Keeping Pediatric Patients Safe

Med errors are three times as likely to occur in infants and children than in adults. Up to one in four pediatric med orders results in an error, and just over 5% of pediatric inpatients may experience a med error.[1-3,5] About one-third of med errors in kids have the potential to cause serious harm.[9] Many aspects of pediatric med use (e.g., weight-based dosing, lack of commercially available dosage forms, complex calculations) pose safety challenges.[1-4] General safety strategies (e.g., tall man lettering) should always be used. In addition, regulatory and safety groups recommend maintaining current pediatric drug info resources, ensuring appropriate 24-hour coverage of pediatric pharmacy services, and including a pharmacist with pediatric training in oversight of technology (e.g., smart pumps, clinical content of electronic health records [EHRs]) and med use committees.[1,4] The following chart provides strategies to prevent med errors in pediatric patients in both inpatient and outpatient settings.

	Prevent ordering errors
	• Ensure that a medication and vaccine history is conducted for pediatric patients by a pediatric pharmacist, whenever possible.[1,9] o Use immunization information systems (US: www.cdc.gov/vaccines/programs/iis/contacts-locate-records.html; Canada: see your local provincial/territorial registry, where available) for vaccine histories.
	• Check that heights and weights are correct, and documented in metric units (e.g., kg) only.[1,6] o Patients should be weighed often (e.g., with new outpatient prescriptions, at inpatient admission [or within four hours of admission]).[4,6] o Ensure that weights are kept current (e.g., infants may require daily weights) during prolonged admissions and with chronic meds.
	• Use only metric units when ordering and giving directions for pediatric medications (e.g., mL instead of teaspoons).[1,8]
	• Ensure that pediatric doses are ordered as dose per weight (e.g., mg/kg) rather than just the total dose.[4,8,9]
	• Standardize and limit the number of concentrations of meds for pediatric patients, especially high-alert meds.[4] o Avoid ordering nonstandard concentrations. (You can access a list of national standardized concentrations online.)
	• Avoid verbal orders whenever possible.[1]
	• For handwritten orders, avoid the use of naked decimals (e.g., .1) or trailing zeros (e.g., 1.0) to prevent ten-fold dosing errors.[5,9]
	• Inquire about adding weight-specific and age-specific dosing alerts to your EHR, if they aren't already being used.[1,4,5]

	Prevent dosing errors
	• Ensure that parents or caregivers understand all administration instructions, including which measuring device to use and how to measure the dose of liquid medications.[11]
	• Be aware of general age definitions used in pediatrics, which is commonly described as patients from birth to 18 years:[8] o a preterm neonate is born at <37 weeks gestation. o a neonate is <1 month old. o an infant is 1 month to 1 year old. o a child is 1 to 11 years old. o an adolescent is 12 to 18 years old.
	• Clarify if your EHR's reference ranges for vital signs and labs default to adult values for all patients. If so, ask if these can be adjusted to normal ranges for pediatric patients, when appropriate.[8] o As a rule of thumb, pediatric respiratory and pulse rates are higher than adults, blood pressure is lower than adults, and body temperatures are the same.[8]
	• Use an appropriate drug reference for premature babies and neonates. Examples include *NeoFax* and *Pediatric & Neonatal Dosage Handbook*. Don't rely on adult drug information references for these patients.
	• Use weight-based dosing for pediatric patients. But most pediatric doses should be capped at adult doses, even if a pediatric patient's weight-based dose is higher than an adult dose.[8,9] o Reassess chronic med doses frequently, as a patient's height and weight increase.[8]
	• Stay alert for mix-ups between units when calculating doses, such as mg/kg/DAY and mg/kg/DOSE.[8,9]
	• Stay alert for confusion with combination meds. For example: o piperacillin/tazobactam mg/kg doses for pediatric patients are based only on the piperacillin component. o amoxicillin/clavulanic acid products come with the components in different ratios that impact dosing frequency.
	• Ensure dose volumes are appropriate. For example, for IM injections, use a max of 0.5 mL in neonates and a max of 1 to 2 mL in children.[10] o If needed, divide doses between multiple syringes to avoid exceeding the max volume for a single injection.[10]
	• Use (and ensure your EHR is using) a pediatric equation (e.g., Schwartz, Bedside Schwartz) to assess kidney function. o Avoid using adult equations, which can overestimate in pediatric patients.[9] o Small changes in serum creatinine can be more significant in pediatric patients than in adults.[8]

	Prevent compounding errors
	• Stock commercially available products for pediatric patients when they're available, to avoid the need for compounding.[1,4]
	• Stick to standardized concentrations for liquid meds (orals and injectables), whether they're commercially available or compounded.[1] o Example: The recommended concentration for compounded atenolol oral liquid is 2 mg/mL.[7]
	• When compounded meds are necessary, ensure that the pharmacy compounds them. Avoid having parents, caregivers, nurses, or others compound pediatric meds.[1]
	• Separate compounding of pediatric and adult doses.[4] o Example: Avoid prepping adult and neonatal parenteral nutrition in the same IV hood at the same time.
	Prevent dispensing and administration errors
	• Store adult and pediatric meds separately, whenever possible.[4] o Avoid stocking adult concentrations of meds on pediatric patient care units such as in automated dispensing cabinets.[4,9] o Example: Stock pediatric strengths of injectable vitamin K (1 mg/0.5 mL) instead of adult strengths of vitamin K (10 mg/mL) in automated dispensing cabinets in neonatal patient care areas.
	• Dispense patient-specific doses for pediatric patients whenever possible, and minimize necessary manipulation (e.g., splitting tablets) prior to administration.[1,2,4,5,9] o If manipulation is necessary after a med is dispensed, provide clear instructions.[5]
	• Ensure inpatient unit-dose packages have readable bar codes for scanning prior to administration.[1,2,4]
	• Dispense oral liquids in oral syringes to reduce the risk of accidental injection.[4,6]
	• Ensure your hospital has a policy on in-house use of insulin pumps.[1]
	• Ensure smart pumps are programmed with appropriate dose limits and hard stops for pediatric patients, and that libraries are maintained and reviewed at least once a year.[1,3,5,9] o Advocate for syringe pumps or modules in your hospital for accurate administration of very small volumes such as <0.1 mL/h.[9]
	• Avoid workarounds with bar-code scanning during med prep and administration.[1] Help identify and prevent issues such as difficulty scanning bar codes on labels on smaller med packaging, etc.[1]
	• Make sure oral syringes are available on patient care units in case an oral liquid dose would need to be drawn up by a nurse or other clinician.[4,6]
	• Recommend labeling IV lines with the name of the med being infused to prevent mix-ups, especially if tubing has to be detached.[5]

	Use extra precautions in high-risk situations
	• Be aware that some medications and excipients may potentially be inappropriate in pediatric patients. o See the Pediatric Pharmacy Association's KIDS (**K**ey Potentially **I**nappropriate **D**rug**s**) list at https://www.jppt.org/doi/pdf/10.5863/1551-6776-25.3.175, for examples.
	• Keep in mind that children younger than five years old are most likely to experience med errors.[5]
	• Stay alert for age-appropriate dosing in areas where both pediatric and adult patients might be treated (e.g., outpatient pharmacies, perioperative areas, emergency department).[4,5] o Ensure high-risk meds (e.g., insulin, opioids) are not able to be auto verified for pediatric patients.
	• Keep in mind that intensive care units (e.g., neonatal ICU, pediatric ICU) are high-risk areas for medication errors.[5]
	• Be aware of meds that are most likely to be implicated in pediatric medication errors. o Example: Pediatric med errors seem most likely with antibiotics, IV fluids, opioids, and vaccines.[5] High-alert meds that seem most likely to be implicated in pediatric med errors include insulin, opioids, and parenteral nutrition.[5]
	Prevent errors in inpatient emergency situations
	• Keep meds for pediatric cardiac or respiratory arrests separate from adult meds.
	• Preprint weight-based dosing sheets for emergency meds for pediatric patients and have them available at bedside.[4]
	• Ensure teams such as CPR, emergency preparedness, rapid response, and trauma include a pediatric pharmacy representative.[1]
	• Ensure a pharmacist with pediatric training participates in pediatric codes, and has appropriate training (e.g., pediatric advanced life support).[1]
	Safely manage pain in pediatric patients
	• Assess pain using scales and tools specifically designed for the patient's age.[12] o Consider patient behavior, physiologic measures, facial expressions, parental assessment, and patient self-report.[12]
	• Encourage parents/caregivers to try non-med pain relief strategies: distractions (e.g., videos, movies, games); repositioning, rocking, or stroking the child; or singing to them or providing soft music.[13] • See our checklist, *Vaccine Administration Strategies*, for more non-med ways to minimize injection pain.
	• Avoid topical benzocaine-containing products for teething pain, due to methemoglobinemia risk. • Suggest using a cool teething ring or cool cloth to chew on for teething pain.

	Safely manage pain in pediatric patients, continued
	• Choose either ibuprofen or acetaminophen for safe and effective management of pediatric pain.[14-16] • Consider ibuprofen over acetaminophen for better efficacy, especially for acute pain, musculoskeletal trauma, headache, tooth extraction, migraine, otitis media.[17-20] • Consider the combination of ibuprofen and acetaminophen for pain with dental extraction or tonsillectomy.[20] However, be aware that there are little data showing that alternating acetaminophen and ibuprofen is more effective or safer than monotherapy most pediatric pain.[15,21]
	• Use strong opioids (e.g., morphine) appropriately, when non-opioids are not enough (e.g., severe pain).[12,24] • For increased safety and equal efficacy: o Choose ibuprofen over opioids as initial pain management for pediatric orthopedic injuries.[22] o Consider ibuprofen plus acetaminophen over morphine plus acetaminophen in children post-tonsillectomy/adenoidectomy.[23] • Consider using a non-opioid with an opioid to reduce the amount of opioid needed.[12,24]
	• If an opioid is prescribed, educate parents to recognize signs of trouble that require emergency medical treatment (e.g., excessive sleepiness, confusion, difficulty or noisy breathing, respiratory pauses during sleep).[25,26]
	• **Avoid codeine or tramadol** in pediatric patients due to the risk of severe respiratory depression and case reports of death (codeine).[27-31,38] • Be aware that tramadol and codeine are metabolized to active metabolites (O-desmethyltramadol and morphine, respectively).[30,38] o **Ultrarapid 2D6 metabolizers** quickly achieve higher than normal levels of active metabolites.[28,38,41] o Tramadol and codeine may provide inadequate analgesia in **poor CYP2D6 metabolizers**.[25]
	• Be familiar with the contraindications and labeling recommendations of **codeine**: o Codeine is contraindicated in children <12 years and <18 years after tonsillectomy and/or adenoidectomy.[31-33] o **US labeling** recommends against codeine use in children between 12 and 18 years with increased risk of respiratory depression (e.g., obesity, obstructive sleep apnea, severe lung disease).[31,34] o **The American Academy of Pediatrics and Canadian labeling** recommends against codeine in all children <18 years.[30,32,35] o Be aware that OTC codeine-containing cough meds are not indicated and should not be recommended for patients <18 years.[36] o These contraindications/warnings also apply to dihydrocodeine (US only, found in combination products [e.g., *Trezix*]).[31,37]
	• Be familiar with the contraindications and labeling recommendations of **tramadol**: o Tramadol is contraindicated in children <12 years, and <18 years after tonsillectomy and/or adenoidectomy.[39,40] o Labeling recommends tramadol should also be avoided in children 12 to 18 years who have risk factors for respiratory depression (e.g., obesity, obstructive sleep apnea, severe lung disease, neuromuscular disease).[39,40] o **Per Canadian labeling,** tramadol is not recommended for use in all children <18 years of age.[40]

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Cite this document as follows: **Clinical Resource,** ***Keeping Pediatric Patients Safe. Pharmacist's Letter/Pharmacy Technician's Letter/Prescriber's Letter.*** **June 2023. [390616]**