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Research Article

OPTIMIZING THE USE OF ANTIMICROBIALS IN PEDIATRIC INFECTIONS: A SYSTEMATIC REVIEW OF CLINICAL AND NURSING STRATEGIES

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Abstract

Antimicrobial resistance (AMR) is a global health threat that significantly impacts the pediatric population, which has unique physiological characteristics and high susceptibility to irrational antibiotic use. This systematic review aims to synthesize scientific evidence on clinical and operational strategies for optimizing antimicrobial use in pediatric infections. A literature search was conducted in major international databases following PRISMA guidelines, with the inclusion of studies evaluating antimicrobial stewardship interventions, diagnostic stewardship, pharmacokinetic/ pharmacodynamic (PK/PD)-based precision dosing, and standardized clinical pathways. Results indicate that an integrated approach consistently reduces antibiotic consumption, improves adherence to clinical guidelines, accelerates time to optimal therapy, and maintains or improves clinical outcomes without increasing mortality. Integration of rapid diagnostic tests and biomarkers supports faster de-escalation of therapy, while model-informed precision dosing improves achievement of therapeutic targets in critically ill populations. Operational factors such as institutional leadership, multidisciplinary collaboration, standardized metrics monitoring, and digital technology support have been shown to strengthen program sustainability. Overall, optimizing antimicrobial use in pediatric infections requires a holistic systems approach to improve the quality of therapy while suppressing the development of global resistance.

Keywords: Antimicrobial Resistance (AMR), Multidisciplinary Collaboration, Pediatric

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INTRODUCTION

Antimicrobial resistance (AMR) is a growing global health challenge in the pediatric population (Toufeeq & Ahmad, 2026). Children face a higher risk of AMR due to several unique factors, including physiological differences in drug metabolism, limited treatment options, and irrational antibiotic use (Obeng et al., 2025). Inappropriate antibiotic use remains a significant problem in pediatric care. Research indicates that approximately 50% of all antibiotics prescribed in pediatric care settings are considered inappropriate (Dona et al., 2025).

In outpatient settings, empirical antibiotic prescribing is very common, particularly for viral illnesses, which directly drives the growth of AMR (Toufeeq & Ahmad, 2026). In pediatric hospitals, previous studies have reported that antibiotic prescription rates remain high with patterns that do not follow guidelines, particularly for upper respiratory tract infections, uncomplicated pneumonia, and urinary tract infections (Dona et al., 2025). This antimicrobial resistance crisis will have a significant impact on child morbidity and mortality, particularly in low- and middle-income countries (Abo et al., 2022).

Although the importance of optimizing antimicrobial use has been widely recognized, strategies to achieve this remain fragmented in the literature. Most antimicrobial treatment guidelines are derived from adult population-based data, which require significant adaptation for pediatric populations with unique physiological complexities (Dona, 2025). Furthermore, evidence regarding the effectiveness of different stewardship interventions in improving clinical outcomes in children remains limited, particularly in resource-limited settings (Dona et al., 2025).

Previous research indicates that strategies for optimizing antimicrobial use remain partial. Some studies focus on clinical aspects such as antibiotic selection and duration of therapy, while others emphasize diagnostic or operational components. However, the systematic integration of these three dimensions clinical interventions, diagnostic stewardship, and operational strategies has not yet been fully addressed in the pediatric literature (Dona, 2025).

This systematic review is designed to synthesize clinical and operational strategies for optimizing antimicrobial use in pediatric infections through a holistic approach that integrates five complementary dimensions. Most importantly, audit- and feedback-based Antimicrobial Stewardship Programs (ASPs) serve as the foundation for interventions proven to improve adherence to clinical guidelines and reduce irrational antibiotic consumption (Chiotos et al., 2025). This intervention demonstrated a significant increase in adherence to recommendations regarding antibiotic choice and duration in children treated for community-acquired pneumonia (Yaghlane, 2026).

Diagnostic stewardship utilizing rapid diagnostics and biomarkers enables rapid and accurate pathogen identification, facilitating antibiotic de-escalation and a significant reduction in broad-spectrum antibiotic use (Graff et al., 2025). Rapid molecular diagnostic technologies such as the BioFire Blood Culture Identification panel reduce the time to optimal antibiotic therapy, which is associated with reduced mortality in Gram-negative infections (Ryu, 2023). Furthermore, dose optimization based on pharmacokinetic and pharmacodynamic (PK/PD) principles ensures that every pediatric patient achieves optimal therapeutic targets through model-informed precision dosing tailored to their unique physiological characteristics (Abdulla et al., 2021).

Model-informed precision dosing for vancomycin in critically ill children improves target attainment and reduces nephrotoxicity through an AUC-based dosing approach (Cock et al., 2024). Meanwhile, clinical management of specific infections using standardized pathways for conditions such as community-acquired pneumonia, urinary tract infection, and sepsis harmonizes prescribing practices and improves the rationality of therapy based on current evidence (Attaianese, 2025). The implementation of integrated clinical pathways reduces treatment duration and increases the use of narrow-spectrum antibiotics (Rossin et al., 2021).

Operational factors supporting program sustainability including institutional leadership, multidisciplinary collaboration, monitoring of standardized metrics, and the implementation of digital technology create an infrastructure that enables the program to operate sustainably and have a long-term impact (Gregorio M et al., 2025). Antimicrobial stewardship telehealth platforms and the integration of electronic health records with clinical decision support systems enhance the effectiveness of stewardship interventions (Stallsmith et al., 2025). The integration of these five dimensions aims to produce measurable impacts on antibiotic consumption, guideline adherence, and superior clinical outcomes, while simultaneously curbing global antimicrobial resistance in the pediatric population.

The ultimate goal is to identify and recommend integrated approaches that can improve clinical outcomes while reducing global antimicrobial resistance in the pediatric population. The ultimate goal is to identify and recommend integrated approaches that can improve clinical outcomes while reducing global antimicrobial resistance in the pediatric population.

RESEARCH METHOD

Research Design

This systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and employs a systematic literature review methodology to identify, evaluate, and synthesize scientific evidence regarding strategies for optimizing antimicrobial use in pediatric infections (Gres, 2025). Qualitative and narrative approaches were used to synthesize the heterogeneity of study designs, interventions, and outcome metrics.

Research Target/Subject

Inclusion criteria included studies in pediatric populations (≤18 years) with confirmed or suspected infections that evaluated at least one antimicrobial optimization strategy, including stewardship programs, diagnostic stewardship, precision dosing, or clinical pathways. Studies must also report measurable clinical or operational outcomes, such as antibiotic consumption, guideline adherence, clinical outcomes, resistance rates, or costs. Accepted study designs include randomized controlled trials, controlled before-and-after studies, interrupted time series, observational cohort studies, and systematic reviews.

Exclusion criteria include studies limited to adult or mixed populations without pediatric stratification, narrative reviews lacking a systematic methodology, case reports or series with n <10, and studies focusing solely on the epidemiology of resistance without evaluating interventions. Duplicate publications or gray literature without peer review are also excluded.

Research Procedure

The literature search was conducted in leading international databases: MEDLINE (PubMed), Embase, the Cochrane Library, Scopus, and Google Scholar. Search keywords included a combination of MeSH and free-text terms. Population keywords included: pediatric, children, neonates, infants, and school-aged children. For interventions, the search focused on: antimicrobial stewardship, antibiotic stewardship, rapid diagnostic tools, biomarker-guided therapy, precision dosing, pharmacokinetic/pharmacodynamic principles, clinical pathways, and audit-feedback interventions. Outcomes: antibiotic prescribing, guideline adherence, antimicrobial resistance, clinical outcomes, and days of therapy. The search was conducted without language restrictions, focusing on publications from 2007 to 2025 to capture contemporary trends and historical evidence.

Instruments, and Data Collection Techniques

Two independent reviewers screened titles and abstracts using RAYYAN software, followed by a full-text review to assess eligibility for inclusion. Disagreements were resolved through discussion or consultation with a third reviewer. Data were extracted using a standardized form covering study characteristics (authors, year of publication, country, setting, design), population characteristics (sample size, age, type of infection), interventions (type of stewardship, program components, duration of implementation), and primary outcome metrics including days of therapy (DOT), guideline adherence rate, antimicrobial resistance rate, and clinical outcomes. Study quality assessment was also conducted by identifying the risk of bias and conflicts of interest for each included publication.

Data Analysis Technique

A narrative-comparative synthesis was used to integrate evidence across studies based on primary outcomes, including the program's impact on changes in antibiotic consumption and adherence to guidelines, clinical effectiveness evaluated through changes in patient outcomes (mortality, length of stay, and readmissions), and operational effectiveness encompassing institutional leadership, multidisciplinary collaboration, and the implementation of digital technology. Additionally, the economic aspects of stewardship programs including cost-effectiveness and cost savings were also analyzed as a key dimension of program sustainability. Heterogeneity in study design, populations, interventions, and outcome metrics was noted as a limitation to the generalizability of the findings. Comparative tables and qualitative narratives were used to present the results in a comprehensive and easily understandable manner.

RESULTS AND DISCUSSION

Table 1. Literature Review Summary - Strategies for Optimizing Antimicrobial Use in Pediatric Infections

Study/ Location	Design & Population	Main Interventions	Main Outcome	Significant Results	Citation
			ASP - Audit & Feedback		
France (Pediatric ED)	Prospective before-after	Repeated clinical audits + systematic feedback	Adherence initiation & AB selection	Adherence: 88.9% → 96.6%; AB correct: 82.2% → 93.2%	(Yaghlane , 2026)
Pakistan (Children's CAP)	Two-cycle clinical audit	WHO AWaRe/IMNCI audit + education	Amoxicillin & azithromycin prescribing	Guideline-concordant amoxicillin: 3.8% → 62.7%; Azithromycin: 50% → 3.3%	(Ahmed, 2026)
Italy (Pediatric PACU)	Quasi-experimental study	Multifaceted ASP (audit, education, pathway)	Broad-spectrum AB reduction	Broad-spectrum AB: 100% → 38.5%; Amoxicillin: 33.3% → 76.1%	(Rossin et al., 2021)
Serbia (Primary Care)	Long-term surveillance	Public awareness campaign + professional education	Antibiotic prescriptions per 1,000 children	32.8% decrease (2015-2021) in systemic prescriptions	(Dona, 2026)

Perú (Multicenter Cohort)	Retrospective cohort study	ASP maturity assessment with ID consultation	ESBL infection rates & clinical outcomes	Higher ASP maturity → lower ESBL infection (aOR 0.85)	(Palacios & Barreto, 2026)
		ASP - Clinical Pathways			
USA (Pediatric Hospital)	RCT-based evaluation	Guideline implementation + local pathways	Antibiotic duration (CAP & UTI)	Duration: 10 → 7 days ($p<0.001$); Adherence: significantly increased	(Fernandez et al., 2022)
Italy (Acute Pediatric Unit)	Before-after study	CAP pathway with procalcitonin guidance	Broad-spectrum AB & amoxicillin use	Broad-spectrum: 100% → 38.5%; Early IV-to-oral switch increased	(Teteeh, 2025)
USA (Multi-state collaboration)	Quasi-experimental analysis	CARE PATH mobile app with facility-specific pathways	Pathway adherence rates (CAP, UTI, SSTI)	CAP adherence Q1→Q2 increases; average adherence 46-84%	(Bozzella et al., 2026)
		Diagnostic Stewardship - RDT & Biomarkers			
Italy (PED)	Retrospective cohort (1,238 children)	Rapid molecular tests (influenza/adenovirus)	AB discontinuation & prescribing avoidance	Positive RDT: significant AB discontinuation ($p<0.001$); 72-h return visit no different	(Bellini, 2026)
Guatemala (Multicenter)	Pragmatic clinical trial	BioFire BCID2 + ASP advice	Time to optimal AB therapy & mortality	Time to optimal: 979 → 315 hours ($p=0.03$); Gram-neg mortality: 25% → 5% ($p=0.05$)	(Graff et al., 2025)
India (Tertiary Hospital)	Prospective observational	Procalcitonin vs CRP for febrile neutropenia	Diagnostic accuracy for BSI	PCT AUC 0.93 vs CRP AUC 0.76; Superior for Gram-negative bacteremia	(Pandey et al., 2026)
Neonatal ICU	Retrospective analysis	Procalcitonin with a cutoff of 0.5 µg/L	Late-onset sepsis exclusion	High sensitivity PCT to exclude bacterial infection in neonates	(Mrela & Marki, 2026)
		Precision Dosing - PK/PD			
Multi-center (NICU/PICU)	RCT (beneficial trial)	Model-informed precision	AUC target attainment & nephrotoxicity	Target AUC24h 400-600 mg·h/L; Primary endpoint: target	(Cock et al., 2024)

		dosing (MIPD) of vancomycin		attainment 24-48h	
Pediatric ICU	Retrospective PK analysis	Meropenem dosing with SIRS & CRRT assessment	Pharmacokinetic clearance & target PD	ARC: clearance increased by 35%; Recommended dose: 40-80 mg/kg q8h for 100% fT>MIC	(Saito et al., 2020)
Pediatric Nephrology	PopPK study	Vancomycin dosing based on eGFR	AUC0-24/MIC target 400-600	Dose: 12.5-70 mg/kg/day according to eGFR groups; >85% CFR across MRSA MIC distribution	(Chuphan et al., 2022)
		Specific Infection Management			
Italy (Pediatric CAP)	Prospective observational (263 cases)	Clinical pathway + procalcitonin guidance	Antibiotic duration & broad-spectrum reduction	Broad-spectrum: 100% → 38.5%; earlier IV-to-oral switch; stable outcome	(Rossin et al., 2021)
Italy (Pediatric UTI)	8-year quasi-experimental study	Local guidelines for UTI with audit cycles	Guideline adherence & antibiotic patterns	Adherence was highest immediately post-intervention, decreasing gradually over time.	(Brigadoi, Liberati, et al., 2024)
Perú (Multicenter Sepsis)	Retrospective cohort	ASP intervention for bloodstream/UTI infections	Time to appropriate therapy & mortality	ASP intervention: hospital LOS 3 days shorter; 30-day mortality 4.2% lower	(Palacios & Barreto, 2026)
		Operational Factors - Technology & Leadership			
USA (23 Hospitals)	Quasi-experimental pre-post	Telehealth ASP (PT-ASP) + audit feedback	Antimicrobial DOT per patient day	Total DOT: -21%; IV DOT: -24% per patient day	(Stallsmith et al., 2025)
USA (Pediatric ED)	Usability testing (21 providers)	CDS-enhanced order set integration into EHR	Guideline-adherent prescribing & workload	CAP guideline-adherent: +31% improvement; Provider workload trend is decreasing	(McGonagle et al., 2022)
USA (State-wide)	Public health surveillance	Automated AU feedback reports +	ASP monitoring &	94% of ACH and 69% of CAH received	(Schaefer et al., 2025)

		pathway adherence reports	benchmarking	feedback reports; Well-received and actionable	
Italy (Multisociety Consensus)	Delphi consensus process	Multidisciplinary leadership & standardized metrics	ASP framework & implementation recommendations	33 recommendations developed; Emphasis on multidisciplinary approach & institutional commitment	(Dona, 2025)
Peruvian ICU	Prospective study	Weekly ID team rounds in PICU	Clinical recommendations compliance & recommendation types	90% compliance with recommendations; 88% for treatment modifications	(Gregorio M et al., 2025)
Program Impact - Measurable Outcomes					
USA (Post-op Pediatric Surgery)	Multi-center RCT (OPerAtiC 2.0)	Enhanced ASP facilitation + order set review	Post-operative AB duration & C. difficile prevention	Unnecessary post-op AB reduction; C. difficile infection prevention	(Teteeh et al., 2025)
USA (High-risk Pediatric Patients)	Retrospective cohort (NICU/HO/PICU)	ASP recommendations (stop/narrow/modify AB)	Mortality, readmission, CDI, hospital LOS	No increased mortality/readmission; Shorter LOS with agreed recommendations (10.2 vs 13.2 days)	(Goldman et al., 2019)
Japan (Tokyo Metropolitan)	Quasi-experimental (2010-2017)	Sustained ASP with ID consultation	Carbapenem resistance & infection-related mortality	Carbapenem resistance of P. aeruginosa: significantly decreased ($p<0.01$); Mortality: decreased ($p=0.05$)	(Horikoshi et al., 2017)
USA (Pediatric Hospital)	Cost-effectiveness analysis	Ped ASP with chart reviews & handshake rounds	Annual cost savings & DOT reduction	Projected cost savings: $99,186/year; DOT PED: 290.4 → 100.2	(Lien et al., 2022)
USA (CAP Hospitalized Children)	Interrupted time series analysis	Clinician feedback	Antibiotic choice &	Adherence: 52% → 80% post-intervention; RR	(Teteeh, 2025)

		reports via email	duration of adherence	1.32 (95% CI: 1.12-1.56, $p<0.01$)	
		Meta-analysis & Systematic Reviews			
25 LMICs (13 Africa, 12 Asia)	Systematic review & meta-analysis	ASP ± POCT (78 reports evaluating 68 ASP & 30 POCT)	Antibiotic prescribing & guideline adherence	ASP+POCT: 85% success; ASP only: 73%; POCT only: 80%; No adverse clinical outcomes	(Gres, 2025)
Pediatric ICU	Scoping review (18 studies)	ASP & DSP interventions in PICU	Antimicrobial consumption & resistance changes	ASP: positive effects on AB consumption; DSP biomarkers without significant impact on AB prescribing	(Liberati et al., 2025)

The evidence synthesized in Table 1 indicates that antimicrobial stewardship (ASP) interventions in pediatric populations are consistently associated with significant improvements in antimicrobial prescribing behavior, clinical outcomes, and healthcare system performance across varied clinical and geographical settings. Multifaceted strategies including audit and feedback mechanisms, implementation of clinical pathways, diagnostic stewardship using rapid molecular tests and biomarkers, and model-informed precision dosing demonstrate substantial effectiveness in reducing inappropriate broad-spectrum antibiotic use, enhancing guideline adherence, optimizing therapeutic timing, and improving overall treatment efficiency without adversely affecting mortality outcomes. Furthermore, structural and operational determinants such as multidisciplinary collaboration, leadership engagement, integration of digital clinical decision support systems, and continuous performance monitoring are shown to be critical for sustaining program effectiveness. Collectively, the aggregated evidence from primary studies and systematic reviews underscores that integrated, data-driven ASP frameworks represent a robust and evidence-based approach for optimizing antimicrobial utilization and mitigating the progression of antimicrobial resistance in pediatric healthcare systems.

Integration of Clinical, Diagnostic, and Operational Strategies

This systematic review reveals that optimizing the use of antimicrobials in pediatric infections requires an integrated approach that combines three complementary dimensions: The clinical and nursing dimension includes the implementation of guideline-based clinical pathways, periodic audits and feedback, and educational interventions for prescribers. This effectiveness is reinforced by strong clinical leadership and multidisciplinary commitment from infectious disease specialists (physicians and nurses), pediatricians, and pharmacists (Dona, 2026).

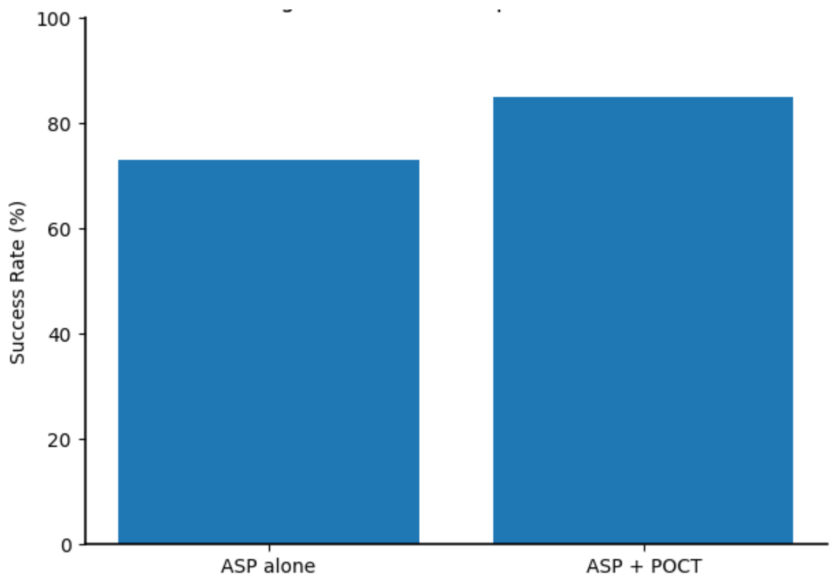

Figure 1. Diagnostic Stewardship Success Rate

The diagnostic dimension utilizes rapid molecular diagnostics and biomarker-guided decision-making to quickly identify pathogens and distinguish bacterial from viral infections. Integrating point-of-care testing with the ASP strategy increases the intervention success rate to 85% compared to ASP alone (73%) (Chiotos et al., 2025). Procalcitonin-guided therapy reduces unnecessary antibiotic exposure without compromising safety or increasing treatment failure.

The Operational Dimension encompasses monitoring standardized metrics (DOT, guideline adherence, AMR rates), implementing digital technologies (EHR integration, decision support systems, telehealth ASP), and establishing sustainable program infrastructure with dedicated leadership and resources (Dona et al., 2025). The synergy of these three dimensions yields a greater impact than single-component interventions. Programs that integrate rapid diagnostics, clinical pathways, audits and feedback, and leadership support demonstrate the greatest reduction in antibiotic consumption while maintaining clinical safety (Teteeh et al., 2025).

Clinical and Public Health Implications

Relevance for Strengthening Healthcare Systems: These findings are highly relevant for strengthening pediatric healthcare systems, particularly in low- and middle-income countries. The meta-analysis indicates that ASP and POCT are both feasible and effective in resource-limited settings, with an 80% improvement in guideline adherence through bundled interventions (Chiotos et al., 2025). The implementation of automated feedback reports and state-wide antibiograms provides a cost-effective tool for supporting ASP across various hospital settings (Schaefer et al., 2025).

Evidence-Based Policy: These findings support the adoption of the WHO AWaRe (Access, Watch, Reserve) classification framework in pediatric prescribing, which prioritizes narrow-spectrum Access antibiotics for empirical therapy (Ramzan, 2025). The development of pediatric-specific antibiograms and clinical pathways adapted to local resistance patterns is a critical step toward rational antibiotic use (Linam et al., 2023).

Cost-Effectiveness: Pediatric ASP demonstrates a favorable cost-effectiveness profile. Studies indicate projected average cost savings of $99,186 per year through reduced broad-spectrum antibiotic use and shorter therapy duration (Lien et al., 2022). Reduced hospital length of stay and fewer healthcare-associated infections further enhance the cost-benefit of ASP implementation (Palacios & Barreto, 2026).

Limitations of the Literature and Research

Heterogeneity in Study Design and Outcomes: The literature reveals significant heterogeneity in study design (RCTs, before-after studies, observational studies), interventions (type and intensity of ASP), study populations (age groups, types of infection), and outcome metrics (variations in DOT, differing definitions). This complicates direct comparisons and meta-analytic synthesis, underscoring the importance of standardization in future research (Liberati et al., 2025).

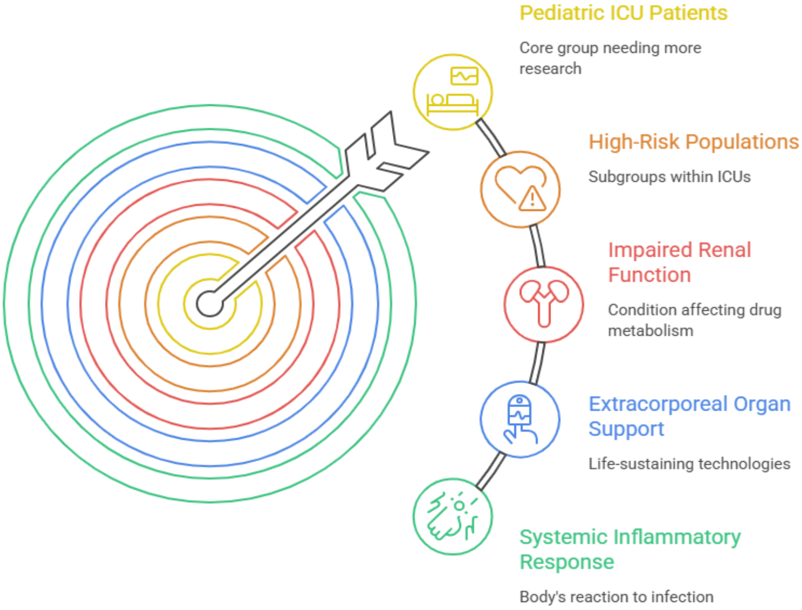

Figure 2. ASP Research Gaps in Pediatric ICUs

Limited Data on Pediatric ICUs and High-Risk Populations: Although ASP in inpatient pediatric units and emergency departments has been extensively evaluated, evidence regarding pediatric ICU patients particularly those with impaired renal function, extracorporeal organ support, or systemic inflammatory response remains limited. Most studies report data from predominantly healthy, non-critically ill children (Liberati et al., 2025).

Sustainable Implementation: Although the short-term effectiveness of ASP interventions has been demonstrated, long-term data regarding sustainability and the long-term impact on resistance rates remain very limited. Some studies indicate a decline in adherence to intervention guidelines over time, emphasizing the need for ongoing reinforcement (Brigadoi, Liberati, et al., 2024).

Limited Pediatric-Specific Evidence: Most pharmacokinetic/pharmacodynamic data and precision dosing recommendations are still based on extrapolation from adult data or limited pediatric cohorts. Future research should focus on large-scale prospective studies in pediatric populations across diverse age groups (Abdulla et al., 2021).

Future Research Directions

Development of AI Technology and Digital Tools: The integration of artificial intelligence and machine learning with EHR systems holds promise for real-time, personalized antibiotic recommendations. AI-based prediction models can identify high-risk patients for treatment failure or adverse events, facilitating more targeted interventions (Bajetic, 2026). Digital twins that integrate mechanistic modeling with real-time clinical data also demonstrate potential for simulating patient-specific responses to therapy (Gres, 2025).

Long-Term Assessment of Resistance: Large-scale, long-term surveillance studies using standardized antimicrobial susceptibility testing and molecular epidemiology are needed to measure the impact of ASP on resistance trends. Population-level genetic and epidemiological studies can identify mechanism-specific drivers of resistance emergence and guide targeted stewardship efforts (Le, 2025).

Precision Dosing Implementation and Validation: Randomized trials evaluating MIPD in diverse pediatric populations (neonates, critically ill patients, those with organ impairment, and specific infections) are needed to establish optimal implementation strategies and cost-effectiveness (Minichmayr et al., 2024). Standardization of pharmacokinetic models across centers and validation in diverse populations will facilitate widespread adoption.

Health Equity and Resource-Limited Settings: Research specifically designed for pediatric ASP implementation in low-resource settings, considering context-specific barriers and available infrastructure, is a critical priority. Community-based and primary care pediatric ASP which are often underserved require adapted strategies that are feasible with limited resources (Abo et al., 2022). Health Equity and Resource-Limited Settings: Research specifically designed for pediatric ASP implementation in low-resource settings, considering context-specific barriers and available infrastructure, is a critical priority. Community-based and primary care pediatric ASPs which are often underserved require adapted strategies that are feasible with limited resources (Abo et al., 2022).

CONCLUSION

The results of this systematic review indicate that the most effective way to optimize antimicrobial use in pediatric infections is through an integrated approach that combines audit- and feedback-based antimicrobial stewardship, diagnostic stewardship using rapid diagnostics and biomarkers, precision dosing based on PK/PD principles, the implementation of standardized clinical pathways, and nursing support facilitated by institutional leadership and digital technology. The integration of these strategies consistently reduces antibiotic consumption, improves adherence to clinical guidelines, accelerates appropriate therapy, and maintains or improves clinical outcomes without increasing mortality. Thus, a holistic and sustainable systems approach is recommended as the primary strategy to improve the quality of therapy while reducing antimicrobial resistance in the pediatric population.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work the author(s) used ASWERTHIS in order to looking literature. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Searching literature; Review; Writing.

Author 2: Review; Analysis; Writing and Editing.

Author 3: Writing and Editing.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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