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Quality Indicators for Antibiotic Use in Hospitalized Children: A Narrative Review

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Abstract

Background: Antimicrobial resistance (AMR) causes substantial morbidity and mortality worldwide, with children under five years disproportionately affected. Despite progress in adult antimicrobial stewardship, validated quality indicators (QIs) for antibiotic use in hospitalized children remain limited.

Objective: To review available evidence on QIs for pediatric inpatient antibiotic use, identify evidence gaps, and propose a framework aligned with the WHO AWaRe classification.

Methods: A narrative review was conducted using key reviews, PubMed literature, and grey literature from WHO and ECDC sources.

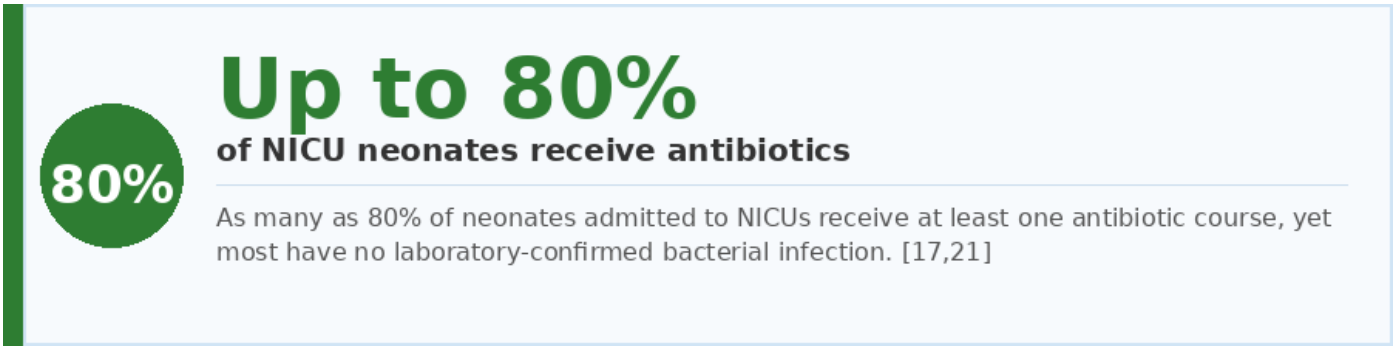
Results: Ten priority QI domains were identified: empirical prescribing, IV-to-oral switch, microbiological sampling, de-escalation, treatment duration, surgical prophylaxis, AWaRe-concordant prescribing, stewardship infrastructure, neonatal antibiotic use, and documentation.

Conclusion: There is an urgent need for rigorously developed and validated pediatric-specific QIs integrated with the WHO AWaRe framework to support benchmarking and antimicrobial stewardship globally.

Keywords: *quality indicators, antimicrobial stewardship, pediatrics, neonatal care, AWaRe, antimicrobial resistance.*

1. Introduction

AMR represents one of the most serious public health threats of the modern era. It was directly linked to 1.27 million deaths worldwide in 2019 and associated with nearly five million additional fatalities [1]. Inappropriate prescribing — whether relating to drug choice, dosage, treatment duration, or clinical indication — is widely regarded as a key driver of resistance [2,3]. Hospitalised children are particularly heavily exposed: antibiotic use on paediatric wards often far exceeds the rate of microbiologically confirmed diagnoses, with broad-spectrum agents frequently given even in the absence of an established bacterial aetiology[4].



Quality indicators are standardised, evidence-based measures of healthcare performance — quantifiable aspects of clinical practice that allow assessment of the appropriateness of care [5]. Within antimicrobial stewardship programmes (ASPs), QIs serve as the practical instruments through which antibiotic prescribing can be monitored, audited, and compared over time [6]. They translate the broad objective of prescribing appropriately into tangible, measurable standards.

Two reviews have been especially influential in shaping the QI landscape. Kallen and Prins (2017) conducted the first systematic inventory of QIs for antibiotic use in hospitalised adults, cataloguing 200 indicators from 14 studies [5]. Funiciello et al. (2024) subsequently extended this work through a narrative review covering both hospital and community settings internationally, identifying 773 indicators across 61 studies and 14 websites[7]. A notable shared limitation — acknowledged explicitly by Kallen and Prins — is the near-total absence of children from the underlying evidence base [5,7]

This review addresses this paediatric gap directly. Drawing on adult QI frameworks, the WHO AWaRe classification, paediatric and neonatal stewardship evidence, and emerging LMIC data, it synthesises existing knowledge, highlights paediatric-specific considerations, and proposes a QI domain framework applicable to hospitalised children across varied clinical and resource settings [6,7,8,9,10].

2. Background and Context

2.1 The Global AMR Burden in Children

The burden of AMR is unevenly distributed across populations. Children under five bear a disproportionately heavy burden, particularly across sub-Saharan Africa and South Asia, where limited diagnostic capacity, constrained antibiotic access, and widespread self-medication collectively accelerate resistance development [1,2,11]. Respiratory infections, bloodstream infections, and meningitis — conditions disproportionately affecting children — account for the greatest share of AMR-attributable deaths [1,11].

Even in higher-income settings, hospitalised children face considerable risks from suboptimal antibiotic prescribing. Research in North American children's hospitals has documented up to threefold variation in antibiotic days per 1,000 patient-days across institutions, even after adjusting for case mix [4,12]. In neonatal units, antibiotic exposure during sensitive developmental windows has been associated with lasting consequences, including disruption of the gut microbiome, increased risk of necrotising enterocolitis, and alterations to immune development [13,14,15].

2.2 Paediatric Antibiotic Stewardship: Current State

Paediatric ASPs have expanded considerably over the past decade. A scoping review by Dona et al. (2020) identified 145 reports documenting paediatric ASP implementation or evaluation, demonstrating antibiotic reductions of 10–40% and cost savings without measurable increases in treatment failure in most cases. Fewer than 40% of these reports, however, used validated outcome measures, and very few employed formally developed QIs — highlighting how underdeveloped the paediatric QI evidence base remains [10].

Adult ASP programmes can draw on well-established, validated QI sets. Van den Bosch et al. (2015) developed what is arguably the most rigorous adult benchmark — a generic QI set produced through a four-step RAND-modified Delphi process with international experts and validated in nearly 1,900 patients across 22 Dutch hospitals [16,17]. The DRIVE-AB consortium (2018) further developed 51 indicators through an international multidisciplinary panel spanning 15 countries. No comparable paediatric-specific validated set currently exists [18].

2.3 The WHO AWaRe Classification

The WHO Access, Watch, Reserve (AWaRe) classification, introduced in 2017 and updated in the AWaRe Antibiotic Book (2022), groups antibiotics into four categories based on their spectrum of activity, resistance potential, and clinical indications [8,19]. Table 1 summarises the four categories.

Table 1. WHO AWaRe Classification System: Categories, Definitions, and Paediatric Examples

Category	Definition	Paediatric Examples	Stewardship Target
Access	First- and second-line antibiotics for common infections; narrow spectrum; low resistance potential	Amoxicillin, ampicillin, benzylpenicillin, cefalexin, trimethoprim	≥60% of total consumption (WHO 13th GPW target)
Watch	Higher resistance potential; reserved for specific indications	Ceftriaxone, azithromycin, ciprofloxacin, meropenem, vancomycin	Use monitored; indication documented
Reserve	Last-resort agents for confirmed/suspected MDR infections	Colistin, ceftazidime-avibactam, fosfomycin IV	Requires infectious disease specialist authorisation
Not Recommended	Fixed-dose combinations where risks outweigh benefits	Chloramphenicol+streptomycin combinations	Avoid; regulatory phase-out recommended

Source: WHO AWaRe Antibiotic Book (2022) [8]; WHO 13th GPW [19].

The AWaRe framework is designed as a stewardship tool applicable across all income levels, including resource-limited settings. The 2022 AWaRe Antibiotic Book addresses 34 common infections in primary and hospital care and includes paediatric formulations — making it uniquely suited as a foundation for globally applicable paediatric Qis [8,19]. Despite this, Funiciello et al. (2024) found that only 1% of the 773 identified QIs directly referenced AWaRe, and no dedicated AWaRe QIs for children have yet been developed [7].

The WHO 13th General Programme of Work targets a minimum of 60% of antibiotic consumption from the Access group at country level [19]. Hospital-level AWaRe distribution data in paediatric settings, stratified by ward type and clinical indication, would represent a directly actionable QI metric — yet no such indicator has been formally developed or validated [7,8,20].

3. Methods

This narrative review followed standard methodology for narrative synthesis. A primary literature search was conducted in MEDLINE via PubMed using terms combining: quality indicator, antibiotic stewardship, antimicrobial stewardship, paediatric, pediatric, neonatal, children, hospitalised, inpatient, and AWaRe. The reference lists of Kallen & Prins (2017) and Funiciello et al. (2024 were manually screened. Additional sources were identified through grey literature from the WHO, ECDC, national infectious disease society websites, and clinical guideline repositories [5,7]

Articles were included if they reported the development, validation, or application of QIs for antibiotic use in paediatric, neonatal, or mixed-age inpatient populations; if they described methodological frameworks relevant to paediatric QI development; or if they addressed infection-specific stewardship targets applicable to children. No

formal quality appraisal tool was applied, given the narrative design.

4. Existing Evidence: Comparison of Key Reviews

The two most comprehensive existing reviews — Kallen and Prins (2017) and Funiciello et al. (2024) — form the primary evidence base for this review. Table 2 provides a comparative overview. Both reviews confirm a growing but incompletely validated QI landscape, and both explicitly identify the paediatric population as an unaddressed priority [5,7].

Table 2. Comparison of Key Existing Reviews: Kallen & Prins (2017) vs. Funiciello et al. (2024)

Characteristic	Kallen & Prins (2017) [5]	Funiciello et al. (2024) [7]
Studies included	14 (PubMed only)	61 studies + 14 websites (PubMed + grey literature)
Total QIs	200 (17 structure; 183 process)	773 (after removing duplicates and irrelevant QIs)
Population	Hospitalised adults only; paediatrics excluded	Adults and children; hospital + primary care; HICs and LMICs
Most cited infections	LRTI, UTI, sepsis	Respiratory tract infections (~50% of infection-specific QIs)
Development method	RAND-modified Delphi in 57% of studies	RAND/UCLA Appropriateness Method in 50% of studies
QI validation	Only 36% of studies validated QIs	Consensus = face validity only; formal validation lacking
AWaRe alignment	Not assessed (pre-AWaRe era)	1% cite AWaRe directly; 57.6% reflect AWaRe guidance indirectly
Paediatric specificity	None	Sparse; only a few studies (e.g., Li 2017, de Bie 2016)

QI: quality indicator; LRTI: lower respiratory tract infection; UTI: urinary tract infection; LMICs: low- and middle-income countries.

Several observations are worth noting. The growth from 200 to 773 QIs between 2017 and 2024 reflects both a broader scope — extending to primary care and LMICs — and genuine global expansion in stewardship activity [5,7]. The persistent shortfall in validated QIs, with only 36% of adult studies testing clinimetric properties [5], suggests that despite quantitative growth, rigorously tested tools remain scarce. Most importantly, neither review addressed paediatric inpatients as a primary focus [5,7].

Of the 14 studies included by Kallen and Prins, a RAND-modified Delphi procedure was used in 57%, with expert panels ranging from 11 to 51 individuals [5]. Only five studies tested clinimetric properties; of 63 QIs tested, 41 (65%) were deemed valid — the most common grounds for invalidity being poor data feasibility and limited room for improvement [5]. These findings carry direct implications for paediatric QI development: indicators must be designed with routine data capture in mind from the outset.

Table 3. Top 10 Most Frequently Cited Quality Indicators from Kallen & Prins (2017) [5]

QUALITY INDICATORS	STUDIES (n/14)	FREQUENCY	KEY REFERENCE
Perform at least two sets of blood cultures	8/14	57%	[5,21,22]
Change to pathogen-directed therapy on culture results	8/14	57%	[5,16,23]
Timely initiation of antibiotic therapy	7/14	50%	[5,6,29]
Adjust dose and dosing interval to renal function	7/14	50%	[5,24]

Document antibiotic plan in medical record	7/14	50%	[5,17,25]
Perform a site culture	6/14	43%	[5,26]
Discontinue antibiotic if infection not confirmed	6/14	43%	[5,16,27]
Duration of antibiotic therapy appropriate to indication	6/14	43%	[4,5 ,28]
Prescribe empirical antibiotic therapy per guidelines	10/14	71%	[5,27,29]
Timely initiation of antibiotic therapy	7/14	50%	[5,6,29]

Source: Kallen & Prins, Infectious Disease Reports, 2017 [5]

5. Proposed Quality Indicator Domains for Hospitalised Children

Drawing on the adult QI literature, paediatric stewardship evidence, and paediatric-specific clinical considerations, ten key QI domains are proposed below. These are summarised in Table 4, with descriptions, example measurable indicators, key citations, and priority ratings.

Table 4. Proposed Quality Indicator Domains for Antibiotic Use in Hospitalised Children

QI Domain	Description	Example Measurable Indicator	Key Citations	Priority
Empirical prescribing	Guideline-concordant choice; age/weight-based dosing	% receiving empirical therapy concordant with paediatric guidelines	[1,5,6,27,29,30]	High
Microbiological sampling	Cultures before first antibiotic dose; weight-adjusted volumes in neonates	% receiving appropriate cultures before antibiotics, by age band	[5,11,22,26,29,31]	High
De-escalation	Spectrum narrowed/stopped at 48–72h review using culture results	% with documented de-escalation decision at 48–72h	[6,7,16,23,27,32]	High
Duration of therapy	Adherence to condition-specific evidence-based duration	% completing therapy within guideline-recommended duration range	[2,4,24,28,33,34]	High
Surgical prophylaxis	Correct agent; administration within 60 min of incision; cessation within 24h post-op	% paediatric surgical patients with appropriate prophylaxis timing and cessation	[18,30,35,36,37]	Medium-High
AWaRe-aligned prescribing	Proportion of prescriptions from Access vs Watch vs	% Access group prescriptions; % Watch/Reserve with	[8,19,20,38,39]	High

QI Domain	Description	Example Measurable Indicator	Key Citations	Priority
	Reserve; Reserve requires justification	documented justification		
ASP infrastructure	Paediatric ID specialist, pharmacist, dosing tools, ASP committee present	Number of WHO/IDSA core ASP structural elements in place	[6,8,36,40,41, 42]	Medium
IV-to-oral switch	Timely switch when clinically eligible age appropriate oral formulation	% eligible patients switched within 48–72 hours of clinical stability	[7,21,28,33,35,43]	High
Neonatal antibiotic use	Indication documented; culture-guided duration; early discontinuation for negative cultures	% neonates with documented indication; % completing culture-guided vs empiric-only courses	[3,10,11,13,14,15]	Critical
Documentation	Indication, intended duration, review date, weight-based dose documented within 24h	% patients with complete antibiotic documentation at 24h and 72h	[5,6,7,17,25]	Medium

QI: quality indicator; IV: intravenous; AWaRe: Access, Watch, Reserve; ASP: antimicrobial stewardship programme; NICU: neonatal intensive care unit.

5.1 Empirical Prescribing Aligned with Paediatric Guidelines

Adherence to local or national guidelines in empirical prescribing is the most frequently cited QI in the adult literature, appearing in 71% of studies reviewed by Kallen and Prins [5]. The same principle applies in paediatrics but requires age-specific and weight-adjusted implementation. Fluoroquinolones are generally avoided in children under 18 except in specific circumstances; tetracyclines are contraindicated in those below age 8; and dosing of aminoglycosides and vancomycin is highly dependent on weight and age, necessitating therapeutic drug monitoring [30,44]

Guideline concordance can only be meaningfully assessed where evidence-based paediatric prescribing guidelines are available. A significant challenge in LMICs is the absence of such guidelines — many low-income settings rely on adult guidance extrapolated to children, or on clinical experience alone [3,32]. Developing AWaRe-aligned local paediatric guidelines is therefore a prerequisite for meaningful measurement of this QI [8,19].

5.2 Intravenous-to-Oral (IV-to-Oral) Switch

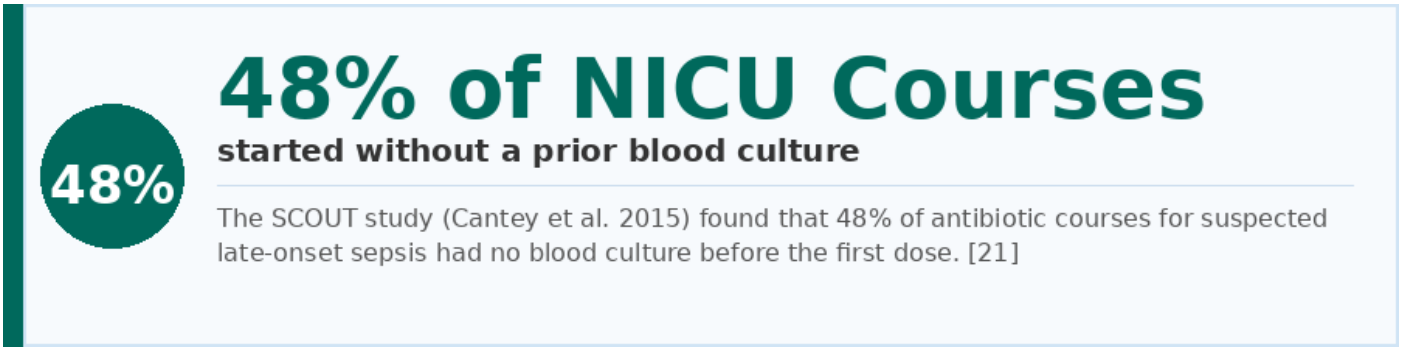
Prompt switching from intravenous to oral antibiotics in eligible patients is the second most commonly cited adult QI (64% of studies) [5] and is of equal or greater importance in children. IV access in paediatric patients carries particular risks — catheter-related bloodstream infections, painful procedures, prolonged hospital stays, and the risk of dislodgement [25,33]. Extended IV therapy is a common and preventable contributor to excess hospital days in paediatric wards worldwide.

Harvey et al. (2023) developed national IV-to-oral switch criteria for adult inpatients in the UK through a four-step Delphi process — a methodological model that can be adapted for paediatric use [33]. A paediatric IV-to-oral switch QI must also account for age-appropriate oral formulations, palatability in infants, and weight-based oral dose equivalence. A measurable indicator — the proportion of eligible inpatients switched within 48–72 hours of clinical stability — would be both clinically meaningful and practically auditable [28,33,43]

5.3 Microbiological Sampling Prior to Antibiotic Initiation

Obtaining appropriate microbiological specimens before starting antibiotics is fundamental to de-escalation and precision prescribing, allowing clinicians to narrow empirical treatment once culture results become available [22,26]. In adults, collecting at least two blood culture sets before antibiotic therapy was cited in 57% of studies reviewed by Kallen and Prins [5].

In children, this QI requires important age-specific modifications. Blood culture volumes are weight-dependent — the optimal volume in neonates is 1–4 ml per bottle, far less than the adult standard of 10 ml [11,31].Lumbar puncture thresholds vary with age; urine culture techniques differ (suprapubic aspiration or catheter specimens in infants versus clean-catch in older children); and respiratory specimen collection is technically challenging in non-intubated young children [30,42].A stratified QI capturing the proportion of children receiving antibiotics with appropriate preceding cultures, stratified by age band and clinical indication, would reflect this complexity while remaining auditable [21,26].



5.4 De-escalation and Pathogen-Directed Therapy

De-escalation — reducing antibiotic spectrum or stopping therapy once culture results are available or infection has been excluded — is one of the most clinically significant stewardship processes in paediatrics, yet it remains among the least measured. Funiciello et al. (2024) found that only 26 of 206 antibiotic prescribing indicators in their review included any information on therapy review — a notable underrepresentation of this critical domain [7].

In children, the consequences of failing to de-escalate extend beyond resistance selection. Prolonged broad-spectrum antibiotic use in early life, disrupts the developing gut microbiome, with associations documented for increased risks of necrotising enterocolitis, obesity, asthma, and inflammatory bowel disease later in life [14,24]. A QI requiring documented therapy review and a de-escalation decision at 48–72 hours — informed by culture results and clinical trajectory — would directly address this gap [16,23].

5.5 Duration of Therapy

Defining and measuring appropriate antibiotic duration is clinically complex, but a growing body of paediatric evidence supports shorter treatment courses. Randomised trial evidence now supports 5-day courses for paediatric community-acquired pneumonia (compared with traditional 7–10 days), 3–5 days for uncomplicated urinary tract infections, and 7–10 days for paediatric bacteraemia without focus — compared with the 14-day courses historically used [4,28,34]. QIs benchmarking therapy duration against condition-specific evidence-based targets — and flagging courses exceeding the upper recommended limit — represent clinically meaningful, auditable process measures.

5.6 Surgical Antibiotic Prophylaxis

Appropriate timing, agent selection, and discontinuation of surgical antibiotic prophylaxis is a well-established QI domain in adult settings, featured in multiple international indicator sets [18,35]. In paediatrics, the same principles apply with the additional requirements of weight-based dosing and age-specific contraindications to standard prophylactic agents. The WHO Global Action Plan on AMR includes the proportion of surgical patients receiving appropriately timed prophylaxis as a core outcome indicator — directly applicable to children [8].

A paediatric surgical prophylaxis QI should assess: (1) agent selection consistent with procedure-specific guidelines; (2) administration within 60 minutes of incision (or 120 minutes for vancomycin or fluoroquinolones); and (3) discontinuation within 24 hours postoperatively. Each component has independently been shown to reduce surgical site infection rates in adult and mixed-age studies [35,36].

5.7 AWaRe-Aligned Prescribing

Monitoring the AWaRe distribution of antibiotic prescriptions — the proportion from Access versus Watch versus Reserve groups — provides a globally standardised, actionable metric for paediatric hospital stewardship [8,19,20]. Unlike many process QIs, AWaRe-based

indicators can be derived from pharmacy dispensing data alone, without requiring individual patient chart review — making them highly feasible for routine monitoring even in resource-limited settings [7,38].

The WHO 13th GPW target of at least 60% Access group consumption provides a clear quantitative benchmark against which hospital-level paediatric AWaRe ratios can be tracked over time [19]. Funiciello et al. (2024) explicitly identified this as the next priority area for QI development — paediatric hospitals are the natural primary focus [7]. Hospital-level AWaRe data stratified by ward type and clinical indication would enable targeted stewardship interventions.

5.8 Antimicrobial Stewardship Programme Infrastructure

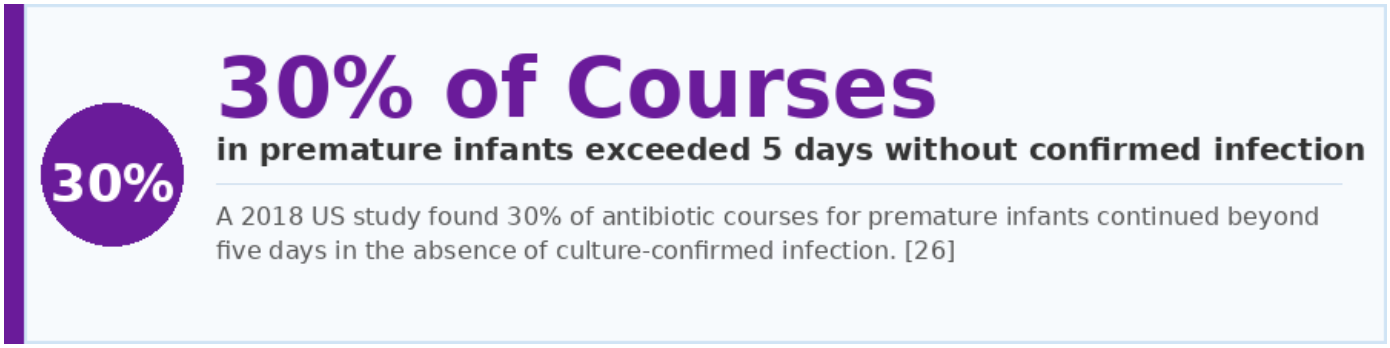
Structural QIs — assessing the existence and composition of paediatric ASPs — are the enabling conditions for all process-level indicators. Without adequate infrastructure, process indicators cannot be meaningfully measured or acted upon [6,36]. Core structural requirements for paediatric ASPs include: access to a paediatric infectious disease specialist or clinical microbiologist; involvement of a clinical pharmacist with paediatric expertise; availability of age-appropriate, weight-based antibiotic dosing tools; an ASP committee with paediatric representation; and regular antibiogram reporting [40,41,45]

Pulcini et al. (2019) developed seven core elements and 29 checklist items for hospital ASPs globally through an international Delphi procedure spanning 13 countries — a directly adaptable structural QI template for paediatric contexts [41]. Science et al. (2016, 2019) identified four core metrics for paediatric ASP evaluation in Canadian hospitals, demonstrating that structural paediatric QI measurement is achievable [28,40].

5.9 Neonatal Antibiotic Use

The NICU represents the highest-intensity antibiotic prescribing environment across all of paediatrics. Studies from the United States, Europe, and LMICs consistently show that 60–80% of NICU admissions involve at least one antibiotic course, with empirical treatment for suspected early- or late-onset sepsis accounting for the majority of prescribing [13,15,31]. A substantial proportion of these courses — estimated at 30–50% in most studies — occur without culture-confirmed infection [13,31].

Neonatal-specific QIs should include: (1) the proportion of antibiotic courses with a documented indication; (2) the proportion of empirical courses for suspected early-onset sepsis discontinued within 36–48 hours following negative blood cultures; (3) the proportion of late-onset sepsis episodes with a culture obtained before the first antibiotic dose; and (4) the proportion of neonates receiving prolonged (>5 day) antibiotic courses without confirmed infection [11,14,31].These indicators directly target the modifiable prescribing behaviours most responsible for excess antibiotic exposure in NICUs.



5.10 Documentation

Documenting antibiotic indication, intended duration, weight-based dose calculation, and planned review date within 24 hours of prescribing is both a standalone QI and a prerequisite for all other quality measures — including de-escalation, duration auditing, and prescriber accountability [5,6,7].Kallen and Prins identified documentation as a top-10 adult QI (cited in 50% of studies); in paediatrics, the added complexity of weight-based prescribing and age-related contraindications makes thorough documentation even more important [5,17,35].

Electronic prescribing systems with mandatory documentation fields represent the optimal tool for implementing this QI, but paper-based audit tools and antibiotic checklists have also been shown to significantly improve documentation rates and reduce inappropriate prescribing in both high- and low-resource settings [16,17,46].

6. Methodological Considerations for Paediatric QI Development

Both landmark reviews confirm that RAND-modified Delphi and RAND/UCLA Appropriateness Method procedures offer the most rigorous approach to QI development, combining systematic evidence with structured multidisciplinary expert consensus [5,7,24,29]. For paediatric QIs, Delphi panels should include paediatric

infectious disease specialists, neonatologists, paediatric clinical pharmacists, nurses, microbiologists, and — where possible — patient and family representatives. International panels spanning WHO regions and including LMIC perspectives are essential if the resulting indicators are to have global applicability [7,19].

Funiciello et al. (2024) outline a clear methodological pathway: (1) narrative literature review to identify existing indicators; (2) Delphi process with panellists across WHO regions and both HICs and LMICs; (3) formal RAND/UCLA Appropriateness Method with leading international experts; and (4) formal validation and testing encompassing content validity, reliability, and feasibility [7]. This pathway should be adopted and extended with paediatric-specific components at each stage.

Validation is the critical step that follows consensus. Kallen and Prins found that 35% of tested QIs in the adult literature were ultimately invalid — most often due to poor data feasibility or insufficient room for improvement [5]. Paediatric QI validation studies should prospectively assess: measurability, applicability, inter-observer reliability, room for improvement, and case-mix stability [5,7].

7. Gaps and Future Directions

Several important gaps in the current evidence base warrant priority attention. First, validated paediatric-specific quality indicators (QIs) for antibiotic use remain limited, with most currently available indicators developed for adult populations and only partially transferable to children. Existing reviews have consistently highlighted the underrepresentation of paediatric inpatient settings in stewardship quality measurement frameworks [3,5,10].

Second, neonatal antibiotic stewardship indicators are particularly scarce despite neonatal intensive care units representing one of the highest antibiotic-use environments in paediatric practice. Empirical antibiotic exposure remains common in neonates, often in the absence of culture-confirmed infection, underscoring the need for targeted neonatal QIs addressing initiation, review, de-escalation, and duration of therapy [13,14,31].

Third, low- and middle-income countries (LMICs) remain underrepresented in the QI literature, despite carrying a disproportionate burden of childhood infectious diseases and antimicrobial resistance. Many currently proposed indicators are based on high-income country prescribing systems and may not be fully applicable in settings with limited diagnostic capacity, workforce shortages, or restricted antibiotic availability [1,3,7].

Fourth, there is limited evidence linking adherence to antibiotic QIs with patient-centred clinical outcomes in children, such as mortality, treatment failure, readmission, adverse drug events, or length of hospital stay. Future multicentre prospective studies should evaluate whether improved QI performance translates into measurable clinical benefit [5,10].

Fifth, digital health technologies such as electronic prescribing systems, clinical decision support tools, automated audit dashboards, and real-time surveillance platforms offer significant opportunities to improve stewardship measurement and implementation. Future QI development should prioritize indicators that are feasible to capture electronically and suitable for routine benchmarking [7,25]

Finally, the perspectives of patients, parents, and caregivers have been largely absent from antibiotic quality indicator development. Incorporating family-centred outcomes such as communication quality, shared decision-making, and treatment understanding may improve both stewardship acceptance and quality of care.

Future research should focus on internationally validated paediatric QI sets aligned with the WHO AWaRe framework, tested across diverse healthcare systems, and linked to meaningful antimicrobial stewardship and patient outcomes [8,19].

8. Conclusions

Hospitalized children represent a major yet under-addressed population in antimicrobial stewardship research. This review proposes ten priority domains for pediatric antibiotic quality indicators and highlights the urgent need for internationally validated measures integrated with the WHO AWaRe framework. Implementation of such indicators may improve prescribing quality, patient outcomes, and global AMR control efforts

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