Pediatric Medication Safety across the Continuum of Care

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July 28, 2009
Objectives

- List vulnerabilities in the medication use process that occur as a pediatric patient transitions between different levels of care
- Describe strategies used to limit pediatric medication errors
- Describe methods in which pharmacists can proactively prevent pediatric medication errors
Background

- Pediatric medication orders are more prone to errors than adult orders
  - Doses are not standard
  - Math errors can occur when calculating the dose
  - Suspensions often have to be compounded
  - Tablets may have to be cut
  - Dilutions need to be made to make amounts that are measurable
  - However, children have less tolerance for errors
**Definition of a child is based on age**

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preemie</td>
<td>&lt;37 weeks gestation (gestational age is the time from conception until birth)</td>
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<tr>
<td>Full Term</td>
<td>37-42 weeks gestation</td>
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<tr>
<td>Neonate</td>
<td>First 30 days of life</td>
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<tr>
<td>Infant</td>
<td>First year of life</td>
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<tr>
<td>Toddler</td>
<td>From 1 to 2 years of life</td>
</tr>
<tr>
<td>Child</td>
<td>Age 3-11</td>
</tr>
<tr>
<td>Adolescent</td>
<td>Age 12 on</td>
</tr>
</tbody>
</table>
Pharmacokinetic considerations

Absorption

- Gastrointestinal
  - pH: gastric acid output maturity is related to postnatal age and approaches adult values by 3 months of age
  - GI motility: neonates have a delay in gastric emptying time, adult values are reached at 6-8 months of age
  - GI contents: develops rapidly within the first year of life, underdeveloped flora can increase absorption of drugs (digoxin)

- Percutaneous
  - Absorption is increased in the newborn due to immature epidermal barrier and increased skin hydration during the first 2 weeks of life
  - Increased surface area to weight ratio increases percutaneous absorption
Pharmacokinetic considerations

- **Distribution**
  - **Body Water**
    - Neonates are 85% body water compared to 55% in adults
    - Vd is increased for drugs that distribute to aqueous parts of the body (aminoglycosides)
  - **Percutaneous**
    - Total body fat is 1% in a 29 wk neonate
    - Total body fat is 15% in a full term baby
    - Total body fat is 20-25% in 2yo toddler
    - Fat content tends to increase between 5-10 years followed by a decrease through age 17
    - Vd is increased for drugs that are highly lipid soluble
  - **Plasma Protein Binding**
    - Neonates have decreased plasma protein which increases unbound concentrations (ex. Phenytoin may only be 70% bound in a neonate compared to 90% in an adult)
  - **Blood Brain Barrier**
    - An immature BBB due to incomplete CNS myelination results in increased CNS drug penetration
Pharmacokinetic considerations

- **Metabolism**
  - Neonates have decreased activity of many enzyme pathways, that is why drug dosages are decreased for neonates
    - P450 activity is 50% of adult levels
    - Decreased hydroxylation activity leads to decreased metabolism of phenobarbital, phenytoin, lidocaine
    - Children have increased hepatic enzyme activity between 2-4 years of age. This may be due to large liver size compared to total body weight. Doses are increased during this time for theophylline, phenytoin, and phenobarbital.
Pharmacokinetic considerations:

- **Excretion**
  - At birth, kidney function is decreased, GFR matures first, then tubular secretion, and lastly tubular reabsorption.
  - GFR at birth is 2-4 ml/min, which is 0.5% of an adult level.
  - After the first week of life, a significant increase in GFR is seen, this explains why recommended doses change after 7 days of life.
  - At 1 year, GFR reaches 70 ml/min/m².
  - Around 2-24 month of age, GFR and tubular secretion are more mature than tubular reabsorption and cause an increased renal clearance of drugs (digoxin).
National Spotlight

- Heparin Overdose in Quaid twins

http://www.oprah.com/media/20090219-tows-dennis-quaid
National Spotlight

- Dennis Quaid recently made a trip back to the Cedars-Sinai Medical Center for a segment with Oprah Winfrey.
- Quaid campaign for better labelling systems
  - Keynote speaker for next ASHP Midyear Clinical Meeting
Recent article published in Pediatrics

Cardiovascular Medication Errors in Children (Pediatrics 2009;124:324-332)

- Reviewed cardiovascular medication error reports from 2003-2004 in MEDMARX database for pt <18yrs
- 147 facilities (mostly community hospitals) reported 821 reports
- Mean patient age was 4yr
- Drug administration (improper dosing) implicated most commonly, human error in 74% of causes
- 5% near misses, 91% errors without harm, 4% harmful errors, no reported fatalities
- Infants <1yr accounted for 50% of reports
- Recommended standard concentrations, max doses, CPOE linked to MAR, pharmacy based dilutions to limit calculation errors
Joint Commission’s
Sentinel Event Alert

- April 11, 2008 “Preventing Pediatric Medication Errors”

- Risk reduction strategies
  - Develop and maintain pediatric formulary
  - Standardize protocol start dates
  - Limit concentrations and dosage strengths
  - Ensure accurate transitions between home and hospital for compounded meds
  - Use oral syringes to administer oral medications
Risk reduction strategies

- Assign pediatrics practitioner to med management committees
- Ready access to peds specific information
- Appropriate orientation to peds services
- Dosage calculation sheets for critical care patients
- Preprinted med order forms
- Peds satellite or assign pharmacists with peds experience to peds units
  - Keeps peds meds away from adult meds
Risk reduction strategies

- Ensure accuracy of technology used for IV solutions (ex. TPNs)
- Enable dose and dose range checking software
- ADCs meds should not be released without appropriate pharmacist review
- Appropriate education about smart pump technology
- Use consistent physiological monitoring while children are under sedation during office-based procedures
- Develop bar-coding technology with pediatric capability
JCAHO’s NPSGs

- **NPSG.02.02.01**
  - There is a standardized list of abbreviations, acronyms, symbols, and dose designations that are not to be used throughout the organization

- **3-Improve the safety of using medications**
  - Goal 3b: Standardize and limit the number of drug concentrations available in the organization
  - Managing Look Alike, Sound Alike Medications (revised NPSG.03.03.01)
  - Labeling Medications (revised NPSG.03.04.01)
  - Reducing Harm from Anticoagulation Therapy (revised NPSG.03.05.01)

- **8-Accurately and completely reconcile medications across the continuum of care.**
Guidelines for Preventing Medication Errors in Pediatrics

- Collaborative effort between ISMP and PPAG
- Published in 2001, but still considered one of the best publications available on the topic of prevention of pedsmed errors
- Provides strategies to consider for the development of
  - Organizational systems
  - Educational systems
  - Manufacturing and regulatory systems
Challenges in the Inpatient Setting

- Complex orders
  - Weight-based dosing
  - Wide range of doses
  - Dose rounding challenges
  - Lack of pediatric formulations
Weight-based dosing

- Doses for patients are customized
  - Drugs
  - Fluids (chance for fluid-overload from meds)
- Requires accurate calculations
  - Dry weight
  - Actual weight
- If not careful, can result in doses that exceed adult doses
Wide Range of Doses

- Same drug can have different dose ranges according to indication (Vasopressin for DI and shock)
  - Very difficult to get computer systems to differentiate, thus hard to put in alerts
- Same drug can be ordered in different ways in different settings (Fentanyl in mcg/kg/hr or mcg/kg/min)
- Often dosing is not found in typical references
  - Off-label use
- Dosing charts can be very helpful to nursing
Dose Rounding

- Same medication can be administered by syringe or infusion bag
  - Decimal capabilities differ accordingly
  - Often, computer systems have a set number of decimal points, hard to differentiate between NICU doses and doses for older patients
    - Example: chlorothiazide dosed at 1.5mg/kg/day for a 22kg child results in a 33.04mg dose ordered- computer system converts to pounds and then back to kilograms.
Lack of Pediatric Formulations

- Adult capsules/tablets are often manipulated into solutions for pediatric use
- Solution concentrations can differ, leading to prescribing errors when volume doses are written
- Use is often off-label, so finding dosing information can be challenging
Inpatient Strategies

- CPOE
- Bar-coding
- Smart Pump libraries
Table 2. Functions important to the “ideal” computer order entry system (Guidelines for preventing medication errors in pediatrics)

- Prescriber order entry for verification by nurse and pharmacist
- Computer-generated medication administration records from a common data base shared with the pharmacy and the prescriber
- For each patient, lists of current medications that are readily accessible by caregivers
- Two-way interface between the pharmacy and other institutional systems (e.g., laboratory, admission and discharge, clinical records)
- Access to historical patient data (i.e., archived information)
Functions important to the “ideal” computer order entry system (cont)

- Ability to calculate and verify appropriate height-weight range and dosage for patient
- Access to vital patient and drug information directly from order entry, medication profile, and medication administration screens
- Ability of system to use patient and drug information to provide unsolicited information during order entry to reduce potential for adverse drug events (e.g., drug interactions, contraindications, excessive doses, allergies). This should be part of a comprehensive decision support program.
- Provide a forced function by limiting the route and frequency by which a drug is ordered
Barcoding

- **Excellent method to catch errors right before administration**

- **Joint commission sentinel event alert**
  - Providers are encouraged to develop bar-coding technology with pediatric capability. Potential errors should be carefully considered while adapting this technology to pediatric processes and systems (must be able to provide readable code for small-volume patient-specific dose labels)

- **Practical guide to bar coding for patient medication safety** *(Am J Health-Syst Pharm 2003;60:768-79)*
  - Written in collaboration with ISMP
Smart Pump Technology

- Excellent method to catch errors right before administration
- Implementation requires standardization of concentrations and dosing for optimal drug library build
- Best implementation includes routine review of use data (override data) to look for opportunities to further improve safety
Transition of Care: Inpatient Discharge

- 2008 National Patient Safety Goal regarding medication reconciliation
  - “Accurately and completely reconcile patient medications across the continuum of care (including the outpatient setting)

- Christiansen et al, recently published article “Impact of a Prescription Review Program on the Accuracy and Safety of Discharge Prescriptions in a Pediatric Hospital Setting”
Prescription Review Program

- Time of patient discharge, pharmacy-coordinated discharge medication counseling and prescription review have reduced discharge prescribing errors

- Voirol et al reported that a discharge medication service offered by a pediatric pharmacy team positively impacted patient education and adherence

- Sexton surveyed pharmacists in UK to assess involvement of pharmacy services at discharge
  - Verification of discharge prescriptions occurred in 45% of hospitals surveyed

- Stowasser et al evaluated impact of a pharmacy medication liaison service at discharge
  - Fewer subsequent health care visits
  - Reduction in number of readmissions to the hospital
Objective: Evaluate the ability of a pharmacist discharge prescription review program to enhance the accuracy and safety of prescriptions written for pediatric patients as they are discharged from the hospital.

Study Design:
- Discharge review program
- Over a 30-day period
- All discharge prescriptions were given to a pediatric pharmacist to review prior to patient discharge
- Each prescription was reviewed
- Interventions needed to clarify the prescription were documented
Table 1. Items that were assessed by a pharmacist in reviewing a discharge prescription

<table>
<thead>
<tr>
<th>Item</th>
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<tbody>
<tr>
<td>Date of Birth (absent or incorrect)</td>
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<tr>
<td>Weight (absent or incorrect)</td>
</tr>
<tr>
<td>Medication Name (absent or incorrect)</td>
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<tr>
<td>Medication Strength (absent or incorrect)</td>
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<tr>
<td>Medication Formulation (absent or incorrect)</td>
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<tr>
<td>Medication Dose (absent or incorrect)</td>
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<tr>
<td>Weight-based Dosing (absent or incorrect)</td>
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<tr>
<td>Mathematical Error</td>
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<tr>
<td>Instructions to the pharmacist (absent or incomplete)</td>
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<tr>
<td>Incorrect Quantity (absent or incorrect)</td>
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<tr>
<td>Medication Omission</td>
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<tr>
<td>Contraindication (e.g., allergy, age, organ function)</td>
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<tr>
<td>Drug Interaction</td>
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<tr>
<td>Medication without Indication</td>
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<tr>
<td>Other</td>
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## Patient Demographics

N = 24  
Ave. # scripts per patient = 3.1

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<thead>
<tr>
<th>Age</th>
<th>%</th>
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<tbody>
<tr>
<td>0-1 yrs</td>
<td>12.5</td>
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<tr>
<td>1-5 yrs</td>
<td>33.3</td>
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<td>6-10 yrs</td>
<td>29.1</td>
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<tr>
<td>11-15 yrs</td>
<td>12.5</td>
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<tr>
<td>16-18 yrs</td>
<td>0</td>
</tr>
<tr>
<td>≥ 18 yrs</td>
<td>4</td>
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<table>
<thead>
<tr>
<th>Gender</th>
<th>%</th>
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<tbody>
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<td>Male</td>
<td>50</td>
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<tr>
<td>Female</td>
<td>50</td>
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<table>
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<tr>
<th>Weight (kg)</th>
<th>%</th>
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</thead>
<tbody>
<tr>
<td>0-10</td>
<td>12.5</td>
</tr>
<tr>
<td>10.1-20</td>
<td>29.1</td>
</tr>
<tr>
<td>20.1-30</td>
<td>12.5</td>
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<tr>
<td>30.1-40</td>
<td>12.5</td>
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<tr>
<td>≥ 40.1</td>
<td>25</td>
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</table>

<table>
<thead>
<tr>
<th>Location</th>
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<tbody>
<tr>
<td>General Pediatrics</td>
<td>87.5</td>
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<tr>
<td>Pediatric ICU</td>
<td>12.5</td>
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</table>

<table>
<thead>
<tr>
<th>Diagnosis/ Reason for Admission</th>
<th>%</th>
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<tbody>
<tr>
<td>Asthma</td>
<td>41.6</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>25</td>
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<tr>
<td>Infection/Fever</td>
<td>16.7</td>
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<tr>
<td>Other</td>
<td>12.5</td>
</tr>
</tbody>
</table>
Results

- 74 discharge prescriptions for 24 patients were reviewed by a pediatric clinical pharmacist
- Average number: 3 per patient (1-9 prescription range)
- 81% contained at least one error
- 101 prescribing errors were detected and documented
  - Majority pertaining to pertinent patient info, dose calculations, specific drug information
  - Based on Pharmacy-OneSource Quantifi method of estimation, $7670 cost savings
Type and Number of Interventions

Types of Interventions

- No Date of Birth
- Wrong or No Weight
- No Weight-Based Dosing
- Incorrect Dose
- Incorrect Formulation
- Wrong Strength
- SIG
- Incomplete
- Medication Omission
- Wrong Drug
- Math Error
- Incorrect Quantity

Number of Interventions

Nemours. Alfred I. duPont Hospital for Children
Results

- Specific examples:
  - Prescription written for Dornase Alfa instead of intended Budesonide
  - Amoxicillin prescription with calculation error resulting in a 5-fold overdose
  - Omission of a discharge prescription for Azithromycin for the remainder of a 5-day course of therapy
Conclusions

- Discharge prescription review program allowed the pediatric clinical pharmacists to make interventions on the majority of prescriptions reviewed.
- Review resulted in the correction of several dosing and drug selection errors that may have resulted in sub-optimal dosing or possible detrimental health-related consequences.
- Suggestions: further education of pediatric medical staff, use of standardized, pre-printed pediatric discharge prescriptions.
Discharge Process

- **ISMP recommends**
  - Establish criteria for an automatic consult to a pharmacist to educate hospitalized patients at risk for med errors (e.g., complex medication regimens, and patients being discharged on five or more prescription drugs).
  - Pharmacists can provide details about
    - Medication purpose
    - How to take
    - When to take
    - What to do if medication is missed
MedActionPlan for Pediatrics version 5.0

Supported by

Astellas TRANSPLANT
Advancing the Future of Transplantation

This program has been endorsed by the International Transplant Nurses Society (ITNS)

INTERNATIONAL TRANSPLANT NURSES SOCIETY

"We have recently started using MedActionPlan.com for our newly transplanted patients."

MedActionPlan shows schedules of medications, complete with pill images, time, purpose, and route of administration. Schedules print in regular-print, large-font, and wallet size. Prescription medications listed are marketed in the United States.

This FREE web-based program will:

- Empower patients and caregivers to take a proactive role in their healthcare
- Help your facility satisfy the Joint Commission 2009 National Patient Safety Goals
- Improve patient compliance through better understanding of medication therapy

Other features available with MedActionPlan:

- Route of Administration included for each medication
- Taper schedule—quickly create complex tapering schedules
- Anticoagulation schedule—prevent dosing errors
- Flexible new dosing options—includes fractional dosing
Weekly Med Checklist

It is important to bring this completed list with you to each healthcare or dental visit.

**Peters, Stephan T**  DOB: 01-06-1995  MRN: 13555
Allergies: **No Known Drug Allergies (NKDA)**

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<th>Time</th>
<th>Medication</th>
<th>Dose</th>
<th>SUN</th>
<th>MON</th>
<th>TUES</th>
<th>WED</th>
<th>THUR</th>
<th>FRI</th>
<th>SAT</th>
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<td>Myfortic®</td>
<td>2 Tablet(s)</td>
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<td></td>
<td>(Mycophenolate sodium)</td>
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<td>Prevents rejection</td>
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<td>Prednisone</td>
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<td>Valcyte®</td>
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<td>Treats/prevents viral infections</td>
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<td>Clotrimazole</td>
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<td></td>
<td>10mg</td>
<td>Treats/prevents fungal infections</td>
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<td>(Amlodipine)</td>
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<td>Niferex®</td>
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<td></td>
<td>30mg</td>
<td>Treats/prevents stomach ulcer/heartburn</td>
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Revised by: Elora Hilmas

7/13/2009 4:05:00 PM
Pediatric Medication Error Prevention in the Community Setting

- Tara L. Smith, PharmD & Marrolyn L. Simmons, PharmD

Potential medication dosing errors in outpatient pediatrics (J Pediatrics 2005;147:761-7)

- Potential overdoses and under-doses were assessed in 1,933 children
  - 15% had potential medication errors (8% overdosed, 7% underdosed)
  - Overall, errors greatest in patients <35kg
  - Analgesic medications were most likely to be overdosed, anticonvulsant medications most likely to be underdosed, 3x increase in potential overdose rates among “as needed” medications.

- Looked at rates and types of ADEs in 6 peds outpatient clinics classified as preventable or non-preventable
  - 1,788 patients with 283 having ADE
  - 57% preventable
  - 70% of ADE associated with administration
  - Show a need for increased patient/parent counseling
Strategies to prevent outpatient ADEs

- Oral syringe considered most accurate device for measurement of liquid medications
  - Tip should be placed near the back inside cheek and plunger should be slowly depressed (avoid admin to back of the mouth)

- Rx Medibottle is shaped like a standard infant bottle with an inner sleeve to hold 3 or 5ml oral syringe
  - Can’t be used with clarithromycin or tylenol

http://www.medibottle.com/
Strategies to prevent outpatient ADEs

- **CPOE-e-prescribing**
  - Electronic prescribing reduced prescribing errors in a pediatric renal outpatient clinic (J Pediatrics 2008;152:214-18.)
    - 520 patients prescribed 2,242 medication, with 20 medications being excluded due to incomplete info
      - Overall prescribing errors decreased from 77.4 to 4.8%
      - # of orders missing essential information decreased from 73.3 to 12.3%
      - # of error free visits to the clinic increased from 21-90%
      - Incidence of incorrect drug ordered increased during study
Strategies to prevent outpatient ADEs

- Patients/caregivers should be counseled and the name/purpose/route/dose/frequency/potential adverse effects/ways to manage adverse effects verified
- Appropriate measuring tools should be provided and instructions given on how to appropriately use them
- Current, pediatric focused medication references should be available in all outpatient pharmacies
- Separation of look-alike, sound-alike medications
- Counseling about OTC medications
- Education to caregivers to store medications out of reach of children with child-proof caps
Empowering Parents

Josie was 18 months old. In January of 2001, Josie was admitted to Johns Hopkins after suffering first and second degree burns from climbing into a hot bath. She healed well and within weeks was scheduled for release. Two days before she was to return home, she died of severe dehydration and misused narcotics.
Medication Safety Resources

- FDA website about medications in the home
  - www.fda.gov/medsinmyhome
- Pediatric pharmacy advocacy committee (PPAG) Parents Section: Kids Meds
  - www.ppag.org
- CDC parent website
  - www.cdc.gov/ncidod/dhqp/ps_forParents.html
- Community pharmacy medication safety assessment tool
  - www.ismp.org/Survey/NewMssacap/Index.asp
  - www.ismp.org/Tools/communitySafetyProgram.asp
# What Can Pharmacists Do?

<table>
<thead>
<tr>
<th>Table 7. Recommendations to assist pharmacists in preventing medication errors (Guidelines for preventing medication errors in pediatrics)</th>
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<tbody>
<tr>
<td>• Be available regularly in patient-care areas</td>
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<td>– Source of information to other healthcare professionals for appropriate use of medications.</td>
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<tr>
<td>• Review the original medication order prior to dispensing the medication</td>
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<tr>
<td>– Screening for prescribing errors, allergies, drug and disease interactions, correct dose, indication.</td>
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<tr>
<td>– Dosage calculations should be checked against acceptable dosage ranges.</td>
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<tr>
<td>– Prescriber should be contacted for clarification prior to dispensing the medication.</td>
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<tr>
<td>– Compare the original order with the label and the product being dispensed.</td>
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<tr>
<td>• Research or request information from the prescriber regarding new or unfamiliar medications, uses, or doses.</td>
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<tr>
<td>• Dispense medications for individual patients in a pre-measured, ready-to-administer form</td>
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<tr>
<td>– When this is not possible, auxiliary labels should be used to clearly communicate preparation instructions prior to administration.</td>
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<tr>
<td>– Auxiliary labels should also be used in other situations when they will clearly aid in the prevention of errors.</td>
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Recommendations to assist pharmacists in preventing medication errors (cont)

- Carefully document products used and steps and calculations performed in the preparation or manufacture of a drug product
  - Primarily for high alert drugs, an independent double-check be used for all calculations.

- Carefully document all verbal orders received from prescribers as new orders, renewals, or corrections to a new order
  - Should be done immediately after receiving and carefully verifying the order by repeating it back to the prescriber, spelling the drug name and any other word that might have been misheard and restating numbers that may be confused, such as those in the teens.

- Ensure that medications arrive in the patient-care area in a timely fashion following the receipt of the order
  - If medication delivery will be delayed for any reason, the nurse caring for the patient should be notified of the delay and the reason.

- Counsel patients and their caregivers
  - Verify that they understand the name, purpose, route of administration, dose, dose frequency, potential adverse effects, and how adverse effects might be managed for each medication.
Conclusions

- Pediatric Medication Errors and have a substantial impact on patient morbidity and mortality
- There are several opportunities as pediatric patients transition through levels of care to improve their safety
- Pharmacist are uniquely positioned to positively impact safety outcomes
Questions?
References


References


- Josie King Foundation.  www.josieking.org

