates, with only one organism (8.3%) recovered from blood culture.

Among the organisms identified, *Streptococcus pneumoniae* was the most common (41.7%), followed by *Streptococcus agalactiae* (25.0%), *Staphylococcus aureus* (16.7%), and methicillin-resistant *Staphylococcus aureus* (MRSA, 8.3%). *Escherichia coli* (8.3%) was the only Gram-negative isolate cultured from a patient with sickle cell disease. Overall, Gram-positive organisms accounted for 91.7% of the isolates,

while Gram-negative organisms accounted for 8.3%.

**Table III: Frequency of use of diagnostic tools used in parapneumonic effusion (n = 42)**

| **Investigations** | n **(%)** |
|---|---|
| Chest radiograph | 42 (100.0) |
| Features of Effusion, consolidation, atelectasis | 42 (100.00) |
| Pleural fluid aspirate M/C/S | 42 (100) |
| Organism cultured | 11 (26.2) |
| No Organism cultured | 31 (73.8) |
| Retroviral Screening | 42 (100.0) |
| Reactive | 0 (0.0) |
| Non-reactive | 42 (100.0) |
| Full blood count and differentials | 42 (100.0) |
| Leukocytosis > 12000 with predominant neutrophilia | 27 (64.3) |
| Anaemia (haemotocrit < 30%) | 19 (45.2) |
| Normal leucocyte count | 15 (35.7) |
| Erythrocyte Sedimentation Rate | 42 (100.0) |
| Elevated > 80millimeters/hour | 42 (100.0) |
| GeneXpert MTB/RIF | 42 (100.0) |
| *M. tuberculosis* detected | 4 (9.5) |
| *M. tuberculosis* undetected | 38 (90.5) |
| Mantoux | 27 (64.3) |
| 0-millimeter induration | 24 (88.9) |
| >5 millimetres induration | 3 (11.1) |
| Pleural fluid aspirate AAFB | 12 (28.6) |
| Organism cultured | 0 (0.0%) |
| No Organism cultured | 12 (100.0%) |
| Blood Culture | 5 (12.0%) |
| Organisms cultured | 1 (20.0%) |
| No organism cultured | 4 (80.0%) |
| Gastric washout for AAFB | 4 (9.5) |
| Organism cultured | 1 (25.0) |
| No Organism cultured | 3 (75.0%) |
| Sputum AAFB | 2 (4.8) |
| Organism cultured | 0 (0.0) |
| No Organism cultured | 2 (100.0) |
| Chest Ultrasound | 1 (2.4) |
| Pleural effusion, pleural thickening, loculation, atelectasis | 1 (100.0) |

**AAFB - Acid Alcohol Fast Bacilli, M/C/S - Microscopic Culture and Sensitivity, MTB/RIF - *Mycobacterium tuberculosis* Resistance to Rifampicin**

Among the 12 culture-positive cases, Gram-positive bacteria predominated (91.7%), with only one Gram-negative isolate (8.3%). *Streptococcus pneumoniae* was the most frequent Gram-positive isolate, followed by *Streptococcus agalactiae*, *Staphylococcus aureus*, and MRSA. *Escherichia coli* was the only Gram-negative isolate identified (Table V).

Gentamicin demonstrated universal sensitivity across all isolates tested (100%), while cefuroxime was effective against all six isolates tested. Ceftriaxone was active against 81.8% of

isolates, mainly Gram-positive. Sensitivity to amikacin and augmentin was also observed in some *Streptococcus pneumoniae* and *Staphylococcus aureus* isolates.

**Table IV: Microbiological profile of parapneumonic effusion**

| Culture Yield | Organisms | N (%) | 95% C.I (%) |
|---|---|---|---|
| Culture Negative | | 30(71.4) | 57.7 - 85.1 |
| Culture Positive | | 12(28.6) | 14.6 - 42.3 |
| Pleural Fluid | *Streptococcus Pneumoniae* | 4 (33.3) | |
| | *Streptococcus agalactiae* | 3 (25.0) | |
| | *Staphylococcus aureus* | 2 (16.7) | |
| | *MRSA* | 1 (8.3) | |
| | *Escherichia coli* | 1 (8.3) | |
| Blood | *Streptococcus Pneumoniae* | 1 (8.3) | |

**MRSA - Methicillin-Resistant *Staphylococcus aureus***

**Table V: Antibiotic susceptibility patterns of bacteria isolated from parapneumonic effusions**

| Pathogen (n) | Antibiotic | Sensitive n (%) | Resistant n (%) |
|---|---|---|---|
| Streptococcus pneumoniae (n = 5) | Gentamicin | 5 (100) | 0 (0) |
| | Ceftriaxone | 4 (80) | 1 (20) |
| | Cefuroxime | 4 (100) | 0 (0) |
| | Amikacin | 4 (80) | 1 (20) |
| | Augmentin | 3 (60) | 2 (40) |
| | Penicillin | 1 (25) | 3 (75) |
| | Ciprofloxacin | 4 (80) | 1 (20) |
| Streptococcus agalactiae (n = 3) | Ceftriaxone | 3 (100) | 0 (0) |
| | Gentamicin | 3 (100) | 0 (0) |
| | Erythromycin | 1 (33.3) | 2 (66.7) |
| | Penicillin | 0 (0) | 3 (100) |
| Staphylococcus aureus (n = 2) | Cefuroxime | 2 (100) | 0 (0) |
| | Gentamicin | 2 (100) | 0 (0) |
| | Ciprofloxacin | 1 (50) | 1 (50) |
| | Clindamycin | 1 (50) | 1 (50) |
| | Oxacillin | 0 (0) | 2 (100) |
| MRSA (n = 1) | Vancomycin | 1 (100) | 0 (0) |
| | Ciprofloxacin | 1 (100) | 0 (0) |
| | Penicillin | 0 (0) | 1 (100) |
| | Ceftriaxone | 0 (0) | 1 (100) |
| Escherichia coli (n = 1) | Gentamicin | 1 (100) | 0 (0) |
| | Ceftriaxone | 1 (100) | 0 (0) |
| | Ciprofloxacin | 1 (100) | 0 (0) |
| | Augmentin | 0 (0) | 1 (100) |
| | Cotrimoxazole | 0 (0) | 1 (100) |

Conversely, penicillin resistance was noted in 75.0% of isolates, while oxacillin, cefalexin, and ampicillin also showed high resistance rates. MRSA was resistant to multiple antibiotics but remained sensitive to vancomycin and ciprofloxacin. Similarly, the single multidrug-resistant *Escherichia coli* isolate retained sensitivity to ciprofloxacin and gentamicin but showed resistance to ceftriaxone, augmentin, and cotrimoxazole.

Hypoxaemia was the most frequent complication, present in all cases (100%), followed by congestive heart failure (92%) and sepsis in a

smaller proportion of patients **(**Figure 3). Most patients (78.6%) had at least one comorbidity, with underweight status being the most prevalent (69.0%) **(**Figure 4)**.** Other comorbidities included measles and sickle cell anaemia, while only 9 patients (21.4%) had no comorbidity. The majority of patients (90.5%) were successfully discharged, while a small fraction (9.5%) developed severe complications or succumbed to illness.

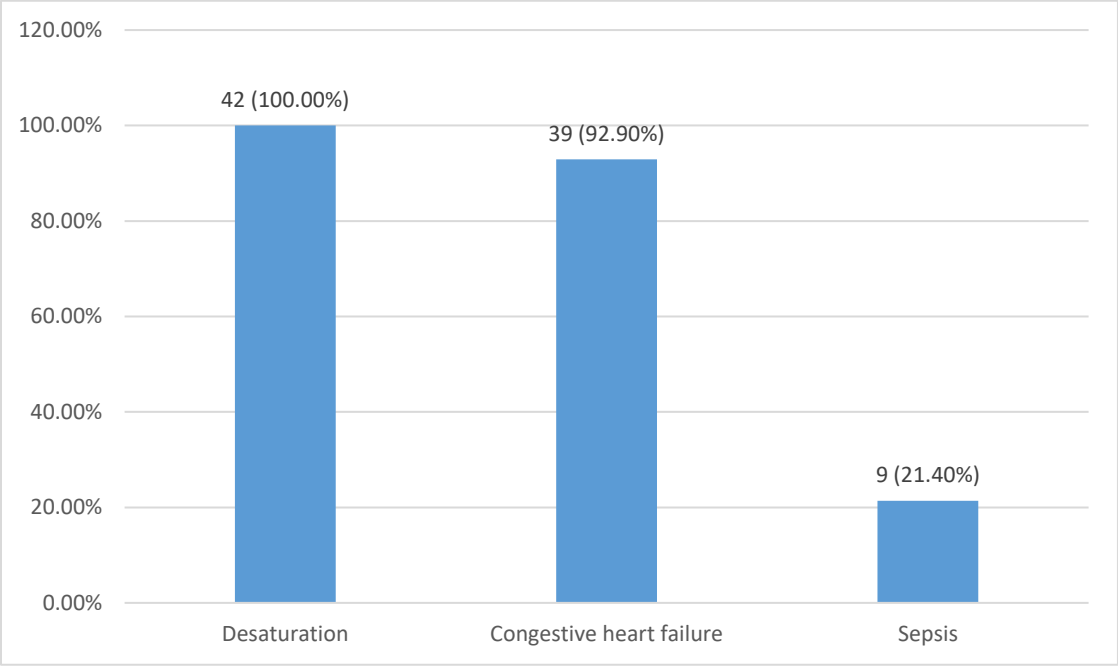


**Figure 3: Complications associated with parapneumonic effusion**

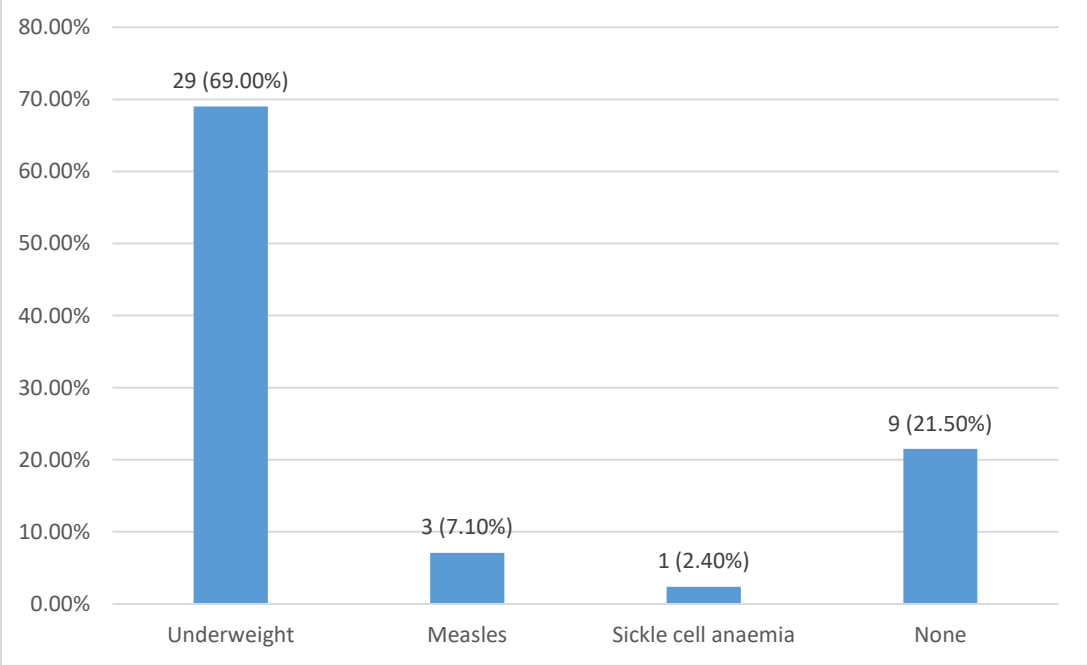


**Figure 4. Comorbidities in children with parapneumonic effusion**

## Discussion

This study found that PPE complicated 1.1 per 1000 pneumonia admissions in children. This incidence is within the range reported in other countries, such as South Africa (1.46%), India (1.44%), and the USA (0.4–6%). [20, 31, 32] However, markedly higher rates have been documented in Southwest Nigeria (8.0%), South-South Nigeria (6.7%), and the Poland (6.8%). [23, 24, 33] The variation in reported incidence may reflect differences in case definitions, diagnostic practices, and population characteristics. Importantly, the introduction of the pneumococcal conjugate vaccine (PCV) into Nigeria's national immunisation schedule between 2014 and 2016 is likely to have contributed to the lower incidence observed in our study compared to earlier Nigerian reports. Global evidence consistently shows that PCVs reduce pneumococcal-associated pneumonia and PPE. [34-36] This suggests that vaccination rollout is beginning to impact disease epidemiology, though gaps in vaccine uptake remain.

The male sex predominated in our series, accounting for two-thirds of cases, with a mean age of 7.9 years. These findings align with several studies indicating that male children are more susceptible to infectious diseases, including PPE. [23, 24, 33, 37-41] Biological and behavioural factors, including sex-linked immune responses and differential exposure risks, may contribute to this pattern. The peak age group affected (6–10 years) also mirrors earlier reports, highlighting the vulnerability of school-aged children to lower respiratory tract infections and their complications.

Nutritional status emerged as an important determinant. Over two-thirds of cases were underweight, reflecting the established bidirectional relationship between malnutrition and infections: malnutrition predisposes children to severe illnesses. In contrast, recurrent infections exacerbate poor nutritional status. [42] This is consistent with studies from Pakistan and elsewhere showing that undernutrition is the commonest comorbidity in PPE. [43] Malnutrition may also explain the poor sensitivity of immunological diagnostic tools in our cohort, particularly the Mantoux test, as undernourished children often fail to mount an adequate immune response to purified protein derivative (PPD). [44, 45]

Diagnostic evaluation in our cohort was in line with international recommendations. All patients underwent chest radiography, pleural fluid aspiration for microbiological analysis, full blood count, ESR, retroviral screening, and GeneXpert testing. Chest radiographs universally confirmed massive effusions, necessitating tube thoracostomy. This parallels earlier studies emphasising the central role of radiography in PPE evaluation. [37, 40, 46, 47] However, chest ultrasound was rarely used (2.4%), despite its well-documented superiority over radiographs in detecting effusions, identifying loculations, and guiding drainage. [23, 48 – 51] This underuse likely reflects the limited availability of ultrasound in many Nigerian centres and underlines the need for resource strengthening. Pleural fluid GeneXpert detected *Mycobacterium tuberculosis* (MTB) in fewer than 10% of cases, while Mantoux was positive in only 11% of those tested. Nonetheless, clinical assessment identified additional TB-associated PPE, underscoring the diagnostic challenges of tuberculous effusions in children. TB PPE is often paucibacillary, making smear and culture insensitive. [10, 11] In endemic settings such as Nigeria, careful clinical evaluation remains essential, supported by guidelines from WHO and national TB programs recommending empirical treatment when clinical suspicion is strong. [28, 29, 34, 37, 52] Our finding of MTB in 14.3% of cases is higher than the 3–5% reported in non-

endemic settings, but consistent with other African data. [15, 20, 53]

Blood and pleural fluid cultures, though recommended, yielded pathogens in only 28.6% of cases, similar to global reports. [17, 20, 32, 36, 54-55] The low yield contrasts with higher rates in Pakistan (52.7%) and the UK (43%). [20, 56] Multiple factors contribute to this difference, most notably the high rate of prior antibiotic use in our cohort (88.1%), which likely sterilised pleural fluid before sampling. Culture-based methods also lack sensitivity, particularly in children. Molecular diagnostics such as PCR can improve pathogen detection, identify resistance genes, and provide faster results. [57] However, their high cost and limited availability in resource-constrained settings remain barriers.

The most common organisms isolated were Gram-positive bacteria, with Streptococcus pneumoniae (41.6%) leading, followed by *Streptococcus agalactiae* and *Staphylococcus aureus*. One MRSA and a single Gram-negative *Escherichia coli* isolate were identified. This distribution aligns with global and African studies that consistently report *S. pneumoniae* as the major pathogen in paediatric PPE. [1, 2, 4, 13, 36] Nevertheless, some Nigerian and regional studies have reported *S. aureus* as the leading cause, highlighting local epidemiological variations. [23, 30, 37] These differences reinforce the need for empirical antibiotic regimens that cover both pneumococci and staphylococci while awaiting culture results.

The antibiotic susceptibility profile is noteworthy. Gentamicin, cefuroxime, and ceftriaxone demonstrated high effectiveness, with nearly universal sensitivity among Gram-positive isolates. This suggests these agents remain reliable first-line therapies for PPE in our setting, consistent with findings from Eslami *et al.* [39] However, penicillin resistance was widespread (75%), echoing the global trend of rising pneumococcal resistance, particularly in sub-Saharan Africa and Asia, where PCV coverage is incomplete, and antibiotic misuse is common. [58-60] The MRSA and MDR *E. coli* isolates, though rare, raise concern, given their association with complicated PPE cases and global reports of increasing prevalence. [61-63]

Interestingly, ciprofloxacin showed activity against both MRSA and MDR *E. coli* in our cohort, suggesting it may be a valuable second-line agent in cases of resistance. However, its role in paediatrics is limited by safety considerations, underscoring the importance of stewardship and susceptibility-guided therapy. The discrepancy between empirically prescribed antibiotics (mainly ceftriaxone or cefuroxime, sometimes with metronidazole) and the high gentamicin sensitivity observed highlights an opportunity to optimise treatment protocols in Nigerian hospitals.

Nearly all patients developed hypoxaemia, and over 90% had congestive heart failure, reflecting the severe cardiorespiratory compromise caused by massive effusions. Sepsis was another frequent complication, consistent with the earlier Nigerian study. [23] These complications underscore the critical importance of early recognition and aggressive supportive management in PPE.

Despite the high burden of complications and comorbidities, treatment outcomes were favourable. Over 90% of children were successfully discharged after an average stay of 22 days. Mortality was below 10%, in line with global averages (~10%). [64] Importantly, none of the patients left against medical advice, suggesting strong adherence to inpatient care once treatment was initiated. Historical data show much higher mortality rates (up to 50%) before the advent of modern antibiotics, chest drainage techniques, and vaccines. [64] The improved survival in our cohort reflects advances in

supportive care and the benefits of widespread antibiotic availability, though antibiotic resistance remains a looming threat.

Our findings have several public health implications. First, strengthening vaccination coverage, particularly PCV, is crucial to sustaining and amplifying the decline in PPE incidence. Second, preventing and promptly treating childhood malnutrition should remain a priority, given its significant role as both a comorbidity and a factor reducing diagnostic test sensitivity. Third, antimicrobial stewardship is urgently needed to mitigate indiscriminate antibiotic use, which likely contributes to the high resistance rates observed. This includes promoting evidence-based prescribing, restricting over-the-counter antibiotic sales, and improving diagnostic microbiology capacity to guide therapy. Finally, investment in diagnostic technologies such as ultrasound and molecular assays could improve accuracy, reduce delays, and optimise outcomes.

*Limitations*

This study has several limitations. Its retrospective design led to missing or incomplete records, limiting the assessment of some clinical and laboratory variables. Pleural fluid biochemical analysis, important for differentiating empyema from other effusions, was inconsistently available. Culture yields may have been underestimated due to widespread pre-hospital antibiotic use and the absence of molecular diagnostic tools such as PCR. Low use of chest ultrasound may also have led to underrecognition of loculated disease. Finally, being a single-centre study, the findings may not be generalisable to other regions of Nigeria with different vaccination coverage, diagnostic capacities, or epidemiological profiles.

## Conclusion

This study highlights that while the incidence of paediatric PPE in our centre is lower than older Nigerian reports, it remains a significant complication of pneumonia. *Streptococcus pneumoniae* remains the leading cause, with Gram-positive bacteria predominating. Gentamicin, cefuroxime, and ceftriaxone remain highly effective antibiotics, though penicillin resistance is widespread. The emergence of MRSA and MDR *E. coli*, though infrequent, warrants vigilance.

Improving vaccination coverage, strengthening nutritional interventions, expanding access to modern diagnostics, and enforcing antimicrobial stewardship are essential strategies to reduce PPE burden and improve outcomes. Collaboration between clinicians and microbiologists is key to guiding effective therapy, curbing resistance, and ultimately improving survival in Nigerian children with PPE.

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