

Role of Clinical Pharmacists in Supporting Pediatric Nurses in Safe Medication Management

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Abstract

Medication management in pediatric practice is inherently complex because medication doses are frequently individualized according to body weight, age, developmental status, renal and hepatic function, and clinical condition. Pediatric patients are therefore vulnerable to prescribing, transcription, dispensing, preparation, administration, and monitoring errors. Pediatric nurses are central to medication administration and are often the final healthcare professionals to verify and administer medicines at the bedside. Clinical pharmacists can complement this role by providing pharmacotherapeutic expertise, dose verification, medication reconciliation, identification of drug interactions and contraindications, formulation guidance, therapeutic monitoring, education, and real-time clinical consultation. This narrative review examines the contribution of clinical pharmacists to pediatric medication safety, with particular emphasis on pharmacist–nurse collaboration. Published evidence indicates that pharmacist interventions can reduce medication errors in hospitalized pediatric patients, while nursing-focused interventions, standardized processes, double-checking, barcode medication administration, smart infusion technology, and education provide additional safeguards. However, pharmacist involvement alone cannot prevent all administration-related errors. Safe pediatric medication management therefore requires a multilayered system in which pharmacists and nurses perform complementary functions within a multidisciplinary team. Strengthening pharmacist access, medication reconciliation, dose verification, high-alert medication safeguards, clinical decision support, caregiver education, and non-punitive incident reporting may improve the reliability of pediatric medication-use processes. Future research should focus on standardized outcome measures, cost-effectiveness, staffing models, and implementation strategies across different pediatric healthcare settings.

Keywords: Clinical pharmacist; pediatric nursing; medication safety; medication errors; medication administration; pediatric patients; dose calculation; medication reconciliation; high-alert medications; patient safety; pharmacist–nurse collaboration.

1. Introduction

Medication safety is a core component of pediatric patient safety. The medication-use process includes prescribing, order entry and transcription, dispensing, preparation, administration, monitoring, documentation, and transitions of care. At each stage, patient-specific factors can influence the probability and potential severity of an error. Unlike many adult regimens, pediatric prescriptions frequently require calculations based on weight, age, body-surface area, renal function, or other clinical parameters. The same medicine may also be available in multiple concentrations or dosage forms, increasing the possibility of selection and measurement errors [1,2].

Pediatric pharmacotherapy is further complicated by developmental pharmacology. Physiological maturation changes drug absorption, distribution, metabolism, and elimination throughout childhood. Neonates and infants may have immature organ function, while older children and adolescents may require different dose ranges, formulations, or monitoring approaches. Consequently, medication decisions must be individualized rather than based solely on adult prescribing practices [3,4].

Nurses are central to the final stages of medication management. They verify patient identity, assess relevant clinical information, prepare and administer medicines, monitor responses, and document administration. Clinical pharmacists contribute complementary expertise in pharmacotherapy, dose optimization, drug interactions, formulation selection, medication reconciliation, and monitoring. Evidence from pediatric hospitals suggests that pharmacist interventions can identify medication-related problems and reduce medication-error occurrence [10,11].

The purpose of this review is to examine how clinical pharmacists can support pediatric nurses and how collaborative pharmacist–nurse practice can create multiple safety barriers. The article also considers technology, high-alert medicines, transitions of care, caregiver education, and organizational factors that influence pediatric medication safety.

2. Objectives

- To describe medication-safety risks that are particularly relevant to pediatric patients.
- To explain the responsibilities of pediatric nurses in safe medication administration.
- To examine the clinical pharmacist's contribution to pediatric medication management.
- To describe practical mechanisms for pharmacist–nurse collaboration.
- To review technology-assisted and system-level medication-safety strategies.
- To identify challenges and opportunities for implementing pharmacist-supported pediatric medication safety.
- To propose a multilayered model suitable for pediatric inpatient and transitional-care environments.

3. Medication Safety Challenges in Pediatric Patients

3.1 Weight-Based Dosing

Weight-based dosing is one of the most important sources of complexity in pediatric pharmacotherapy. A small numerical error can have a clinically meaningful effect when the final dose is calculated by multiplying a dose-per-kilogram value by body weight. Errors can occur when weight is outdated, documented in the wrong unit, transcribed incorrectly, or used from a previous encounter. Standardized documentation in kilograms and clear maximum-dose limits are therefore important safety measures [1,2,18].

Clinical pharmacists can independently verify the calculation and assess whether the resulting dose is therapeutically appropriate. Nurses can provide the most current bedside weight and ensure that the weight used for administration corresponds to the current medication order.

3.2 Age-, Development-, and Organ-Function-Related Differences

Drug handling changes throughout childhood. Renal and hepatic maturation can affect clearance, while developmental changes may alter drug distribution and pharmacodynamic response. These differences are especially relevant for neonates, infants, and children with renal or hepatic dysfunction. Pharmacists can assist nurses by identifying medicines requiring age- or organ-function-specific dosing and by recommending appropriate monitoring.

3.3 Limited Pediatric Formulations

Many medicines are manufactured primarily for adults. Pediatric treatment may consequently require oral liquids, diluted solutions, split tablets, compounded preparations, or alternative dosage forms. Each manipulation introduces additional steps at which an error can occur. Pharmacists can recommend commercially available pediatric formulations when appropriate, provide validated preparation instructions, and advise nurses on concentration and volume.

3.4 Oral Liquid Medication Errors

Oral liquids may be supplied in different concentrations and are vulnerable to measurement errors. Confusion between milligrams and milliliters can result in significant overdosing or underdosing. Metric-only instructions, standardized concentrations, appropriate oral syringes, and clear labeling are important safeguards [18]. Nurses

should verify both the prescribed dose in mass units and the corresponding volume, while pharmacists can help ensure that the concentration used for calculation is correct.

3.5 High-Alert Medications

High-alert medicines require additional safeguards because an error may produce serious harm. The specific high-alert list should be defined locally according to patient population and institutional risk assessment. Examples in pediatric settings may include selected opioids, anticoagulants, insulin, concentrated electrolytes, vasoactive medicines, sedatives, and chemotherapy. Pharmacists can assist in developing standardized concentrations, dose limits, monitoring parameters, and administration protocols [25].

3.6 Transitions of Care

Medication discrepancies can arise whenever a child moves between care settings. Admission, transfer between units, and discharge can involve medication omissions, duplications, dose changes, or formulation changes. Medication reconciliation provides a structured method for identifying these discrepancies and communicating intended changes to nurses, prescribers, caregivers, and other healthcare professionals [13,14].

4. Role of Pediatric Nurses in Medication Safety

Pediatric nurses provide the direct bedside interface between the medication order and the child. Their role includes verifying patient identity, reviewing orders, confirming allergies, checking dose and route, preparing medication, administering it safely, monitoring the response, documenting the event, and communicating concerns. The nursing role is therefore not limited to the mechanical act of administration; it also includes clinical assessment before and after medication use.

Medication administration can nevertheless be affected by interruptions, workload, staffing pressures, unfamiliar medicines, incomplete orders, calculation complexity, and communication failures. Systematic review evidence indicates that nursing interventions such as education, double-checking, medication-information services, interruption reduction, smart infusion pumps, and pharmacist participation can contribute to medication-error prevention [8].

- Verify the correct patient using institutional identification procedures.
- Confirm current weight and relevant clinical parameters before weight-based dosing.
- Review medication, dose, route, timing, indication, allergies, and relevant monitoring requirements.
- Use standardized preparation and administration procedures.
- Minimize interruptions during preparation of medicines.
- Observe therapeutic response and adverse effects.
- Document administration and clinically important observations accurately.
- Escalate discrepancies or uncertainties before administration rather than relying on assumptions.

5. Role of Clinical Pharmacists in Pediatric Medication Management

5.1 Medication Order Review

Clinical pharmacists can review pediatric medication orders for indication, dose, frequency, route, formulation, maximum daily dose, contraindications, allergies, interactions, therapeutic duplication, and monitoring requirements. Their involvement is particularly valuable when prescriptions involve complex weight-based calculations, narrow therapeutic ranges, high-alert medicines, or nonstandard formulations. Pediatric clinical pharmacist interventions have been associated with identification of clinically relevant medication problems [10,11].

5.2 Independent Dose Verification

Independent dose verification creates a second professional assessment of a calculation. For example, for a prescribed dose of 10 mg/kg in a child weighing 18 kg, the calculated dose is 180 mg. The pharmacist can then assess whether the dose is within the recommended therapeutic range, whether it exceeds an accepted maximum dose,

and whether the available concentration permits accurate administration. This process is especially useful when decimal points, unit conversions, dose rounding, or dilution are involved.

5.3 Medication Reconciliation

Medication reconciliation is the systematic comparison of the medication history with current orders. Pediatric pharmacist-led reconciliation has been shown to identify discrepancies and generate medication-related interventions [13,14]. Pharmacists can clarify the indication, formulation, strength, dose, frequency, and actual use of home medicines. Nurses can support the process by obtaining caregiver information and communicating changes observed during the admission.

5.4 Drug Interaction and Contraindication Assessment

Children receiving multiple medications may be exposed to pharmacokinetic and pharmacodynamic interactions. Pharmacists can evaluate interactions involving metabolism, renal elimination, QT prolongation, bleeding, sedation, nephrotoxicity, hepatotoxicity, and additive adverse effects. They can also identify contraindications related to allergies, organ dysfunction, or disease-specific considerations and communicate recommendations to the healthcare team.

5.5 Therapeutic Drug Monitoring

Some medicines require laboratory or clinical monitoring to optimize efficacy and reduce toxicity. Pharmacists can recommend appropriate sampling times, interpret concentrations in relation to dose and timing, and communicate dose-adjustment recommendations. Nurses contribute by ensuring that samples are collected correctly and at the appropriate time and by monitoring the patient's clinical response.

5.6 Adverse Drug Reaction Support

Because nurses observe children continuously, they may be the first professionals to recognize a possible adverse drug reaction. Pharmacists can help determine whether a symptom is medication-related, evaluate alternative explanations, recommend changes, and support documentation and reporting. This collaborative process is particularly important for reactions that may resemble disease progression.



Figure 1. Collaborative pediatric medication-safety pathway. The model shows sequential safety barriers with bidirectional communication between pharmacists and nurses.

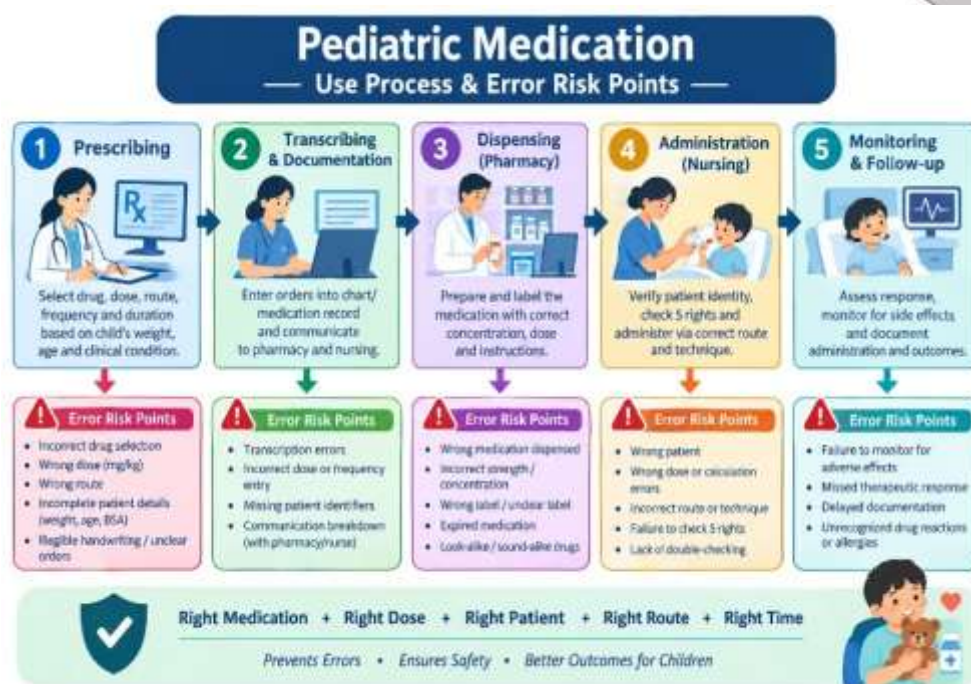


Figure 2. Pediatric medication-use process and common error-risk points. Error opportunities can occur at multiple stages rather than only during administration.

6. Pharmacist Support for Pediatric Nurses

6.1 Real-Time Clinical Consultation

A readily accessible clinical pharmacist can answer medication-related questions at the point of care. Common consultation topics include dose calculation, dilution, intravenous compatibility, infusion rates, stability, administration through feeding tubes, missed doses, alternative formulations, drug interactions, and adverse effects. Timely consultation can prevent nurses from having to rely on incomplete information or informal sources.

6.2 Medication Education and Competency Development

Pharmacists can deliver structured education to pediatric nursing teams using case-based learning, medication-safety briefings, competency assessments, and updates when new medicines or formulations are introduced. Topics may include weight-based dosing, high-alert medications, oral liquid measurement, infusion preparation, therapeutic drug monitoring, look-alike/sound-alike medicines, and electronic prescribing. Education should be repeated periodically and evaluated for practical competency rather than treated as a one-time intervention [8,9].

6.3 Standardized Medication Information

Pharmacists can prepare standardized medication references that specify pediatric dose ranges, dilution instructions, administration rates, compatibility information, monitoring parameters, and important precautions. Consistent references reduce variation between individual practitioners and can support nurses during urgent or unfamiliar medication situations.

6.4 Participation in Ward Rounds

When pharmacists participate in pediatric multidisciplinary rounds, medication problems can be identified close to the time they arise. The pharmacist can review new orders, monitor treatment response, suggest adjustments, and communicate directly with nurses and prescribers. This approach can also strengthen shared understanding of the child's medication plan.



Figure 3. Clinical pharmacist support for pediatric nurses. Pharmacist activities translate into practical bedside safety benefits through coordinated communication.

7. Collaborative Pharmacist–Nurse Medication-Safety Model

Medication safety is strongest when responsibilities are complementary rather than duplicated or isolated. The pharmacist can provide an independent pharmacotherapeutic review, while the nurse verifies patient-specific information immediately before administration and observes the child during and after treatment. The following model illustrates areas of collaboration.

Activity	Pediatric nurse	Clinical pharmacist
Patient identification	Bedside identification and clinical assessment	Medication-profile verification
Current weight	Obtains and documents weight	Checks dose calculations using current weight
Order verification	Confirms order before administration	Reviews indication, dose, route, frequency and safety
Dose calculation	Performs/validates bedside calculation	Independently verifies calculation and limits
Preparation	Prepares medication according to protocol	Provides formulation, dilution and compatibility guidance
Administration	Administers and documents medication	Advises on administration requirements
Monitoring	Observes response and adverse effects	Interprets medication-related effects and recommends action
Reconciliation	Provides caregiver/home-medication information	Identifies and resolves discrepancies

Education	Reinforces bedside instructions	Provides detailed medication counseling
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8. Technology-Supported Medication Safety

8.1 Computerized Provider Order Entry

Electronic prescribing can standardize medication orders, support weight-based dosing, and provide clinical decision support. Pediatric-specific safeguards may include dose-range checking, maximum-dose limits, age restrictions, and alerts for allergies or interactions. Nevertheless, electronic systems can create new hazards when interfaces are confusing, defaults are inappropriate, or alerts are excessive. Pharmacist and nurse review therefore remains necessary [16,25].

8.2 Barcode Medication Administration

Barcode medication administration can provide a structured verification step before administration. When implemented appropriately, it can help match the patient, medication, and scheduled administration event. Staff must still respond appropriately to alerts and avoid workarounds that bypass the intended safety process [9].

8.3 Smart Infusion Pumps

Smart infusion pumps can incorporate drug libraries and dose or rate limits for intravenous medicines. They may be particularly useful for high-risk pediatric infusions. Effective use requires accurate drug-library maintenance, staff training, and a process for reviewing overrides and near misses.

8.4 Clinical Decision Support

Clinical decision-support systems can provide alerts for allergies, interactions, dose limits, renal adjustment, duplicate therapy, and maximum daily doses. Excessive or low-value alerts can produce alert fatigue. Pharmacists can contribute to alert optimization by reviewing which warnings are clinically meaningful and which should be modified or suppressed according to local policy.



Figure 4. Technology-enabled pediatric medication safety. Electronic prescribing, decision support, pharmacist review, barcode verification, and smart infusion technology operate as complementary safeguards.

9. High-Alert Medication Management

High-alert medicines warrant additional controls because a single error may cause substantial harm. Institutions should maintain a locally approved list based on pediatric clinical risks. Pharmacists can help standardize concentrations, preparation procedures, storage, labeling, dose limits, monitoring requirements, and reversal strategies. Nurses can implement the bedside verification and monitoring steps specified in institutional protocols.

Independent double-checking can be valuable for selected high-alert medications when the process is genuinely independent and clearly defined. However, double-checking should not be considered a substitute for robust system design. Standardization, technology, pharmacist review, appropriate staffing, and clinical monitoring should operate together [7,9,25].

10. Medication Reconciliation and Transitions of Care

Medication reconciliation should occur at admission, significant transfers, and discharge. The process should identify what the child was actually taking before admission, compare that information with current orders, determine which medicines were intentionally changed, and communicate the final regimen clearly. Pediatric pharmacist involvement can improve the identification and resolution of discrepancies [13,14].

Nurses play an important role because caregivers often provide the most accurate information about home administration patterns, missed doses, formulation preferences, and medicines obtained outside the hospital. Combining caregiver information with pharmacist review and nursing documentation can produce a more complete medication history.

11. Caregiver Education

Medication safety extends beyond the hospital. Caregivers may need to measure liquid medicines, administer inhaled treatments, follow complex schedules, or recognize adverse effects. Communication should be adapted to health literacy and language needs. Pediatric guidance supports metric dosing, use of kilograms for weight, appropriate measuring devices, and teach-back/show-back techniques [18].

- Provide a written medication schedule using clear dose and frequency instructions.
- State liquid doses in both the medication name/concentration and the exact volume to administer when appropriate.
- Demonstrate use of an oral syringe or other appropriate measuring device.
- Explain important adverse effects and what caregivers should do if they occur.
- Explain what to do after a missed or vomited dose according to the medication-specific plan.
- Confirm understanding using teach-back rather than asking only whether the caregiver understands.

12. Medication Error Reporting and Safety Culture

Medication-error reporting systems provide information about failures that may otherwise remain hidden. A near miss can reveal a hazardous process even when no patient is harmed. Pediatric medication-safety programs should encourage reporting of prescribing, dispensing, preparation, administration, monitoring, communication, and technology-related events. Pharmacists can analyze medication-related incidents and nurses can describe workflow conditions that contributed to the event.

A non-punitive safety culture does not mean that unsafe conduct is ignored; rather, it emphasizes learning from system vulnerabilities and distinguishing human error from reckless behavior. Findings should be converted into practical interventions such as revised protocols, education, technology changes, standardized concentrations, or workflow redesign [7,9].

13. Evidence Supporting Clinical Pharmacist Involvement

Evidence from pediatric literature supports clinical pharmacist involvement, although the evidence base is heterogeneous. A systematic review and meta-analysis reported a significant reduction in medication-error

occurrence associated with pharmacist interventions in hospitalized pediatric patients [10]. Interventions included prescription review, education, participation in clinical rounds, and unit-based clinical pharmacy services.

A separate systematic review of clinical pharmacist interventions in pediatric hospital patients found that pharmacists identified problems involving over- and under-dosing, missed doses, medication-history discrepancies, allergies, and near-miss events [11]. These findings support pharmacist integration into multidisciplinary pediatric teams.

However, evidence should not be interpreted as demonstrating that pharmacists alone prevent all medication errors. Earlier research found that pharmacists could intercept many prescribing errors, whereas administration-related errors required additional safeguards [12]. A Cochrane review also identified limitations in the pediatric evidence base, including heterogeneity and low certainty for some outcomes [24]. The practical implication is that pharmacist involvement should be integrated with nursing practice, standardized processes, technology, and continuous monitoring.

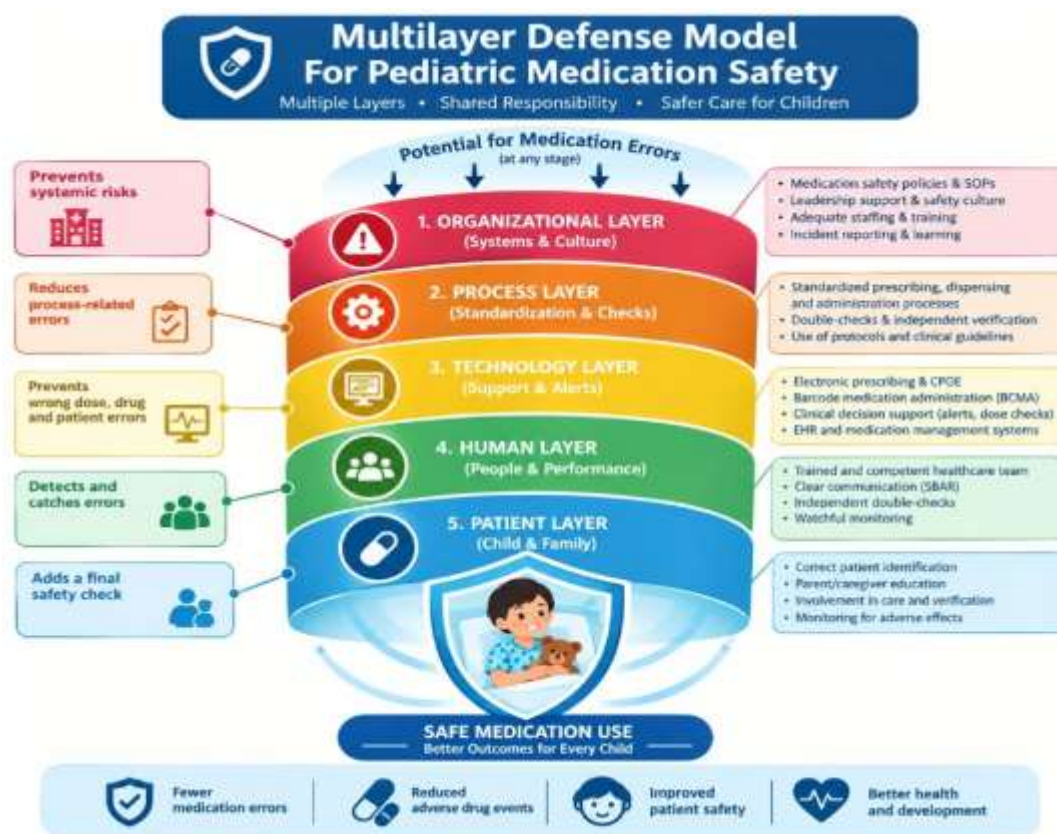


Figure 5. Multilayer defense model for pediatric medication safety. The model emphasizes multiple independent barriers rather than dependence on a single intervention.

14. Challenges to Effective Pharmacist–Nurse Collaboration

- Limited availability of pediatric clinical pharmacists, particularly during nights and weekends.
- High nursing workload and interruptions during medication preparation and administration.
- Communication barriers across professional groups and care transitions.
- Variation in pediatric formulations and medication concentrations.
- Electronic-system limitations, inappropriate defaults, and alert fatigue.
- Insufficient time for medication education and competency assessment.
- Variation in local policies and resources between hospitals.
- Difficulty measuring medication-safety outcomes consistently across institutions.

Implementation strategies should therefore be adapted to local staffing, patient volume, medication risk, technology infrastructure, and institutional priorities. A phased approach may begin with high-risk wards or medication classes and expand after evaluating outcomes.

15. Recommendations

- Integrate clinical pharmacists into pediatric multidisciplinary teams and medication-safety committees.
- Provide timely pharmacist access for complex or high-risk medication questions.
- Use standardized pediatric formularies, concentrations, dose limits, and preparation procedures.
- Record patient weight in kilograms and ensure that the current weight is used for weight-based dosing.
- Implement structured medication reconciliation at admission, transfers, and discharge.
- Develop pharmacist–nurse consultation pathways for dose, dilution, compatibility, and monitoring questions.
- Use barcode medication administration and smart infusion technology where appropriate.
- Use independent verification for selected high-alert medicines according to institutional policy.
- Reduce interruptions during medication preparation and administration.
- Provide regular competency-based education for pediatric nurses and pharmacists.
- Encourage non-punitive reporting of errors and near misses.
- Review medication incidents for system-level learning and corrective action.
- Provide structured caregiver education and teach-back before discharge.
- Track process and outcome indicators to evaluate whether interventions are improving medication safety.

16. Potential Medication-Safety Indicators

Institutions implementing pharmacist-supported pediatric medication-safety programs should define measurable indicators. Process measures can include the proportion of admissions receiving medication reconciliation, the proportion of selected high-alert orders reviewed by a pharmacist, and completion of required independent checks. Outcome measures may include medication-error rates, near-miss rates, preventable adverse drug events, and medication-related readmissions. Balancing measures, such as pharmacist workload and alert burden, should also be considered.

Indicator	Example measurement approach
Medication reconciliation	Percentage of eligible pediatric admissions with documented reconciliation
Pharmacist intervention	Number and type of clinically relevant medication interventions
High-alert review	Percentage of eligible high-alert orders receiving required review/check
Medication errors	Errors per defined medication-use volume or patient-days
Near misses	Reported near misses by medication-use stage
Preventable adverse events	Number of preventable medication-related patient harms
Education	Percentage of relevant staff completing competency assessment

17. Limitations

This manuscript is a narrative review and is not a systematic review or meta-analysis. The included literature varies in design, population, intervention, healthcare setting, and outcome definition. Consequently, findings should be interpreted within the context of local medication systems, staffing models, regulatory requirements, and institutional policies. The figures are conceptual models developed for this manuscript and are not reproductions of

individual published figures. Additional systematic evidence may be required before specific interventions are generalized across all pediatric settings.

18. Conclusion

Clinical pharmacists can provide a valuable medication-safety resource for pediatric nurses by supporting dose verification, medication reconciliation, interaction assessment, formulation selection, therapeutic monitoring, adverse drug reaction assessment, education, and real-time consultation. Pediatric nurses remain essential to bedside patient identification, medication preparation and administration, clinical observation, and documentation. The available evidence supports pharmacist involvement as one component of a broader medication-safety system rather than as a replacement for nursing or medical responsibilities.

A multilayered model that combines pharmacist expertise, nursing vigilance, standardized medication processes, high-alert safeguards, technology, caregiver education, and continuous learning provides multiple opportunities to detect errors before they cause harm. Strengthening pharmacist–nurse collaboration can therefore contribute to safer pediatric medication management, particularly when supported by appropriate staffing, accessible medication information, effective communication, and institutional commitment to a culture of safety.

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