Section: Miscellaneous

Original Research Article

ESTIMATION OF ANTIBIOTIC CONSUMPTION USING WHO AWARE CLASSIFICATION AMONG PAEDIATRIC ICU PATIENTS IN A TERTIARY CARE HOSPITAL

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ABSTRACT

Background: Antimicrobial resistance (AMR) is a growing global health concern, particularly in paediatric intensive care units (PICUs), where critically ill children frequently require empirical broad-spectrum antibiotic therapy. The World Health Organization (WHO) Access, Watch, and Reserve (AWaRe) classification provides a standardized framework for monitoring antibiotic utilization and strengthening antimicrobial stewardship. This study evaluated antibiotic consumption in a tertiary care PICU using the WHO AWaRe classification and Days of Therapy (DOT) per 1,000 patient-days.

Materials and Methods: A prospective observational drug utilization study was conducted in the PICU of a tertiary care teaching hospital from January to December 2024. All paediatric patients admitted for more than 24 hours who received at least one systemic antibacterial agent were included. Antibiotic consumption was quantified using DOT per 1,000 patient-days and categorized according to the WHO AWaRe classification. Monthly prescribing trends, overall AWaRe distribution, antibiotic class utilization, and individual antibiotic consumption were analyzed using descriptive statistics.

Results: The total antibiotic consumption was 7,912.6 DOT/1,000 patient-days. Watch antibiotics constituted the largest proportion of antimicrobial use (58.2%), followed by Access antibiotics (41.1%), while Reserve antibiotics accounted for only 0.8% of total consumption. None of the study months achieved the WHO-recommended benchmark of ≥60% Access antibiotic use. Third-generation cephalosporins (32.5%) and aminoglycosides (28.0%) were the most frequently utilized antibiotic classes. Among individual antibiotics, amikacin demonstrated the highest consumption (1,881.4 DOT/1,000 patient-days), followed closely by cefotaxime (1,871.8 DOT/1,000 patient-days). Reserve antibiotics were prescribed infrequently, indicating appropriate restriction of last-line antimicrobial agents.

Conclusion: Antibiotic prescribing in the studied PICU was characterized by predominant utilization of Watch antibiotics and suboptimal use of Access antibiotics relative to WHO stewardship recommendations. Although Reserve antibiotics were appropriately restricted, the findings highlight the need to strengthen antimicrobial stewardship programmes through culture-guided therapy, regular prescription audits, adherence to institutional antibiotic policies, and promotion of appropriate Access antibiotic prescribing. Continuous surveillance using standardized WHO AWaRe indicators may help optimize antibiotic utilization and reduce the emergence of antimicrobial resistance.

Keywords: Antimicrobial stewardship; WHO AWaRe classification; Paediatric intensive care unit; Antibiotic consumption; Days of Therapy (DOT)

INTRODUCTION

Antimicrobial resistance (AMR) has emerged as one of the greatest global public health challenges, threatening the effective prevention and treatment of infectious diseases across all age groups. Excessive and inappropriate use of antibiotics has accelerated the emergence of multidrug-resistant organisms, resulting in prolonged hospital stay, increased healthcare costs, therapeutic failures, and higher mortality rates.[1,2] Children admitted to paediatric intensive care units (PICUs) constitute a particularly vulnerable population because they frequently require empirical broad-spectrum antimicrobial therapy owing to severe infections, invasive procedures, and compromised physiological status.[3].

To address the growing burden of AMR, the World Health Organization (WHO) developed the Access, Watch, and Reserve (AWaRe) classification of antibiotics in 2017 and subsequently updated it within the WHO Essential Medicines List. The AWaRe framework categorizes antibiotics according to their spectrum of activity, resistance potential, and stewardship priority. Access antibiotics are recommended as first- or second-line agents for common bacterial infections and should ideally account for at least 60% of national antibiotic consumption. Watch antibiotics possess a higher potential for selecting resistant organisms and therefore require careful stewardship, whereas Reserve antibiotics are considered last-resort agents reserved for infections caused by multidrug-resistant pathogens.[4,5].

Monitoring antibiotic utilization using standardized metrics is fundamental to antimicrobial stewardship programmes. The WHO recommends measuring antibiotic consumption using Days of Therapy (DOT) per 1,000 patient-days, which provides a reliable estimate of antimicrobial exposure independent of dose adjustments and is particularly suitable for paediatric populations where weight-based dosing varies considerably.[6] Quantifying antibiotic consumption according to AWaRe categories enables hospitals to evaluate prescribing patterns, identify areas requiring intervention, and monitor compliance with WHO stewardship targets.[7].

Several studies conducted worldwide have demonstrated that tertiary-care hospitals and intensive care settings often report a predominance of Watch group antibiotics, with Access antibiotic use remaining below the WHO-recommended threshold. Such prescribing patterns may contribute to increasing antimicrobial resistance unless supported by microbiological evidence and stewardship interventions.[8,9] However, published data describing AWaRe-based antibiotic consumption in Indian paediatric intensive care units remain limited, particularly from government teaching hospitals where the burden of severe infectious diseases is substantial.[10].

The present study was therefore undertaken to estimate antibiotic consumption among paediatric ICU patients in a tertiary care teaching hospital using the WHO AWaRe classification. Antibiotic utilization was quantified using Days of Therapy (DOT) per 1,000 patient-days over a one-year period, and the proportion of Access, Watch, and Reserve antibiotics was evaluated against WHO stewardship recommendations. The findings are expected to provide baseline evidence for strengthening antimicrobial stewardship initiatives and optimizing antibiotic prescribing practices in paediatric critical care.

MATERIALS AND METHODS

Study design and setting: A prospective, observational, hospital-based drug utilization study was conducted in the Paediatric Intensive Care Unit (PICU) of Government General Hospital (GGH), Guntur, a tertiary care teaching hospital, over a 12-month period from January 2024 to December 2024. The study was performed after obtaining approval from the Institutional Ethics Committee before commencement of data collection.

Study population: The study included all paediatric patients admitted to the PICU during the study period who received one or more systemic antibacterial agents during hospitalization. Patients of either sex and all paediatric age groups admitted for more than 24 hours were eligible for inclusion.

Inclusion criteria

- Children admitted to the PICU during the study period.
- Patients receiving at least one systemic antibiotic.
- Availability of complete medical records.

Exclusion criteria

- Patients admitted for less than 24 hours.
- Patients who did not receive systemic antibacterial therapy.
- Records with incomplete documentation of antimicrobial administration.

Data collection: Patient information was obtained prospectively from hospital case records maintained in the Medical Records Department (MRD) and PICU admission registers. Data collected included demographic characteristics, diagnosis, indication for antimicrobial therapy, duration of hospitalization, antibiotic prescribed, dosage, route of administration, frequency, duration of therapy, and clinical outcome. Daily inpatient census records were used to calculate total patient-days during the study period.

Antibiotic classification: All systemic antibacterial agents prescribed during hospitalization were classified according to the latest WHO Access, Watch, and Reserve (AWaRe) classification. Antibiotics were grouped into Access, Watch, and

Reserve categories based on WHO recommendations.

Outcome measures: Antibiotic consumption was quantified using Days of Therapy (DOT) per 1,000 patient-days, calculated according to WHO antimicrobial stewardship guidelines. One DOT was defined as the administration of a single antibiotic to a patient on a calendar day irrespective of dose or frequency.

DOT per 1000 patient-days=[Total Patient-days/Total Days of Therapy]×1000

The monthly proportion of Access antibiotic use was further compared with the WHO stewardship target recommending ≥60% Access antibiotic consumption.

Statistical analysis: Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version 29.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as mean ± standard deviation (SD) or median with interquartile range depending on data distribution, whereas categorical variables were expressed as frequencies and percentages. Antibiotic utilization was reported as DOT per 1,000 patient-days for each AWaRe category. Monthly prescribing trends were illustrated using stacked bar charts with Access antibiotic proportion plotted against the WHO target. Descriptive statistics were primarily used, and statistical significance was considered at $p < 0.05$ wherever comparative analyses were performed.

RESULTS

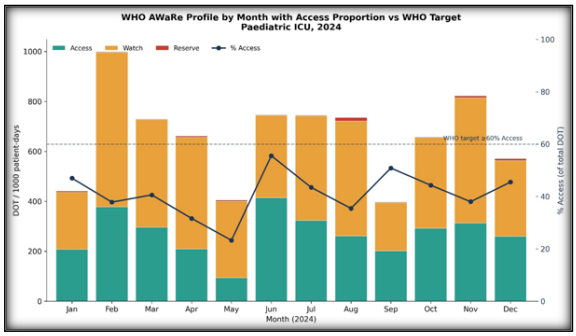

Figure 1: Monthly WHO AWaRe profile of antibiotic consumption with Access proportion versus WHO target in the Paediatric ICU, 2024

[Figure 1] illustrates the monthly antibiotic consumption expressed as Days of Therapy (DOT) per 1,000 patient-days according to the WHO AWaRe classification, along with the monthly proportion of Access antibiotics compared with the WHO-recommended target of ≥60%. Total antibiotic consumption varied throughout the study period, ranging from approximately 400 DOT/1,000 patient-days in May and September to nearly 1,000 DOT/1,000 patient-days in February, indicating considerable month-to-month variation in antimicrobial utilization.

Across all months, Watch antibiotics constituted the largest component of total antibiotic consumption, consistently exceeding Access antibiotics and accounting for the majority of prescribing. Access antibiotic use demonstrated moderate fluctuations, with the highest utilization observed in June, followed by September, while the lowest proportion occurred in May. Reserve antibiotics contributed only a very small fraction of total antibiotic use during the study period and were prescribed only sporadically, reflecting restricted use of these last-line agents.

The superimposed line graph demonstrates that the proportion of Access antibiotics ranged from approximately 24% to 56% over the 12-month period. Although Access antibiotic utilization approached the WHO stewardship target in June (approximately 56%), none of the months achieved the recommended benchmark of ≥60% Access antibiotic use. The Access proportion remained below the target throughout the study period, whereas Watch antibiotics continued to dominate prescribing practices in the PICU.

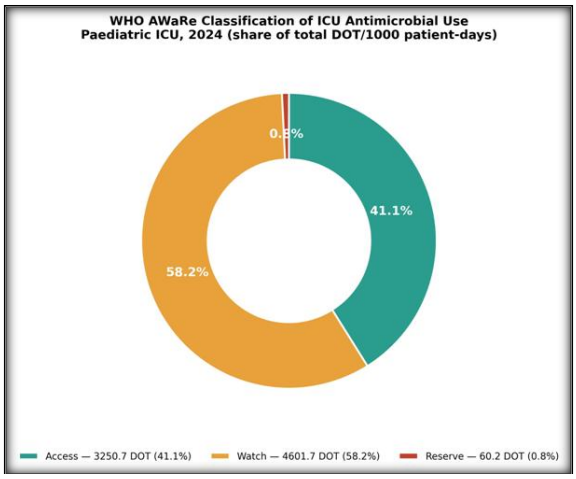

Figure 2: Overall distribution of antibiotic consumption according to the WHO AWaRe classification in the Paediatric ICU

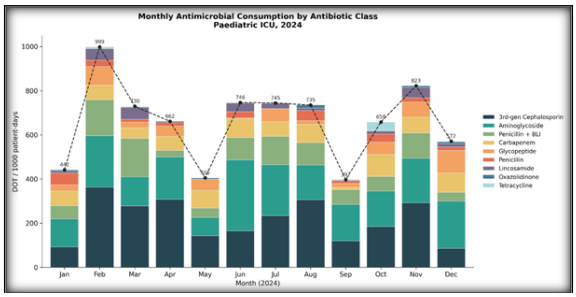

Figure 3: Monthly antimicrobial consumption according to antibiotic class in the Paediatric ICU

[Figure 2] presents the overall distribution of antibiotic consumption according to the WHO Access, Watch, and Reserve (AWaRe) classification, expressed as Days of Therapy (DOT) per 1,000 patient-days during the study period. A total antibiotic consumption of 7,912.6 DOT/1,000

patient-days was recorded. Watch antibiotics constituted the largest proportion of antimicrobial use, accounting for 4,601.7 DOT/1,000 patient-days (58.2%), followed by Access antibiotics with 3,250.7 DOT/1,000 patient-days (41.1%). Reserve antibiotics accounted for only 60.2 DOT/1,000 patient-days (0.8%), indicating minimal utilization of these last-resort antimicrobial agents.

[Figure 3] depicts the monthly antimicrobial consumption stratified by individual antibiotic classes and expressed as Days of Therapy (DOT) per 1,000 patient-days. Overall antimicrobial utilization demonstrated marked temporal variation during the study period, ranging from 397 DOT/1,000 patient-days in September to a peak of 999 DOT/1,000 patient-days in February. Relatively high antibiotic consumption was also observed in November (823 DOT/1,000 patient-days), whereas lower utilization was recorded during January (440 DOT/1,000 patient-days) and May (405 DOT/1,000 patient-days).

Among the various antibiotic classes, third-generation cephalosporins and aminoglycosides consistently contributed the largest proportion of antimicrobial consumption throughout the year, indicating their predominant role in empirical and targeted treatment of critically ill paediatric patients. Penicillin with β-lactamase inhibitor combinations also constituted a substantial proportion of antibiotic use, particularly during February, March, June, and July. Carbapenems demonstrated moderate but persistent utilization across most months, reflecting their selective use in severe infections requiring broader antimicrobial coverage.

Other antibiotic classes, including glycopeptides, penicillins, and lincosamides, accounted for comparatively smaller proportions of total antimicrobial consumption and showed intermittent monthly variation. Oxazolidinones and tetracyclines contributed only a minimal fraction of overall antibiotic use and were prescribed infrequently during the study period.

The trend line superimposed on the stacked bar chart illustrates fluctuations in total monthly antibiotic consumption, with notable peaks during February, June–August, and November, while comparatively reduced antimicrobial utilization was observed during May and September. These findings suggest seasonal and clinical variability in antimicrobial prescribing practices, although broad-spectrum antibiotic classes, particularly third-generation cephalosporins and aminoglycosides, remained the principal contributors to overall antibiotic consumption throughout the study period.

[Figure 4] illustrates the ten most frequently utilized antibiotics during the study period, expressed as annual Days of Therapy (DOT) per 1,000 patient-days and categorized according to the WHO AWaRe classification. Amikacin, an Access antibiotic, demonstrated the highest annual consumption with 1,881.4 DOT/1,000 patient-days, closely followed by the Watch antibiotic cefotaxime with 1,871.8 DOT/1,000 patient-days. Among the remaining antibiotics, meropenem (824.8 DOT/1,000 patient-days), ceftriaxone (701.3 DOT/1,000 patient-days), piperacillin–tazobactam (638.8 DOT/1,000 patient-days), and vancomycin (565.0 DOT/1,000 patient-days) were the predominant Watch group agents, indicating extensive use of broad-spectrum antimicrobials in the PICU.

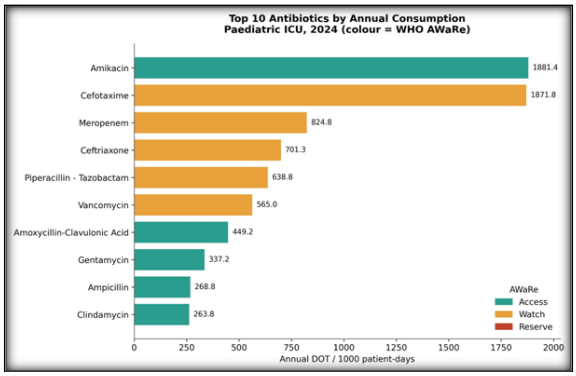

Figure 4: Top 10 antibiotics by annual consumption in the Paediatric ICU according to WHO AWaRe classification

Within the Access category, amoxicillin–clavulanic acid (449.2 DOT/1,000 patient-days), gentamicin (337.2 DOT/1,000 patient-days), ampicillin (268.8 DOT/1,000 patient-days), and clindamycin (263.8 DOT/1,000 patient-days) contributed comparatively lower annual antibiotic consumption. Notably, no Reserve antibiotic was represented among the ten most frequently prescribed agents, reflecting restricted utilization of last-line antimicrobials during the study period.

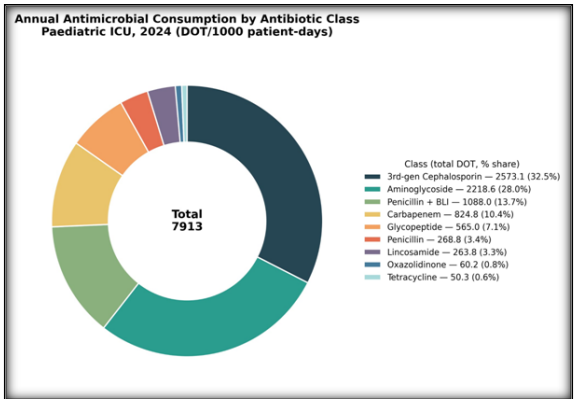

Figure 5: Annual antimicrobial consumption by antibiotic class in the Paediatric ICU

[Figure 5] illustrates the distribution of annual antimicrobial consumption according to antibiotic class, expressed as Days of Therapy (DOT) per 1,000 patient-days. The total antibiotic consumption during the study period was 7,913 DOT/1,000 patient-days. Third-generation cephalosporins constituted the largest proportion of antibiotic use, accounting for 2,573.1 DOT/1,000 patient-days (32.5%), followed by aminoglycosides with 2,218.6 DOT/1,000 patient-days (28.0%). Penicillin plus β-

lactamase inhibitor combinations represented the third most frequently utilized class, contributing 1,088.0 DOT/1,000 patient-days (13.7%).

Among the remaining antibiotic classes, carbapenems accounted for 824.8 DOT/1,000 patient-days (10.4%), while glycopeptides contributed 565.0 DOT/1,000 patient-days (7.1%). Comparatively lower consumption was observed for penicillins (268.8 DOT/1,000 patient-days; 3.4%) and lincosamides (263.8 DOT/1,000 patient-days; 3.3%). Oxazolidinones and tetracyclines were infrequently prescribed, contributing only 60.2 DOT/1,000 patient-days (0.8%) and 50.3 DOT/1,000 patient-days (0.6%), respectively.

DISCUSSION

The present prospective observational study evaluated antibiotic consumption among paediatric intensive care unit (PICU) patients using the WHO Access, Watch, and Reserve (AWaRe) classification and Days of Therapy (DOT) per 1,000 patient-days. The findings demonstrated that Watch antibiotics accounted for the largest proportion of antimicrobial consumption (58.2%), whereas Access antibiotics contributed only 41.1%, well below the WHO-recommended target of at least 60%. Reserve antibiotics represented only 0.8% of total antibiotic consumption, indicating that these last-resort agents were used judiciously. These observations provide important baseline information regarding antimicrobial prescribing practices in a tertiary care government teaching hospital and highlight opportunities for strengthening antimicrobial stewardship.

The predominance of Watch antibiotics observed in the present study is consistent with reports from several international antimicrobial surveillance programmes, which have shown that critically ill paediatric patients frequently receive broad-spectrum empirical therapy because of the high risk of severe bacterial infections, delayed microbiological confirmation, and the need for immediate treatment. The WHO recommends that Access antibiotics should constitute at least 60% of antibiotic consumption because they are effective for most common bacterial infections while exerting relatively lower selective pressure for antimicrobial resistance. Failure to achieve this benchmark suggests that empirical prescribing practices continue to rely heavily on broad-spectrum agents and that opportunities exist to optimize first-line antibiotic selection through local stewardship programmes and regular review of institutional treatment guidelines.[4,9].

Marked month-to-month variation in antibiotic consumption was observed, with the highest utilization occurring during February and the lowest during September. Similar seasonal fluctuations have been reported in hospital antimicrobial surveillance studies and may reflect changes in the incidence of respiratory tract infections, sepsis, seasonal viral illnesses complicated by secondary bacterial infections, and fluctuations in PICU admissions. Despite these temporal variations, the predominance of Watch antibiotics remained remarkably consistent throughout the study period, indicating that prescribing practices were driven more by institutional empirical treatment protocols than by seasonal disease patterns. Continuous surveillance of antimicrobial consumption allows such trends to be identified and provides an opportunity to periodically review empirical antibiotic policies according to local epidemiology.[7].

Analysis according to antibiotic class revealed that third-generation cephalosporins constituted the largest proportion of total antibiotic consumption, followed by aminoglycosides and penicillin–β-lactamase inhibitor combinations. Together, these three classes contributed more than three-quarters of all antibiotic use in the PICU. This prescribing pattern is clinically understandable because third-generation cephalosporins remain important empirical agents for severe community-acquired infections, while aminoglycosides continue to be widely used in neonatal and paediatric sepsis because of their excellent Gram-negative coverage and synergistic activity when combined with β-lactam antibiotics. However, prolonged or inappropriate use of these broad-spectrum agents has been associated with increasing antimicrobial resistance, emphasizing the importance of obtaining microbiological cultures before initiating therapy and de-escalating treatment once culture and susceptibility reports become available.[3,14]

Evaluation of individual antibiotic consumption demonstrated that amikacin was the most frequently utilized antimicrobial, followed closely by cefotaxime. Although amikacin belongs to the Access category, most of the remaining high-consumption antibiotics—including cefotaxime, meropenem, ceftriaxone, piperacillin–tazobactam, and vancomycin—belonged to the Watch category, explaining the overall predominance of Watch antibiotics in the study. Encouragingly, none of the Reserve antibiotics appeared among the ten most frequently prescribed agents, suggesting that clinicians reserved these drugs for carefully selected patients with suspected or confirmed multidrug-resistant infections. Restricting Reserve antibiotics is a key objective of antimicrobial stewardship programmes because indiscriminate use may accelerate the emergence of resistance to the few remaining therapeutic options available for highly resistant pathogens.[4].

Comparison of the present findings with previously published studies indicates that the predominance of Watch antibiotics is not unique to the present institution but represents a broader trend observed in tertiary-care hospitals. Global surveillance studies utilizing the WHO AWaRe classification have consistently reported that Watch antibiotics account

for a substantial proportion of hospital antibiotic consumption, particularly in intensive care settings where empirical broad-spectrum therapy is frequently initiated before microbiological confirmation.[9]. Similarly, international point prevalence surveys have demonstrated considerable variability in antibiotic prescribing practices among hospitals but consistently emphasize the need to increase Access antibiotic utilization while restricting unnecessary use of Watch and Reserve agents.[7] The findings of the present study therefore align with the growing body of evidence supporting continuous surveillance of antibiotic consumption using standardized WHO indicators.

Although comprehensive AWaRe-based data from Indian paediatric intensive care units remain limited, studies conducted in Indian tertiary-care hospitals have similarly reported frequent utilization of third-generation cephalosporins, aminoglycosides, carbapenems, and β-lactam/β-lactamase inhibitor combinations as empirical therapy for severe infections. This prescribing pattern largely reflects the high burden of neonatal and paediatric sepsis, pneumonia, complicated intra-abdominal infections, and healthcare-associated infections encountered in referral centres. Nevertheless, the continued predominance of broad-spectrum antibiotics also highlights the need for strengthening antimicrobial stewardship through regular institutional antibiogram updates, development of evidence-based empirical treatment guidelines, and periodic prescription audits. Such measures can facilitate earlier transition from empirical therapy to targeted antimicrobial treatment, thereby reducing unnecessary exposure to broad-spectrum agents while maintaining favourable clinical outcomes.[8,14].

The minimal utilization of Reserve antibiotics (0.8%) represents an encouraging finding. Reserve antibiotics are intended for the management of confirmed or strongly suspected infections caused by multidrug-resistant organisms and should remain protected to preserve their long-term clinical effectiveness. Their restricted use in the present study suggests reasonable adherence to stewardship principles despite the high overall use of Watch antibiotics. Similar observations have been reported from hospitals implementing structured antimicrobial stewardship programmes, where strict authorization policies, infectious disease consultation, and microbiological guidance have successfully limited inappropriate Reserve antibiotic prescribing while maintaining satisfactory patient outcomes.[4,11].

One of the principal strengths of the present study is the prospective evaluation of antibiotic consumption over a complete 12-month period, allowing assessment of seasonal variations in prescribing behaviour. Furthermore, antimicrobial utilization was quantified using Days of Therapy (DOT) per 1,000 patient-days, which is considered the preferred indicator for paediatric antimicrobial stewardship because it accurately reflects actual antibiotic exposure regardless of dosage adjustments required for age or body weight. Classification of antibiotics according to the WHO AWaRe framework also enables direct comparison with international stewardship benchmarks and facilitates monitoring of institutional prescribing practices over time.[6]. The inclusion of monthly trends, AWaRe distribution, antibiotic class analysis, and individual antibiotic consumption provides a comprehensive overview of antimicrobial utilization that can serve as baseline data for future stewardship interventions within the institution.

Certain limitations of the present study should be acknowledged. First, the study was conducted at a single tertiary-care teaching hospital, limiting the generalizability of the findings to other healthcare settings. Second, the analysis focused on patterns of antibiotic consumption and did not evaluate the clinical appropriateness of prescriptions, microbiological culture positivity, pathogen-specific resistance profiles, duration of empirical therapy before de-escalation, or patient-centred outcomes such as mortality and length of PICU stay. These parameters are important indicators of stewardship quality and should be incorporated into future multicentre studies. Additionally, assessment of antimicrobial consumption together with institutional antibiograms would provide more robust evidence regarding the relationship between antibiotic utilization and emerging resistance patterns.[11,12].

The findings of the present study have important implications for antimicrobial stewardship in paediatric critical care. Increasing the proportion of Access antibiotic prescribing, ensuring timely microbiological investigations before antibiotic initiation whenever clinically feasible, implementing routine prescription audits with prospective feedback, and encouraging early de-escalation based on culture and susceptibility reports should be prioritized. Integration of hospital-specific antibiograms into empirical treatment guidelines, combined with periodic education of prescribers regarding the WHO AWaRe framework, may further optimize antimicrobial utilization. Continuous surveillance using standardized DOT and AWaRe indicators should become an integral component of quality improvement programmes to monitor prescribing trends and evaluate the effectiveness of stewardship interventions over time.[15-18]

Overall, the present study demonstrates that antibiotic prescribing in the studied PICU is characterized by substantial reliance on Watch antibiotics, while Access antibiotic utilization remains below the WHO-recommended threshold. Although Reserve antibiotics were appropriately restricted, continued efforts are required to promote rational antibiotic prescribing and improve compliance with antimicrobial stewardship principles. Strengthening stewardship programmes through evidence-based prescribing, culture-guided

therapy, regular audit and feedback, and ongoing surveillance using WHO AWaRe methodology has the potential to reduce antimicrobial resistance, preserve antibiotic effectiveness, and improve the quality of paediatric critical care.

CONCLUSION

This prospective observational study demonstrated that Watch antibiotics constituted the majority of antibiotic consumption in the paediatric intensive care unit, whereas Access antibiotic utilization remained below the WHO-recommended target. Although the use of Reserve antibiotics was minimal, reflecting appropriate restriction of last-line agents, the findings highlight the need for improved antimicrobial stewardship. Promoting culture-guided therapy, timely de-escalation of empirical treatment, adherence to institutional antibiotic guidelines, and periodic surveillance using the WHO AWaRe classification can optimize prescribing practices. Continuous monitoring of antibiotic utilization is essential to reduce antimicrobial resistance, preserve antibiotic effectiveness, and improve the quality of paediatric critical care.

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