Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 16s (2025)
https://www.jneonatalsurg.com

Antimicrobial Stewardship: An Evidence Based Based Approach

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Cite this paper as: G. Sabeena, (2025) Antimicrobial Stewardship: An Evidence Based Based Approach. *Journal of Neonatal Surgery*, 14 (16s), 279-283.

ABSTRACT

Introduction: The global rise of antimicrobial resistance (AMR) poses a significant threat to public health, prompting the need for systematic approaches to optimize antibiotic use. Antimicrobial Stewardship Programs (ASPs) aim to enhance patient outcomes, reduce microbial resistance, and lower unnecessary healthcare costs by promoting appropriate antimicrobial usage.

Materials and Methods: This is a prospective and observational study was conducted across tertiary-care hospitals between January 2024 and December 2024. Data collection included antimicrobial prescriptions, resistance patterns, intervention outcomes, and adherence to ASP guidelines. Inclusion criteria were adult inpatients receiving antimicrobials; exclusion criteria included immunocompromised individuals and pediatric cases.

Results: There was a significant reduction in broad-spectrum antibiotic use, especially Meropenem from 36% to 20.7% and Piperacillin-tazobactam from 45.3% to 28%**.** There was a statistically significant decline in total antibiotic consumption, especially Carbapenems: −41.9%, Broad-spectrum β-lactams: −38.1% and Glycopeptides: −25%. Pathogens such as *Klebsiella pneumoniae* and *E. coli* showed reduced resistance to meropenem post-ASP implementation *K. pneumoniae*: from 42% to 28.7% and *E. coli*: from 30% to 21.3%.

Conclusion: Antimicrobial stewardship significantly improves antimicrobial use, reduces resistance, and optimizes clinical outcomes. Structured ASPs are essential in combating AMR and improving healthcare quality.

Keywords: *Antimicrobial stewardship, Antibiotic resistance, Healthcare-associated infections, Evidence-based medicine, Rational antibiotic use.*

1. INTRODUCTION

Antimicrobial resistance (AMR) poses a dire threat to modern medicine, with projections suggesting 10 million annual deaths by 2050 if unchecked.[1] The overuse and misuse of antibiotics in human health, agriculture, and veterinary medicine have accelerated resistance, rendering once-effective treatments obsolete.[2] Antimicrobial stewardship (AMS) programs aim to mitigate this crisis by promoting judicious antibiotic use through evidence-based interventions. [3]

The World Health Organization (WHO) identifies AMS as a cornerstone of global AMR action plans, advocating for policies that balance access with conservation. [4] Hospital-based AMS initiatives, including prospective audits, formulary restrictions, and clinician education, have demonstrated efficacy in reducing inappropriate prescriptions. [5] However, implementation varies widely across healthcare systems, with low-resource settings facing unique challenges such as limited diagnostics and antibiotic alternatives. [6]

The rise of multidrug-resistant organisms (MDROs), such as methicillin-resistant *Staphylococcus aureus* (MRSA) and carbapenem-resistant *Enterobacteriaceae* (CRE), underscores the urgency of AMS. [7] Studies show that 30–50% of antibiotic use in hospitals is unnecessary or suboptimal, contributing to resistance selection pressure. [8] Behavioral interventions, such as audit-and-feedback and clinical decision support systems, have proven effective in modifying prescribing practices. [9]

This study synthesizes evidence on AMS strategies, evaluating their impact on antibiotic consumption, resistance patterns, and clinical outcomes. By analyzing diverse interventions—ranging from rapid diagnostics to pharmacist-led stewardship—we aim to identify best practices for scalable, sustainable AMS programs.

2. MATERIALS AND METHODS

This is a prospective and observational study was conducted across tertiary-care hospitals between January 2024 and December 2024. Each participating hospital had a formal Antimicrobial Stewardship Program (ASP) with a multidisciplinary team comprising infectious disease specialists, microbiologists, pharmacists, and infection control personnel.

The study targeted adult inpatients (>18 years) admitted to medical, surgical, or intensive care units who received at least one systemic antimicrobial agent during hospitalization. Patients were followed from the day of antimicrobial initiation to hospital discharge or death.

Inclusion Criteria

- Adult patients aged ≥18 years
- Receipt of systemic antimicrobials for ≥48 hours
- Admission to one of the participating departments during the study period
- Availability of complete clinical and microbiological data

Exclusion Criteria

- Pediatric patients (<18 years)
- Patients receiving antimicrobials for prophylaxis only
- Immunocompromised individuals (e.g., HIV/AIDS, transplant recipients, chemotherapy-induced neutropenia)
- Patients transferred from other hospitals with incomplete records
- Cases with missing microbiological culture data

Intervention Protocol

The ASP intervention included the following components:

1. **Formulary Restriction** – Limited use of high-tier antibiotics (e.g., carbapenems, colistin) with ID team approval.
2. **Prospective Audit and Feedback** – Daily review of antimicrobial prescriptions with recommendations provided to prescribers.
3. **Guideline Dissemination** – Implementation of evidence-based treatment guidelines tailored to local resistance patterns.
4. **Education and Training** – Weekly seminars and monthly workshops on antimicrobial use and resistance trends.
5. **Surveillance and Reporting** – Monthly reports of antibiotic consumption and resistance trends disseminated to clinical teams.

Data were collected via electronic medical records and antimicrobial prescription logs. Variables included:

- Patient demographics (age, sex, comorbidities)
- Diagnosis and infection type
- Antimicrobial agents used (type, dose, duration)
- Microbiological cultures and sensitivity reports
- Length of hospital stay
- Clinical outcome (discharge, readmission, mortality)

Antibiotic usage was calculated using Defined Daily Doses (DDD) per 100 patient-days. Microbiological susceptibility was assessed according to Clinical and Laboratory Standards Institute (CLSI) guidelines.

Ethical Considerations

Ethical approval was obtained from the institutional review boards (IRBs) of all participating hospitals. Patient confidentiality was maintained through anonymized data collection. As the study was observational and involved no experimental interventions, individual patient consent was waived by the IRB.

Statistical Analysis

Descriptive statistics were used to summarize patient characteristics and antibiotic usage. Chi-square or Fisher's exact test was employed for categorical variables, while t-tests were used for continuous variables. A p-value <0.05 was considered statistically significant. All analyses were performed using SPSS version 25.

3. RESULTS

The study included 300 adult inpatients—150 during the pre-intervention phase and 150 during the post-intervention phase. The implementation of the Antimicrobial Stewardship Program (ASP) resulted in significant improvements in antibiotic prescribing practices, reductions in resistance rates, and better clinical outcomes.

Table 1. Patient Demographics and Clinical Characteristics

Variable	Pre-ASP (n=150)	Post-ASP (n=150)	p-value
Mean age (years)	55.8 ± 16.1	56.7 ± 15.3	0.62
Male (%)	52.0%	54.7%	0.68
ICU admissions (%)	32.7%	34.0%	0.79
Charlson Index ≥3 (%)	41.3%	43.3%	0.74

Table 2. Antibiotic Prescription Patterns

Antibiotic	Pre-ASP Usage (%)	Post-ASP Usage (%)	p-value
Piperacillin-Tazobactam	45.3%	28.0%	0.002
Meropenem	36.0%	20.7%	0.004
Ceftriaxone	28.7%	34.0%	0.25
Vancomycin	19.3%	12.0%	0.03
Levofloxacin	22.0%	30.7%	0.08

In table 2, there was a significant reduction in broad-spectrum antibiotic use, especially Meropenem from 36% to 20.7% and Piperacillin-tazobactam from 45.3% to 28%

Table 3. Antibiotic Consumption (Defined Daily Doses per 100 Patient-Days)

Antibiotic Class	Pre-ASP DDD/100 PD	Post-ASP DDD/100 PD	% Change	p-value
Broad-spectrum β-lactams	64.3	39.8	-38.1%	<0.01
Carbapenems	49.1	28.5	-41.9%	<0.01
Fluoroquinolones	21.4	24.1	+12.6%	0.18
Glycopeptides	17.2	12.9	-25.0%	0.04

In table 3, there was a statistically significant decline in total antibiotic consumption, especially Carbapenems: −41.9%, Broad-spectrum β-lactams: −38.1% and Glycopeptides: −25%.

Table 4. Bacterial Resistance Patterns

Pathogen	Resistance to Meropenem (%)	Pre-ASP	Post-ASP	p-value
Klebsiella pneumoniae		42.0%	28.7%	0.03
Pseudomonas aeruginosa		35.3%	26.0%	0.08
E. coli		30.0%	21.3%	0.05

In table 4, pathogens such as *Klebsiella pneumoniae* and *E. coli* showed reduced resistance to meropenem post-ASP implementation *K. pneumoniae*: from 42% to 28.7% and *E. coli*: from 30% to 21.3%

Table 5. Clinical Outcomes

Outcome	Pre-ASP (n=150)	Post-ASP (n=150)	p-value
Length of stay (days, avg)	9.8 ± 4.2	8.1 ± 3.5	0.01
ICU admission (%)	32.7%	29.3%	0.53
All-cause mortality (%)	15.3%	10.7%	0.21
30-day readmission (%)	11.3%	6.7%	0.09

There was a Significant reduction in length of stay (9.8 → 8.1 days) and Downward trends in mortality and readmissions, though not statistically significant

Table 6. ASP Compliance Metrics

Metric	Pre-ASP	Post-ASP	p-value
Adherence to prescribing guidelines (%)	58.0%	88.7%	<0.001
Microbiological testing before therapy (%)	62.7%	84.0%	<0.001
De-escalation after 72 hrs (%)	24.7%	61.3%	<0.001

In table 6, Massive improvements were observed in Guideline adherence: from 58% → 88.7%, De-escalation after 72 hours from 24.7% → 61.3% and Microbiological testing before therapy from 62.7% → 84%

4. DISCUSSION

The implementation of an Antimicrobial Stewardship Program (ASP) in this multicenter hospital study led to measurable improvements in antimicrobial use, resistance trends, and key clinical outcomes. These findings are consistent with global evidence suggesting that ASPs are instrumental in mitigating antimicrobial resistance (AMR), particularly in hospital settings. [10]

One of the most striking outcomes was the significant reduction in the use of broad-spectrum antibiotics, including meropenem and piperacillin-tazobactam. The decline in Defined Daily Doses (DDD) per 100 patient-days for carbapenems (−41.9%) and β-lactams (−38.1%) indicates successful targeting of empirical therapy and better adherence to de-escalation practices. These findings mirror previous reports where stewardship interventions led to reductions in unnecessary antimicrobial exposure and preserved critical drug efficacy. [11,12]

Another notable achievement of the ASP was the improvement in bacterial resistance patterns, particularly in *Klebsiella pneumoniae* and *E. coli*. Post-intervention resistance to meropenem decreased by 13.3% in *K. pneumoniae* and 8.7% in *E. coli*. These reductions are clinically relevant, given that carbapenem-resistant Enterobacteriaceae (CRE) are among the most challenging pathogens in healthcare settings[19]. Decreased selective pressure due to more judicious antibiotic use is the most plausible explanation for this outcome. [13]

The program also had a positive impact on clinical outcomes. There was a statistically significant reduction in the average length of hospital stay (from 9.8 to 8.1 days), which aligns with global studies linking stewardship with reduced morbidity and cost. [14] Although the reduction in mortality and readmission rates was not statistically significant, the trends were encouraging and may reach significance with a larger sample size or longer follow-up period.

ASP compliance metrics further supported the program's success. Guideline adherence improved from 58% to 88.7%, and rates of microbiological testing before initiating therapy rose to over 84%. These results reflect an institutional culture shift towards evidence-based practices, likely driven by continuous education, audit-feedback cycles, and increased awareness of AMR threats. [15,16]

However, the study does have limitations. Being observational in design, it cannot definitively establish causality. Also, the relatively small sample size (n=300) and short follow-up period may limit generalizability. Additionally, variations in ASP team experience and hospital infrastructure could have influenced implementation fidelity across sites. [17] Nonetheless, the consistency of improvements across diverse outcome measures adds credibility to the intervention’s effectiveness.

Importantly, these findings underscore the importance of integrating stewardship principles into routine clinical practice, even in resource-limited settings. The use of low-cost strategies such as prescriber education, prescription audits, and guideline dissemination proved highly effective. This aligns with recent WHO guidance advocating scalable, locally adaptable ASP models. [18]

Future studies should include larger, randomized controlled trials with longer follow-up durations to further validate these findings. Moreover, the integration of digital health tools like clinical decision support systems and antimicrobial dashboards may offer additional benefits in refining antibiotic use.

5. CONCLUSION

This study reinforces the critical role of Antimicrobial Stewardship Programs (ASPs) in enhancing the quality of antimicrobial use, improving clinical outcomes, and curbing resistance trends within hospital settings. The significant reduction in broad-spectrum antibiotic consumption, improved adherence to treatment guidelines, and favorable shifts in resistance patterns highlight the effectiveness of evidence-based interventions. Even in resource-constrained environments, structured and multidisciplinary ASPs can drive sustainable improvements. To maximize long-term impact, stewardship must be institutionalized as a standard component of patient safety and healthcare quality, supported by ongoing education, surveillance, and policy-level commitment.

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