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Guideline adherence, AWaRe antibiotics, and outcomes in severe childhood pneumonia in Tanzania

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Abstract

Background Lower respiratory tract infections are the leading infectious cause of death in children under five, particularly in sub-Saharan Africa. Adherence to World Health Organization (WHO) antibiotic guidelines for severe pneumonia is suboptimal in high-burden settings.

Methods We conducted a retrospective observational study at St. Gaspar Hospital, Itigi, Tanzania, including children aged 2–59 months admitted with severe pneumonia between May 2021 and April 2024. Adherence was defined as the prescription of ampicillin or benzylpenicillin plus gentamicin within 48 h of admission, irrespective of dosage. Clinical features, laboratory results, and outcomes were compared between adherent and non-adherent groups.

Results We included 81 children (42.0% female; mean age 13.1 ± 11.7 months). Adherence to WHO guidelines occurred in 64 patients (79.0%); 11 (13.6%) received at least one antibiotic from the WHO Watch group. Comorbidities were more frequent among patients receiving non-adherent prescriptions. No significant differences in mortality, length of stay, or oxygen requirement were observed between groups. Gentamicin was underdosed in all cases, with most prescriptions at 5 mg/kg/day. Eleven patients (13.7%) died, and 23 (28.4%) were clinically diagnosed with measles.

Conclusions Adherence to WHO guidelines in this Tanzanian referral hospital was higher than reported in several previous studies from African settings. Adherence was not associated with differences in clinical outcomes. All patients receiving gentamicin were prescribed doses lower than the recommended 7.5 mg/kg/day. The high proportion of measles cases highlights the ongoing impact of reduced vaccination coverage following the COVID-19 pandemic. Local and national health authorities should prioritise optimising gentamicin dosing and strengthening measles immunisation efforts.

1 Introduction

Lower respiratory tract infections (LRTIs) are the leading infectious cause of death in children under five, with the highest burden in sub-Saharan Africa. In 2023, LRTIs were responsible for an estimated 610,000 deaths globally in this age group, accounting

for 13.1% of all-cause mortality and a mortality rate of 94.8 per 100,000 children [1]. Although LRTI-related mortality in Tanzanian children under five decreased by 25.5% between 2019 and 2021 [2], rising antimicrobial resistance (AMR) threatens to reverse these gains [3].

In 2019, the WHO African Region recorded an estimated 250,000 deaths attributable to AMR. The two leading pathogens were Klebsiella pneumoniae and Streptococcus pneumoniae, responsible for approximately 50,000 and 39,000 attributable deaths, respectively [4]. Both are common causes of childhood LRTIs. Optimizing antibiotic use is therefore critical to preserve treatment efficacy and reduce healthcare costs [3].

In 2014, the World Health Organization (WHO) updated its childhood pneumonia guidelines, recommending ampicillin or benzylpenicillin plus gentamicin as first-line treatment, with ceftriaxone reserved for second-line use [5]. These recommendations, based on two randomized controlled trials conducted in 2002 and 2008 [6, 7], align with the WHO Access, Watch, and Reserve (AWaRe) framework, which promotes narrow-spectrum, first-line antibiotics to curb AMR [8, 9]. In this system, ampicillin, benzylpenicillin, and gentamicin are classified as Access antibiotics recommended for common infections, whereas ceftriaxone belongs to the Watch group, which should be used more selectively.

In Tanzania, WHO treatment recommendations are incorporated into the National Standard Treatment Guidelines and Essential Medicines List (STG/NEMLIT) issued by the Ministry of Health, which provide standardized prescribing guidance for healthcare workers across all levels of the health system. Updated guidelines are disseminated to health facilities as official clinical reference documents and support prescribing practices in hospitals. Tanzanian national guidelines are largely aligned with WHO recommendations, with minor adaptations such as distinguishing between "severe" and "very severe" pneumonia; for very severe cases (corresponding to WHO severe pneumonia), the recommended first-line regimen remains ampicillin or benzylpenicillin plus gentamicin [10].

However, real-world adherence to these guidelines in high-burden settings remains limited. In Ethiopia, less than half of children with severe pneumonia received WHO-recommended first-line therapy [11, 12], and in South Uganda, only 24.9% received treatment in line with national guidelines [13].

This study aimed to evaluate adherence to the 2014 WHO revised guidelines for severe childhood pneumonia treatment at a referral hospital in Itigi, Tanzania, and to assess the association between adherence and patient outcomes.

2 Methods

2.1 Study design, setting, and population

We conducted a retrospective observational study at St. Gaspar Hospital, Itigi, Singida Region, Tanzania, which recorded 2,437 hospital admissions in the paediatric ward in 2024 [14]. The study included all children aged 2–59 months admitted to the paediatric ward and subsequently discharged or died during hospitalisation between 1 May 2021 and 30 April 2024 with a diagnosis of severe pneumonia.

Exclusion criteria were: known HIV infection; receipt of antibiotic therapy at admission for an indication other than pneumonia; and confirmed or suspected severe

bacterial infection other than pneumonia (e.g., sepsis or meningitis). Eligible cases were identified using discharge diagnoses, and data were extracted from medical records.

Data were collected retrospectively from the hospital's electronic medical records. All records reporting a diagnosis of pneumonia among children admitted during the study period were identified and reviewed. Data extraction was performed by a medical student (G.R.) using a standardized data collection form that included demographic characteristics, clinical presentation, antibiotic treatment, and outcomes. The data collection aimed to be exhaustive by reviewing all eligible admissions recorded in the hospital registers during the study period.

2.2 WHO guidelines and antibiotic classification

According to WHO revised guidelines, severe pneumonia is diagnosed based on the presence of at least one of the following clinical signs: central cyanosis or oxygen saturation below 90%, severe respiratory distress (such as grunting or very severe chest indrawing), inability to drink, persistent vomiting, convulsions, lethargy or unconsciousness, stridor in a calm child, or signs of severe malnutrition [5]. The recommended first-line treatment is a combination of ampicillin (50 mg/kg every 6 h) or benzylpenicillin (50,000 units/kg every 6 h) with gentamicin (7.5 mg/kg once daily) for a minimum of five days. Ceftriaxone is recommended only as a second-line treatment when first-line therapy fails [5].

Prescribed antibiotics were categorized according to the 2023 WHO AWaRe classification [8]. As no distinct pediatric-specific AWaRe classification has been defined, the standard WHO AWaRe framework was applied. Table S1 (Supplementary Materials) reports the complete AWaRe classification, with antibiotics used in the study highlighted.

2.3 Outcomes

Primary outcome was adherence to WHO guidelines, which was defined as administration of ampicillin or benzylpenicillin plus gentamicin as first-line treatment, regardless of dosage. Dosage was analysed separately to distinguish prescribing choice from dosing accuracy. First-line therapy was defined as any antibiotic regimen initiated within 48 h of the first prescription, consistent with previous studies [12, 15]. Secondary outcomes included in-hospital mortality, length of hospital stay, need for oxygen therapy, and number of days requiring oxygen therapy.

2.4 Clinical and laboratory variables

Clinical variables followed WHO severe pneumonia criteria: central cyanosis or oxygen saturation < 90%; severe respiratory distress (grunting, severe chest indrawing); inability to drink; persistent vomiting; convulsions; lethargy/unconsciousness; stridor in a calm child; and signs of severe malnutrition. Laboratory variables included malaria status and quantitative C-reactive protein levels. In addition, the study recorded whether the child had a clinical diagnosis of measles.

2.5 Statistical analysis

Descriptive statistics summarized the study variables. Continuous variables were reported as mean (standard deviation) and categorical variables as frequency

(percentage). Categorical outcomes were compared using the chi-square test or Fisher's exact test, as appropriate. Continuous variables were compared using Student's t-test. Given the exploratory nature and limited sample size, no multivariable analyses were performed. Statistical significance was set at $p < 0.05$. Analyses were conducted using R (version 4.3.2, Windows).

2.6 Ethical considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Ethical Committee of St. Gaspar Medical Centre (Identification code: SG012025) on 25 August 2025. The study consisted of a retrospective analysis of routinely collected clinical data and was approved by the hospital research committee board. The requirement for informed consent was waived due to the retrospective nature of the study.

3 Results

We collected data from 106 children diagnosed with severe pneumonia during the study period. Twenty-five were excluded: 23 due to other suspected severe bacterial infections, one due to HIV positivity, and one due to incomplete antibiotic therapy data. The final analysis included 81 children, of whom 34 (42.0%) were female, with a mean age of 13.1 ± 11.7 months. Table 1 shows patients' characteristics, presenting symptoms, and outcomes for the overall sample and by sex. No significant differences were detected between male and female patients. Twenty-seven patients (33.3%) had comorbidities. Sickle cell disease and anaemia were the predominant comorbidities identified in the cohort (*Table S2*). The most common presenting symptom was severe respiratory distress, observed in 61 children (75.3%), followed by central cyanosis or oxygen saturation < 90% in 46 (56.8%), and inability to drink in 35 (43.2%). Eleven patients (13.7%) died; there were no referrals or self-discharges. Thirteen patients (16.0%) tested positive for malaria. Twenty-three patients (28.4%) were clinically diagnosed with measles.

The most frequently prescribed regimen was ampicillin plus gentamicin, given to 64 patients (79.0%), followed by ceftriaxone alone in 7 patients (8.6%). Eleven patients (13.6%) received at least one antibiotic from the WHO AWaRe "Watch" group. Table 2 presents antibiotic regimens according to the WHO AWaRe classification. Overall, 64 patients (79.0%) received treatment consistent with WHO guidelines. Table 3 shows baseline characteristics, clinical features, outcomes, and laboratory results according to guideline adherence. Patients treated with non-adherent antibiotic regimens more frequently had comorbidities (58.8% vs. 26.6%, $p = 0.01$) (*Table S2*), while were less likely to have a presentation with persistent vomiting, with a borderline significance (17.6% vs. 46.9%, $p = 0.05$), but no other significant differences were found between the two groups.

When antibiotic dosage was considered, gentamicin was underdosed in all cases, with more than 70% of prescriptions at 5 mg/kg/day. Table 4 reports the prescribed doses of first-line antibiotic treatments.

4 Discussion

The main findings of this study can be summarised as follows: 79% of children with severe pneumonia received antibiotic regimens consistent with WHO guidelines, when dosage was not considered; no differences in outcomes were observed between children

Table 1 Sample characteristics divided by sex and total sample

	Total (*n* = 81)		Male (*n* = 47)		Female (*n* = 34)		*p*-value
	NoM	*N* (%)	NoM	*N* (%)	NoM	*N* (%)	
Baseline characteristics							
Age in months, mean (SD) 81 13.1 (11.7)			47	11.8 (11.0)	34	14.9 (12.6)	0,0.2
Comorbidity	81	27 (33.3)	47	15 (31.9)	34	12 (35.3)	0.8
Referred from other hospital	81	19 (23.5)	47	11 (23.4)	34	8 (23.5)	1
Clinical characteristics							
Severe respiratory distress	81	61 (75.3)	47	35 (74.5)	34	26 (76.5)	0.8
Central cyanosis or SpO2 < 90%	81	46 (56.8)	47	28 (59.6)	34	18 (52.9)	0.6
Inability to drink	81	35 (43.2)	47	22 (46.8)	34	13 (38.2)	0.4
Persistent vomiting	81	33 (40.7)	47	17 (36.2)	34	16 (47.1)	0.3
Lethargy or unconsciousness	81	24 (29.6)	47	13 (27.7)	34	11 (32.4)	0.6
Severe malnutrition	81	9 (11.1)	47	5 (10.6)	34	4 (11.8)	1
Convulsions	81	7 (8.6)	47	6 (12.8)	34	1 (2.9)	0.2
Stridor in a calm child	81	3 (3.7)	47	2 (4.3)	34	1 (2.9)	1
No WHO severe defining symptoms	81	0	47	0	34	0	1
Clinical diagnosis of measles	81	23 (28.4)	47	10 (21.3)	34	13 (38.2)	0.1
Therapy and outcome					34		
Therapy corrected	81	64 (79.0)	47	38 (80.9)	34	26 (76.5)	0.8
Referred	81	0	47	0	34	0	1
Self-discharge	81	0	47	0	34	0	1
Deaths	81	11 (13.7)	47	6 (12.8)	34	5 (14.7)	0.8
Oxygen therapy	76	44 (57.9)	43	26 (60.5)	33	18 (54.5)	0.6
Oxygen days, mean (SD)	44	2.7 (2.4)	26	2.7 (2.5)	18	2.8 (2.3)	0.8
Hospitalization days, mean (SD)	80	5.1 (3.2)	46	5.3 (3.6)	34	4.8 (2.5)	0.5
Blood test results							
CRP, mg/dl, mean (SD)	39	34.8 (49.9)	23	28.6 (48.2)	16	43.8 (52.5)	0.4
Malaria blood film positive	81	13 (16.0)	47	6 (12.8)	34	7 (20.6)	0.3

Data are presented in frequency (percentage) or mean (standard deviation)

CRP, C reaction protein; NoM, Number of measurements; SD, Standard Deviation; SpO2, Saturation of Oxygen; WHO, World Health Organization

Table 2 Antibiotic regimens according to WHO AWaRe classification

AWaRe group	Regimen	*N* (%)
Access group, 70 (86.4%)	Ampicillin + gentamicin	64 (79)
	Ampicillin + gentamicin+ metronidazole	2 (2.5)
	Ampicillin + gentamicin+ chloramphenicol	1 (1.2)
	Ampiclox+ gentamicin	1 (1.2)
	Metronidazole+ gentamicin + amoxicillin and clavulanic acid	1 (1.2)
	Metronidazole+ gentamicin	1 (1.2)
Watch group, 11 (13.6%)	Ceftriaxone	7 (8.6)
	Erythromycin	2 (2.5)
	Ampicillin + gentamicin+ ceftriaxone	1 (1.2)
	Ampicillin + erythromycin + gentamicin	1 (1.2)

treated adherently and those treated non-adherently; gentamicin was underdosed in all cases, with most prescriptions at 5 mg/kg/day; and a high proportion of patients (28.4%) were clinically diagnosed with measles.

To the best of our knowledge, this is the first report from Tanzania to analyse adherence to WHO guidelines in childhood severe pneumonia. We found that adherence was higher than in two studies from Ethiopia, which reported that less than half of the

Table 3 Baseline, clinical characteristics, and outcomes by adherence to the revised WHO guidelines

	Therapy not adherent (*n* = 17)		Therapy adherent (*n* = 64)		*p*-value
	NoM	***N* (%)**	**NoM**	***N* (%)**	
Baseline characteristics					
Female sex	17	8 (47.1)	64	26 (40.6)	0.6
Age in months, mean (SD)	17	14.2 (12.4)	64	12.8 (11.6)	0.7
Comorbidity	17	10 (58.8)	64	17 (26.6)	0.01
Referred from other Hospital	17	4 (23.5)	64	15 (23.4)	1
Clinical characteristics					
Central cyanosis or SpO2 < 90%	17	11 (64.7)	64	35 (54.7)	0.5
Severe respiratory distress	17	15 (88.2)	64	46 (71.9)	0.2
Inability to drink	17	7 (41.2)	64	28 (43.8)	0.8
Persistent vomiting	17	3 (17.6)	64	30 (46.9)	0.05
Convulsions	17	1 (5.9)	64	6 (9.4)	1
Lethargy or unconsciousness	17	7 (41.2)	64	17 (26.6)	0.2
Stridor in a calm child	17	1 (5.9)	64	2 (3.1)	0.5
Severe malnutrition	17	1 (5.9)	64	8 (12.5)	0.7
No WHO severe defining symptoms	17	0	64	0	1
Clinical diagnosis of measles	17	3 (17.6)	64	20 (31.2)	0.4
Outcome					
Deaths	17	3 (17.6)	64	8 (12.7)	0.7
Oxygen therapy	16	11 (68.8)	60	33 (55.0)	0.3
Oxygen days, mean (SD)	16	2.5 (2.6)	60	2.8 (2.3)	0.8
Hospitalization days, mean (SD)	17	4.5 (3.3)	60	5.2 (3.2)	0.4
Blood test results					
CRP, mg/dl, mean (SD)	6	28.4 (37.2)	33	36.0 (52.3)	0.9
Malaria blood film positive	17	2 (11.8)	64	11 (17.2)	0.7

CRP, C reaction protein; NoM, Number of measurements; SD, Standard Deviation; SpO2, Saturation of Oxygen; WHO, World Health Organization

Table 4 Dose of prescribed first-line antibiotic treatments

Antibiotic (*n* = prescriptions)	Dose (mg/kg/day)	Number (%)
Ampicillin (*n* = 69)	200	57 (82.6)
	285	1 (1.5)
	NA	11 (15.9)
Gentamicin (*n* = 72)	4	7 (9.7)
	5	52 (72.2)
	5,5	1 (1.4)
	6	3 (4.2)
	7	1 (1.4)
Ceftriaxone (*n* = 8)	75	5 (62.5)
	NA	3 (37.5)
Metronidazole (*n* = 4)	20	2 (50)
	22,5	2 (50)
Erythromycin (*n* = 3)	50	2 (66.7)
	60	1 (33.3)
Chloramphenicol (*n* = 1)	50	1 (100)
Amoxicillin and clavulanic acid (*n* = 1)	200	1 (100)
Ampiclox (*n* = 1)	125	1 (100)

Data are presented as number (percentage). The total number of prescriptions is 159

NA, Not available

children were treated according to WHO guidelines [11, 12], and a study from Uganda, which found that only 24.9% received a prescription for an antibiotic regimen of ampicillin plus gentamicin or benzylpenicillin plus gentamicin [13]. Barriers to adherence in prescribing may include outdated or unavailable guidelines, limited awareness and engagement in efforts to reduce AMR, insufficient knowledge of guidelines among prescribers, and the belief that broader-spectrum antibiotics improve patient outcomes [16, 17].

The presence of comorbidity was associated with non-adherent prescriptions, suggesting that clinicians are more likely to prescribe broader-spectrum antibiotics to patients perceived to be at higher risk of unfavourable outcomes. In line with a previous study, adherence to WHO guidelines was not associated with differences in clinical outcomes in our cohort [11]. In contrast, a larger study conducted in Ethiopia found an association between adherence to WHO guidelines and a longer duration of oxygen therapy [12], whereas a study in Uganda reported increased unfavourable outcomes when non-rational antibiotic therapies were used [13]. However, the observational design of our study does not allow definitive conclusions regarding the potential benefit of broader-spectrum antibiotic prescriptions.

Although sickle cell disease was the most frequent comorbidity, it was more prevalent among patients treated in accordance with WHO guidelines, likely due to concerns regarding the risk of immune haemolytic anaemia associated with ceftriaxone in these patients [18]. In contrast, patients with complex congenital or syndromic conditions were more likely to receive broader-spectrum antibiotics. These findings suggest that a potential barrier to guideline adherence is clinicians' concern about severe outcomes in selected high-risk patients. They also highlight the lack of high-quality data on the outcomes of children with chronic diseases and pneumonia in sub-Saharan Africa [19].

We found that gentamicin was underdosed in all patients who received it, a finding consistent with another study from Ethiopia [12]. This may reflect clinicians' concerns regarding side effects associated with gentamicin administration [20]. The underdosing of gentamicin appears to be common in clinical practice [21], despite evidence that a dose of 7.5 mg/kg/day is more effective in achieving therapeutic targets [22]. From a pharmacological perspective, subtherapeutic dosing may result in inadequate peak serum concentrations, potentially compromising bacterial killing given the concentration-dependent activity of aminoglycosides [23]. Although robust clinical data directly linking underdosing to adverse outcomes in children with pneumonia are limited, insufficient drug exposure could plausibly contribute to treatment failure or delayed recovery. Nephrotoxicity is uncommon and reversible, and ototoxicity is more likely to occur in children with specific risk factors, such as previous treatment for malignancies with ototoxic medicines [24].

We found that 28.4% of children were clinically diagnosed with measles. This finding confirms that the measles outbreak in Tanzania, which followed the COVID-19 pandemic and resulted in a drop in vaccination coverage, remains unresolved [25, 26]. It highlights the urgent need for prompt vaccination interventions in the Singida Region.

The mortality rate observed in our study was 13%, which is higher than that reported in previous studies [11–13]. Although we were unable to further investigate the causes of this difference, it may reflect the challenges of this remote setting, where delays in diagnosis and treatment are common. Additionally, local patterns of AMR may contribute to

poorer clinical outcomes. These findings highlight the need to strengthen the management of childhood pneumonia in this region.

The present investigation is limited by a small sample size and its retrospective design, which restricts the ability to draw strong conclusions regarding clinical outcomes and causal relationships and did not allow the analysis of temporal trends in prescriptions. The single-centre design does not allow generalisation to all Tanzanian hospitals. Despite these limitations, our study serves as a pilot report on severe childhood pneumonia in Tanzania, a major cause of mortality that remains inadequately studied. Additionally, the study highlights an important finding of gentamicin underdosing in clinical practice and provides valuable data on the ongoing measles outbreak in the Singida Region.

5 Conclusion

This study found that adherence to WHO guidelines for severe childhood pneumonia at St. Gaspar Hospital was higher than that reported in several studies from other African countries, and adherence was not associated with differences in outcomes. The findings underscore the need for local and national health authorities to strengthen monitoring of gentamicin dosing and to prioritise efforts to improve measles vaccination coverage.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12982-026-02153-0.

Supplementary Material 1

Acknowledgements
we thank all the staff of St. Gaspar Hospital for their support in the study.

Author contributions
ALV conceptualized and designed the study and the data collection instruments. GR collected data. ALV was responsible for the analysis and interpretation of data. ALV drafted the manuscript. GR, CA, AV and KA performed a critical revision of the manuscript and gave a significant contribution in their field of expertise. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Funding
This study was partially funded by Italian Ministry of Health - Current research IRCCS.

Data availability
Data are available at the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
: The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Ethical Committee of St. Gaspar Medical Centre (Identification code: SG012025) on 25 August 2025. The study consisted of a retrospective analysis of routinely collected clinical data and was approved by the hospital research committee board. The requirement for informed consent was waived by the Ethical Committee of St. Gaspar Medical Centre due to the retrospective nature of the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 19 January 2026 / Accepted: 12 May 2026
Published online: 01 June 2026

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