# Medication Safety

*Best Practices and Proposals to Prevent Errors*

Alan Mancini, R.Ph.
Clinical Assistant Professor, UIC College of Pharmacy

## Conflict of Interest

The speaker has no relevant financial relationships or conflicts of interest to report.

2

## Objectives

- Describe common causes of medication errors
- Describe those situations that create the conditions for medication errors to take place
- Name three practical tips to preclude medication errors
- List three best practice goals

3

## Medication Safety

*Discussion Points*

- Background and definitions
- What are the errors?
- Why do errors happen?
- Best Practices
- Proposals

4

## Medication Safety

*Relevance*

- Why do I need to know this?
  - First, do no harm
    - Don't hurt anyone
  - As a member of the health care team, you are responsible for public health and safety
  - Provide the right drug, to the right patient, at the right time, right the first time
  - Understand and be aware of those circumstances that cause errors and how to avoid them
  - As pharmacists responsibilities expand, pharmacy technicians need to be more aware of the significance and causes of medication errors and to recognize their role in preventing those errors (5)

5

## Medical Errors

*Background*

- Medical errors are an unintended act of either omission or commission that does not achieve its intended outcome, an error of execution, an error in planning or a deviation from the care process that may cause patient harm. (1)
  - Patient harm from medical error can occur at the patient and/or system level
  - Medication safety (us) is part of the overall medical errors situation
  - Human error is inevitable. But we can understand and strive to reduce the frequency and consequences of error

6

## Medical Errors

- Impacts
  - Adverse reactions and outcomes
  - Serious reportable events (Joint Commission "Sentinel Events")
    - Injuries, death
  - Impacts from errors are more pronounced in neonates, pediatrics and the elderly
- Medical errors can be third leading cause of death in US (1)
  - Extrapolation of medical errors to 2013 US admissions: 252,000
  - Total 2013 US admissions: 13,416,020
- Community pharmacy error rates (2)
  - 1.5 to 4% of errors have potential to cause harm
    - Sounds low, but one big chain reported 856 mm Rx's filled in one year (3)
      - (856 million Rx's/year)(1% errors) = 8.6 million errors/year!
- Pharmacy errors are preventable

7

## Medication Errors

*Summary of Common Causes*

- Usually due to confluence of multiple simultaneous factors
  - Work environment
    - Busy, being rushed, no breaks/fatigue, interruptions, work place changes, stress, work flow process patterns, distractions, short cuts, facility layouts, training, multi-tasking, workload/staffing levels
  - Wrong orders and/or incorrect order entry/verification
  - Lack of simple, rugged, robust and reproducible standardized procedures
  - Calculation errors
  - Careless use of zeros and decimal points
  - Inappropriate use of abbreviations
  - Look-Alike / Sound-Alike drugs (LA/SA)
  - Compounding and drug preparation errors
  - Illegible handwriting
  - Computerized physician order entry (CPOE) errors
  - Transcription errors
  - Missing information
  - Wrong route of administration
  - Prescription labeling

8

## Medication Errors

*Summary of Most Common Factors by Pharmacists as Contributing to Error (4)*

- Too many telephone calls
- Overload; workload
- Too many patients
- Lack of concentration; distractions
- Staff shortage, inexperienced and/or temp staff
- No one available to double check
- Similar drug names
- Lack of time to counsel
- Illegible prescription
- Misinterpreted prescription

9

## High-Alert Medications (5)

- What are they?
  - High-alert medications are drugs that bear a heightened risk of causing significant patient harm when they are used in error.
  - Medication errors may not occur more commonly with high-alert medications, but the consequences of an error can be devastating

10

## High-Alert Medications

*Some Examples (8)*

- Narcotics/Opioids
- General anesthetics
- Cardioplegic solutions
- Neuromuscular blocking agents
- Adrenergic agonist and antagonist injectables
- Antithrombotic agents
- Chemotherapeutic agents
- Epidurals and intrathecals
- Radiocontrast IV agents
- Insulins
- Concentrated potassium chloride Injection
- Concentrated sodium chloride injections (> 0.9%)
- Concentrated dextrose injections ( > 20%)
- Potassium and sodium phosphate injections
- Nitroprusside injection
- EPINEPHrine subcutaneous injection

11

## High-Alert Medications (5 - 7)

- Insulin is a high-alert medication
- U-500 insulin is especially prone to medication errors
  - Higher concentration
  - Different dosing regimen
- A medication error with U-500 insulin can lead to a 5-fold overdose (relative to U-100 insulin)
  - Hypoglycemia and potentially death

12

## Leading Therapeutic Areas of Harmful Errors

*Summary of Reports to ISMP (9, 11)*

- Insulin errors
  - Contamination using insulin pens for multiple patients
    - 4,200 patients exposed in NY hospital (3/2014)
    - 3,000 patients exposed in CT hospital (5/2014)
  - Confusion with higher concentration insulins
    - Prescribing in syringe units rather than by dose
    - Dose conversion errors (calculations)
    - Using U-100 syringes for U-500 insulin
    - Mix-ups with U-200, U-300, U-500 insulin pens
  - U-500 HumaLIN-R vial mistaken for U-100 HumaLIN-R
  - "SSc" for "sliding scale" misinterpreted as "55cc"
  - Wrong dose due to incorrect blood glucose level
    - Confusing weight for blood glucose level
  - One patient died because 20 units of insulin was abbreviated as "20 U," but the "U" was mistaken for a "zero." As a result, a dose of 200 units of insulin was accidentally injected

13

## Leading Therapeutic Areas of Harmful Errors

*Summary of Reported to ISMP (5, 9)*

- Opioid errors
  - Inadequate patient assessment resulting in improper dosing
    - Age, weight, opioid-tolerance, comorbid conditions, concurrent sedatives/opioids
  - Incorrect dose conversion calculations – e.g., morphine to HYDROmorphone (7:1)
  - Inappropriate use of long-acting opioids in PCA
    - FentaNYL patches
      - Failure to remove old patches, multiple patches used, wrong dose, cutting patches when they shouldn't, improper disposal, opiate naïve people touching the patches
      - A man died after his wife mistakenly applied six fentaNYL transdermal patches to his skin at one time
  - Inadequate monitoring (pulse oximetry, sedation level)
  - Woman had heart attack and brain injury due to wrong morphine PCA dose = $2.75 million settlement (10)

14

## Leading Therapeutic Areas of Harmful Errors

*Summary of Reports to ISMP (9, 11)*

- Vaccines
  - Reported errors (in order): Influenza, DTaP-IPV, Hep-A, Tdap, HPV4, Hib, DTaP, Hep-B, Zoster, and MMRV
  - Confusion between which vaccines are for adults and which are for pediatrics and the related doses and timings
  - Confusion between single agent and multiple component products
  - Confusion and errors due to LA/SA between Tdap (tetanus, diphtheria, pertussis) and DTap (diphtheria, tetanus, pertussis)
  - *"People don't pay enough attention to vaccines; they're not drugs – right?"* - D. Rich, personal communication, ISMP

15

## Leading Therapeutic Areas of Harmful Errors

*Summary of Reports to ISMP (11)*

- Look-Alike/Sound-Alike (LA/SA) drug mix-ups
  - LA/SA drug mix-ups a frequent cause of serious patient harm
  - Common LA/SA issue is mix-ups between liposomal and conventional forms of the same drug (e.g., doxorubicin, amphotericin)
- Anticoagulants
  - Mix-ups with the novel/new anticoagulants
    - Order for "NoAC"; interpreted to mean no anticoagulant; physician meant "novel anticoagulant"; patient's anticoagulant was erroneously discontinued
- Others sources of problems
  - Drug shortage related, sterile compounding, computerized physician order entry errors (CPOE), wrong route of administration, calculations, wrong orders, IV compounder entry errors

16

## Look-Alikes/Sound-Alikes

*A Few Examples (13)*

| Drug Name | Confused Drug Name |
|---|---|
| acetaZOLAMIDE | acetoHEXAMIDE |
| Amicar | Omacor |
| Benadryl | benazepril |
| CeleBREX | CeleXA |
| CycloSERINE | CycloSPORINE |
| DACTINomycin | DAPTOmycin |
| Doxil | Paxil |
| Enjuvia | Januvia |
| ePHEDrine | EPINEPHrine |
| Fiornal | Fiorcet |

| Drug Name | Confused Drug Name |
|---|---|
| Flovent | Flonase |
| fluoxetine | loxapine |
| Glycotrol | Glucotrol |
| GlyBURIDE | glipizide |
| HumaLIN | Humalog |
| LamISIL | LaMICtal |
| Lantus | Lente |
| Metadate ER | Metadate CD |
| Miralax | Mirapex |
| Microzide | Maxzide and Micronase |

17

## Look-Alikes/Sound-Alikes

*A Few Examples (13)*

| Drug Name | Confused Drug Name |
|---|---|
| methadone | metolazone |
| misoprostol | mifepristone |
| niCARdipine | NIFEdipine |
| Neulasta | Nuedexta |
| OXcarbazepine | carBAMazepine |
| Patanol | Platinol |
| Percocet | Darvocet |
| Pilocar | Dilacor |
| Plavix | Paxil |
| prednisone | primidone |

| Drug Name | Confused Drug Name |
|---|---|
| probenecid | Procanbid |
| Provera | Proscar |
| RABEprazole | ARIPiprazole |
| Reminyl | Robinul |
| RisperiDONE | rOPINIRole |
| Tobradex | Tobrex |
| TOLBUTamide | TOLAZamide |
| Wellbutrin SR | Wellbutrin XL |
| Zantac | Xanax and ZyrTEC |
| Zolpidem | Zyloprim |

18

## Look-Alikes/Sound-Alikes
*A Few Examples (11)*


19

## Look-Alikes/Sound-Alikes
*A Few Examples (14)*



20

## Look-Alikes/Sound-Alikes
*A Few Examples (14)*


21

## Look-Alikes/Sound-Alikes
*A Few Examples (14)*


22

## Look-Alikes/Sound-Alikes
*A Few Examples (15)*


23

## Human Factors
*How and Why Do These Errors Happen? (16)*

- The mind accepts errors:

Aoccdrnig to rscheearch at Cmabridge Uinervtisy, it deosn't mttaer waht oredr the ltteers in a wrod are, the olny iprmtoent tihng is that the frist and lsat lteer be at the rhgit pclae. The rset can be a taotl mses and you can sitll raed it wouthit aporbelm. This is bcuseae the huamn mnid deos not raed ervy lteter by istlef, but the word as a wlohe.

24

## Human Factors
*How and Why Do These Errors Happen?* *(17)*

- The mind accepts errors:

Can you read this?

**Y0UR M1ND 15 R34D1NG 7H15**
**4U70M471C4LLY W17H0U7 3V3N**
**7H1NK1NG 4B0U7 17**

How about these drug names?

- **D0BUTAM1N3**
- **CLON4Z3P4M**
- **3P1N3PHR1N3**

25

## Human Factors
*How and Why Do These Errors Happen?*

- Read the following statement. What does it say? *(17)*

**BUAPMAGY FBRQP BATFS APF LQW**

26

## Human Factors
*How and Why Do These Errors Happen?* *(17)*

- Answer:

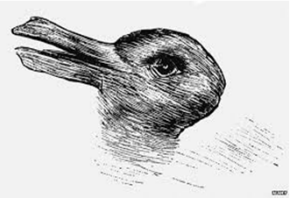
**BUAPMAGY FBRQP BATFS APF LQW**

- Human factors in errors
  - The human brain uses previous experience to fill in gaps, hence the incorrect conclusion that the statement was "pharmacy error rates are low"
  - Human cognitive processes, while adaptive in most contexts, can also promote – or fail to detect – errors

27

## Human Factors
*How and Why Do These Errors Happen?* *(18)*

- What do you see? Is this a rabbit or a duck?



28

## Human Factors
*How and Why Do These Errors Happen?* *(18)*

- It's either one!

- But we can't see both images at the same time! We switch between both images (aspect-switching).
- It's not what we see but how we think about what we are seeing

29

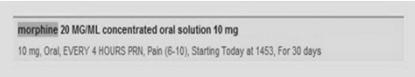
## Human Factors
*How and Why Do These Errors Happen?* *(17)*

- Confirmation bias
  - A type of selective thinking in which people select out information that is familiar or what they expect to see, rather than what is actually there.
- Confirmation bias increases the chances of medication errors
  - Many errors occur when practitioners, because of their familiarity with a certain product, see the product they believe it is rather than what the product actually is.

30

## Human Factors
*How and Why Do These Errors Happen?* (19)

- Confirmation bias
  - Order placed in electronic order system




  - Patient repeatedly received 20 mg doses
  - Dose was misread several times – complaints elevated to administration attention
    - Causes
      - The first number in blue letters after the word morphine is "20". The actual dose, 10 mg, comes after the "20 mg/mL concentrated oral solution".

31

## Abbreviations
*Joint Commission "Do Not Use" List* (20)

| Do Not Use | Potential Problem | Instead Use |
|---|---|---|
| U, u (unit) | Mistaken for "0" (zero), the number "4" or "cc" | Write "unit" |
| IU (International Unit) | Mistaken for "IV" or for the number "10" | Write "International Unit" |
| Q.D., QD, q.d., qd (daily) Q.O.D., QOD, q.o.d., qod (every other day) | Mistaken for each other | Write "daily"<br>Write "every other day" |
| MS<br>$MSO_4$ and $MgSO_4$ | Can mean "morphine sulfate" or "magnesium sulfate"; can be confused for one another | Write "morphine sulfate", or "magnesium sulfate" |
| Use of a trailing zero (X.0 mg) or lack of a leading zero (.X mg) | Decimal point can be missed or confused | Write "X mg" or "0.X mg" |

32

## Additional Abbreviations
*Short List from ISMP* (21)

| Do Not Use | Potential Problem | Instead Use |
|---|---|---|
| "µ" | Mistaken for "mg" | Write "mcg" |
| Drug name abbreviations | Mistaken for other drugs | Write the drug name |
| "&" | Mistaken for "2" | Write "and" |
| "/" | Mistaken for "1" | Write "per" |
| AD, AS, AU | Mistaken for "OD", "OS", "OU" | Write "right ear", "left ear", "both ears" |
| OD, OS, OU | Mistaken for "AD", "AS", "AU" | Write "right eye", "left eye", "both eyes" |

33

## Abbreviation Errors
*Decimals and Zeros* (5)

- Misuse of a leading or trailing zero can lead to a 10-fold over-or-under dosing of a medication

- If a warfarin dose for "1 mg" is written as "1.0" mg with a trailing zero, it can easily be misread as "10 mg," leading to a 10-fold overdose. Likewise, the omission of a leading zero in writing "0.5 mg" as ".5 mg" could also lead to a 10-fold overdose if "5 mg" is mistakenly dispensed.
  - Warfarin overdoses can result in hemorrhaging and strokes

34

## Abbreviation Errors
*Decimals and Zeros* (5)

- Leading zero example
  - Leading zeros should <u>always</u> be used
  - 0.45 contains a leading zero, while .45 does not
    - Without leading zeros the decimal point can be missed
      - If .45 is written, it can be misread as 45; a 100-fold error
- Trailing zero example
  - A trailing zero after the decimal point should <u>never</u> be used
  - 345.0 should be written as 345
  - 34.50 should be written as 34.5
  - Using a trailing zero increases the chances that the decimal point will be overlooked

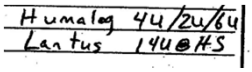
35

## Abbreviation Errors
*Decimals and Zeros* (23)

- Chemotherapeutic agent topotecan
  - Several reported errors of 10-fold overdoses
  - Decimal point was overlooked
    - 2.5 mg dose misread as 25 mg
  - Lack of a leading zero
    - .7 mg dose misread as 7 mg
  - Use of a trailing zero
    - 4.0 mg misread as 40 mg

36

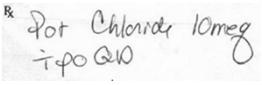
## Abbreviation Examples (24)




Intended Humalog dose of 4 units erroneously interpreted as 44 units. "U" should be written as "unit".

37

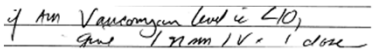
## Abbreviation Examples (24)




"Potassium chloride QD" in medication order erroneously interpreted as QID. Should be written as "daily".

38

## Abbreviation Examples (24)




Intended drug level of "less than 10" was interpreted as "4" (i.e., read as 40). The "<" symbol should be written out as "less than".

39

## Verbal Errors (59)

- "Sixteen" misheard as "sixty"
- "1 to 5 mg" misheard as "125 mg"
- Need to read back verbal orders

40

## Calculations
*Errors (25)*

- Calculation errors pose one of the significant risks of causing harm
  - The more complex the calculation the greater the risk
- Most common calculation errors
  - Converting units of measure
    - Weights, millimoles, mEq, etc.
  - Converting doses when using different salts
  - Decimal points
  - Dilutions

41

## Calculations
*Errors*

- Calculation errors are often made by using the wrong concentration of stock solutions, misplacing a decimal point, or using wrong conversions
- Personnel also neglect to double-check their work or have a second person double check the calculations
  - People rely on their memory instead of looking up a conversion
  - Always ask yourself, "Does the final answer seem reasonable?"
    - Stop if the answer does not make sense!

42

## Calculations
*Decimal Point Errors* (26)

- Patient with infection after bone marrow transplant for leukemia
  - Patient was in remission and had only 1 functioning kidney via a 13 year old transplant
- 2,400 mg foscarnet ordered; 24,000 mg administered
  - A 10X overdose causing renal failure
  - Patient died
- Hospital admitted pharmacy was negligent
- Jury awarded $3.3 million to the family
- *"It shows just how careful hospitals need to be when they are dealing with dangerous drugs",* Sarah King, attorney

43

## Calculations
*Pediatrics*

- Common errors with pediatrics in community pharmacy (22)
  - Calculations
  - Total daily dose prescribed instead of divided doses (calculations needed)
  - 10X dosing errors due to trailing zeros
  - Dose written in mL's rather than mg's
- IV fat emulsion errors in neonatal IUC (30)
  - Errors occurring in neonatal ICU are associated with more severe harm
  - 10% of all errors due to dose calculations and decimal points

44

## Calculations
*Heparin Dosing* (12)

- 17 babies at Christus Spohn Hospital received heparin 100x overdoses despite improved vial labeling changes
  - 2 infants died
- As per ISMP, overall causes due to calculation errors (i.e., wrong dilutions) and/or with use of unfamiliar heparin concentrations
  - Due to shortages, pharmacies forced to use unfamiliar concentrations (i.e., 10,000 units/ml vs. the "routine" 1,000 units/ml)

45

## Calculations
*Hyponatremia Death* (28)

- 6 year old patient routine tonsillectomy
  - Order for "1000cc D5W-600cc q8h"
  - Pharmacist calculated wrong infusion rate and entered 200mL/hr
  - Pharmacist set up the equation wrong. Thinking in terms of how many 600 mL "doses" would be needed, he erroneously set up the calculation as 600 mL (the volume to infuse over 8 hours, divided by 3 (the number of 600 mL "doses" he thought would be needed for 24 hours) and arrived at 200 mL/hr
    - Calculation should have been 600 mL/8 hrs = 75 mL/hr
  - Administration nurse missed it too; *"They (the pharmacists) never make mistakes",* she said
  - Patient died
    - Too much IV fluid too fast that was devoid of sodium chloride
  - What other mistakes happened here?

46

## Calculations
*Hyponatremia Death*

- What other mistakes happened here?

a) Calculations and prescription was not doubled checked
b) Pharmacist did not ask himself if answer made sense
c) Nurse did not check the prescription
d) All of the above

47

## Calculations
*Calcium Chloride Overdose - Two Tragedies* (31)

- Kimberly Hiatt, 27 years dedicated pediatric ICU nurse Seattle Children's Hospital
- Calculated and administered wrong dose of calcium chloride injection
  - 140 mg ordered vs. 1,400 mg administered
  - *"Oh my God, I have given too much calcium!"*, she said
- 8 month old infant died
- Kimberly Hiatt then committed suicide
  - Note: There are second victims to errors
- What mistakes took place here?

48

# Calculations
*Calcium Chloride Overdose - Two Tragedies*

- What mistakes took place here?

  A. Error in calculations; decimal point mistake
  B. Preparation not double checked
  C. Nurse did not ask herself if the answer made sense
  D. All of the above

49

# Sterile Product Drug Shortage
*Patient Safety Impact (32, 33)*

- Nationwide shortage
  - Electrolytes, antimicrobials, chemotherapy, cardiovascular, CNS, anesthetics, hormonals, diluents
    - 260 to 300 active drug shortages per quarter
      - 2012 through 2013
- Issues
  - Pharmacists have to scramble and adjust Rx to what is obtainable
    - Resulting in errors and adverse outcomes
  - Wrong concentration/volume – calculation errors
    - Wrong doses
      - Solu-Medrol® 500 mg/4 ml vs. 500 mg/2 ml mix-ups during shortage of 40 mg and 125 mg vials (calculation errors)
    - IV compounding machine errors (dose entry)
    - Wrong product – LA/SA

50

# Drug Shortage
*Patient Safety Impact (34)*

- An *Associated Press* article on Sept 24, 2011 reported 15 deaths in 15 months that were linked directly to drug shortages
- In early April 2011, a survey conducted by the American Society of Anesthesiologists (ASA) and reported by ABC news revealed that 7 anesthesiologists had drug shortages that led to death in their patients
- In a November 2011 survey by ISMP, 96 hospitals responded "yes" when asked if they had a serious adverse drug event occurred in their hospital as direct result of a drug shortage

51

% Respondents to ISMP Survey Reporting Errors 2012-2014 (32) n=1,800

| Drug Product/Ingredient | % Yes | % No |
|---|---|---|
| Trace Elements | 28 | 72 |
| Sodium Phosphate | 27 | 73 |
| Potassium Phosphate | 25 | 75 |
| Multi-Vitamins (adult) | 23 | 77 |
| Calcium Gluconate | 19 | 81 |
| IV Fat Emulsion | 19 | 81 |
| Zinc Injection | 16 | 84 |
| Magnesium Sulfate | 13 | 87 |
| Amino Acids | 13 | 87 |
| Selenium | 12 | 88 |
| Sodium Chlorides | 10 | 90 |
| Multi-Vitamins (pediatric) | 10 | 90 |
| Potassium Chloride | 9 | 91 |
| Vitamin K | 8 | 92 |
| Copper Chloride | 8 | 92 |
| Sodium Acetate | 7 | 93 |

52

# Drug Shortage
*Patient Safety Impact (32)*

- Most of the dosing related errors pertain to calculation mistakes when switching between different products
  - Potassium chloride
    - Errors when converting from potassium chloride to potassium phosphate
  - Sodium chloride
    - Errors when converting volumes to use from the 23.4% product to the 3% and 5% product
  - Sodium acetate
    - Errors when using different concentrations
      - 2 mEq/ml vs. 4 mEq/ml
  - Trace elements
    - Dosing errors when calculating the volumes to use when switching products
      - Especially with pediatrics and neonates

53

# Drug Shortage
*Patient Safety Impact (32)*

- Dose/volume/calculation errors (cont'd)
  - Selenium
    - Dosing errors when changing between products
      - Dilution errors are most common
    - Numerous reports of infants receiving 5-fold overdoses
  - Zinc
    - Dosing errors when switching between the 10 mg/mL, 10 mg/10 mL (not recognized as 1 mg/mL) and 5 mg/mL drug product concentrations
    - Dosing errors when switching between zinc chloride and zinc sulfate
  - Magnesium sulfate
    - 10% vs. 50%
    - Wrong strengths; wrong dose

54

## Drug Shortage
*Patient Safety Impact* (32)

- Dose/volume/calculation errors (cont'd)
  - Potassium acetate and potassium phosphate
    - Wrong doses; potassium content not adjusted when potassium phosphate became available and patients became severely hypokalemic
  - Calcium gluconate and calcium chloride
    - Dosing errors when switching between mg (calcium gluconate) to mEq (calcium chloride)
    - Wrong dose of calcium chloride causing extravasation, necrosis, resulting in skin grafting and chronic cellulitis
  - IV fat emulsions
    - Wrong doses when switching between products

55

## Drug Shortage
*Patient Safety Impact* (32)

- Dose/volume/calculation errors (cont'd)
  - Amino acids
    - Wrong concentrations
    - Wrong phosphorus levels when switching between products
  - Sodium phosphate and glycerophosphate
    - Wrong doses when switching between products resulting in hypophosphatemia, hyperkalemia, and hypercalcemia
  - Dextrose
    - Errors when switching from dextrose 50% to dextrose 10%
    - Errors due to differences in the densities when switching between dextrose 50% and dextrose 70% when using IV compounding machines

56

## Aseptic Compounding
*Observational Study* (35)

- Random survey taken to assess compliance with USP <797>
- 262 respondents
- One third of facilities reported having had a patient incident involving a compounding error within the past five years

57

## Aseptic Compounding
*Observational Study* (35)

- Pharmacy staff members observed compounding sterile medications for 5 days each at 5 hospitals across the country
- Mean error rate of 9%
  - 145 errors for 1679 doses
  - Wrong dose was most common error
- Parenteral nutrition solutions had highest error rate
  - 37% in manual preparation
  - 22% in automated preparation
- Of every 100 errors, 2 were judged to be of clinical significance

58

## Aseptic Compounding
*Ophthalmics* (36, 37)

- Pittsburgh pharmacy prepared bottles of indomethacin in saline for inflammation post cataract surgery, prescribed by 15 doctors
  - Pseudomonas contamination occurred
    - 10 patients hospitalized; 2 patients lost an eye
  - FDA issued warning to pharmacists to use proper sterilization procedures
- Dallas pharmacy prepared antibiotic/steroid ophthalmic injections for post cataract surgery
  - Dozens of patients suffered vision loss in one eye – retinal damage
    - Some partially recovered; others not
  - Court issued restraining order against the pharmacy
  - FDA cited pharmacy for numerous violations

59

## Automated Aseptic Compounding
*Data Entry – Wrong Dose* (38)

- Baby Genesis Burkett
  - Pharmacy technician typed in the wrong information when processing an electronic IV order
    - The human element
  - Massive sodium chloride overdose
    - 60 times more sodium chloride given than ordered
    - Automated alerts on compounding machine were not activated
    - Label on IV bag did not reflect actual contents
    - Blood test showed high levels, but lab tech assumed number was wrong
    - Electronic communication gap between the CPOE and automated compounding

60

## Automated Aseptic Compounding
*Data Entry – Wrong Dose (38)*

- Outcomes
  - Baby died
  - Family sued
    - *"This did not have to happen",* said Mr. Burkett
  - Hospital apologized
  - Alerts on compounding machines activated
  - Double check policies strengthened for all medications leaving the pharmacy
  - Federal funds used to upgrade electronic systems

61

## Automated Aseptic Compounding
*Zinc Injection - Wrong Dose – Two Tragedies (39)*

- Order received for 330 mcg of zinc for Alyssa Shinn, born 14 weeks premature, at Summerlin Hospital in Nevada
- Pharmacist selected 330 *mg* instead of 330 *mcg* in the IV compounder pull down menu; a 1,000 times overdose
  - Baby died the next day
  - Pharmacist vomited, cried and was shaking
- Prescription not double checked, two other pharmacists failed to check the calculations, pharmacists and technician failed to notice that 48 vials of zinc were added to the TPN solution which was more volume than the entire TPN, nurses failed to notice that the IV bag was four times bigger than the baby
  - A complete system failure

62

## Automated Aseptic Compounding
*Zinc Injection - Wrong Dose – Two Tragedies (39)*

- Investigations done by Nevada Board of Pharmacy and Portfolio magazine
  - Pharmacy operated like a giant temporary agency; staff came and went; high turnover
    - 6 pharmacy directors in 6 years
    - Pharmacy run by a management company
  - Pharmacy was short staffed the night of the incident
  - Very hectic and stressful environment
  - Failures of pharmacists, supervision and work environment
  - *"A safe pharmacy has to be very organized, regimented place with very few distractions",* Nevada Board of Pharmacy
- Pharmacy department fined, individual pharmacists fined and suspended
  - Pharmacist has a rose tattoo on her wrist to remind her every day of this little girl

63

## Aseptic Compounding
*Automated Workflow Managers*

- IV workflow systems/managers effective in reducing errors - ensures correct ingredients, correct amounts – but they are not perfect
  - However, barcode verification, image capture and gravimetric systems cannot safeguard against the contamination of compounded preparations
  - Still need to pay attention and check
- Efficiencies in catching errors also dependent upon the human element
  - Information must be correctly transcribed, entered and checked

64

## Computerized Physician Order Entry (CPOE)
*E-Prescribing (40)*

- Cincinnati Children's Hospital
  - 421,730 IV doses evaluated
    - 3,101 total documented errors (0.74% error rate)
      - Workflow manager system caught 72% of those errors
        - That means 28% of the total errors were missed by the system
      - Errors caught by the pharmacist after the system check
        - Wrong drug or diluent, incorrect volume, damage to the final Rx

65

## Computerized Physician Order Entry (CPOE)
*E-Prescribing (41)*

- Does CPOE and e-prescribing help to reduce errors?
  - Yes, but it's not perfect
  - Systems usually catch about 90% of the possible errors
  - But what about the missed 10%?
    - About 13% to 40% of the errors from the missed 10% considered to be serious
  - Remember: Automated systems greatly help but cannot catch all types of errors
    - Cannot run IV pharmacy on "automatic pilot"
    - Human check is still needed

66

## Computerized Physician Order Entry (CPOE)

*E-Prescribing* (11, 41)

- Causes due to the human element
- Order entry input errors: wrong product selection, type in wrong number, entry into wrong field
  - Similar product descriptions
  - Mnemonics, order entry auto fill
    - Example: Ox for **Ox**carbazepine and oxaprozin
    - Example: QD entry yields Q8H dosing interval
  - Inaccurate patient information in the records
  - Alarms set too low
  - Pharmacy transcription errors
  - Boilerplate warnings ignored when thought to be not applicable
  - Copying and pasting of orders
- Prescriptions still need to be checked!

67

## *Systems and Procedures OR Errors* (42, 43)

- Half of all surgeries had some kind of medication error
  - 124 out of 277 operations in 2013-2014 had at least one medication error
    - Syringe labeling, incorrect dosages, drugs that should have been given but were not
    - Most common errors with fentanyl and phenylephrine
  - 79% were preventable
  - 65% were serious, 33% were significant 2% were life threatening
- Summary
  - 1 in 20 medication administrations, and every second operation resulted in a medication error and/or ADE
    - 1/3 of these errors led to patient harm while 2/3 had the potential for harm
  - *"Medication error are at least as high at many other hospitals. The type of errors are not unique……",* K. Nanji

68

## Criminalization of Errors (44)

- Pharmacist (Eric Cropp) missed pharmacy technician dilution error with 23.4% sodium chloride for an etoposide IV
  - Child (Emily Jerry) died two days later due to cerebral edema
  - $7 million hospital settlement (Rainbow Babies and Children Hospital, Cleveland, OH)
  - Pharmacist charged with involuntary manslaughter and pleaded no contest in a plea bargain agreement
    - Loss of license, 6 months in prison, 6 months home confinement, 400 hours of community service, $5,000 fine plus court costs
  - "Emily's Law" enacted that pharmacy technicians in Ohio must be trained and pass competency test

69

## Criminalization of Errors

*NECC Charges (45-51)*

- 753 people in 20 states with fungal meningitis
  - 64 patients killed in 9 states in fall of 2012; 3,500 total victims
  - 131 count indictment Dec 2014
    - 14 people arrested
    - 25 acts of 2° murder filed in 7 states
    - FDA cited numerous cGMP violations
      - Fraud
      - Not following procedures
    - Charges of criminal contempt
    - Hundreds of lawsuits
  - Convictions to date
    - Mail fraud and racketeering
    - Conspiracy
    - Adulterated drugs in interstate commerce
    - Sentenced to 9 years in prison
  - $200 million compensation fund for victims created

70

# Proposals To Preclude Errors

*ISMP Best Practice Goals*

## ISMP Targeted Medication Safety Best Practices (11, 52)

*Based Upon True Events*

- Dispense vinCRIStine and all other vinca alkaloids only in a diluted minibag and never in a syringe
  - To preclude intrathecal injection which is almost always fatal due to CNS destruction
  - Most frequently reported accidental intrathecal injection
  - Errors occur because vincas are sometimes used in conjunction with other medications that are administered intrathecally (e.g., methotrexate, cytarabine, and/or hydrocortisone).

72

## ISMP Targeted Medication Safety Best Practices (52)
*Based Upon True Events*

- Use and document patient weights only in the metric system
  - Ensure that balances used for weighing patients measure only in kg and/or gm and not pounds
  - Dosing errors take place when patient's weights are documented in non-metric units and then weight conversions are incorrectly calculated when the patient is weighed one way (non-metric) and then documented in the metric system
    - Especially true in pediatrics
  - Modify any dual scale balances to lock out the ability to weigh in pounds
  - Post metric/non-metric conversion charts

73

## ISMP Targeted Medication Safety Best Practices (52)
*Based Upon True Events*

- Dispense all oral liquids that are not commercially available as unit dose products only in an oral syringes and never in a syringe for injections
  - Only use oral syringes that have ends that are incompatible with needles
    - To preclude IV administration which can be fatal
- Use oral liquid dosing devices (oral syringes/cups/droppers) that only display the metric scale
  - To avoid mix-ups with the metric and household units of measure (teaspoons, tablespoons, etc.)
  - Place label "For Oral Use Only"

74

## ISMP Targeted Medication Safety Best Practices (52)
*Based Upon True Events*

- Segregate, sequester and differentiate all paralyzing agents (neuromuscular blocking agents) from all other medications wherever they are stored in the organization
- Eliminate storage of paralyzing agents from areas where they are not needed
- In needed areas (i.e., ICU) store paralyzing agents in color coded sealed boxes with a breakaway lock
- Segregate paralyzing agents in the pharmacy from all other medications
  - Place in separate lidded containers in an isolated area
- Differentiate paralyzing agents by placing labels on storage bins and dispensed prescriptions
  - "WARNING: PARALYZING AGENT – CAUSES RESPIRATORY ARREST"

75

## ISMP Targeted Medication Safety Best Practices (52)
*Based Upon True Events*

- Administer high alert IV medication infusions via programmable infusion pumps that use error reducing software ("smart pumps")
  - Includes in-patient, ambulatory infusion centers, emergency departments, MRI clinics, etc.
  - Exception: small volume chemotherapy vesicants (drugs that damage tissue if extravasation takes place); administer via gravity
- Ensure error reducing software is actually being used and drug libraries are current
- Perform periodic maintenance, updating and testing of the software and drug library on all smart pumps

76

## ISMP Targeted Medication Safety Best Practices (52)
*Based Upon True Events*

- Ensure all antidotes, reversal agents and rescue agents are in stock and readily available
  - Any delay in administration could be life threatening
- Use standardized protocols
- Post use/administration directions in the areas where such agents are used
- Identify which agents should be used in emergency situations
  - EPINEPHrine for anaphylaxis
  - Naloxone for opioids overdose
  - Flumazenil for benzodiazepines
  - Uridine for fluorouracil
  - Methylene blue for methemoglobulinemia

77

## ISMP Targeted Medication Safety Best Practices (52)
*Based Upon True Events*

- When compounding sterile preparations, perform an independent verification to ensure that the proper ingredients (medications and diluents) are added, including confirmation of the proper amounts and volumes of each ingredient prior to and after addition to the final container
- Pay special attention and verification for all high alert medications/situations, such as chemotherapy, parenteral nutrition, pediatric/neonatal preparations, pharmacy prepared bulk containers/stock solutions, intrathecals, epidurals, intraoculars
- Use technology to assist/augment (but not replace) the verification processes
  - Barcoding, robotics, IV workflow software

78

## ISMP Targeted Medication Safety Best Practices (52)
*Based Upon True Events*

- Use a default weekly dosage regimen for oral methotrexate in electronic systems
  - Require a hard stop verification for an appropriate oncologic indication for any daily oral methotrexate orders
  - Stop and ask yourself if the dosage regimen and diagnosis make sense
    - Double check the diagnosis and corresponding dosing regimen
  - Fatal errors reported when oral methotrexate accidentally given daily instead of one tablet weekly for 1 month for psoriasis, rheumatoid arthritis
    - Taking tablets daily or all at once can lead to profound neutropenia and infection
  - Make sure the patient/caregiver understand the dosing
    - Provide clear verbal and written directions
      - Have the patient repeat the directions

79

## ISMP Targeted Medication Safety Best Practices (52)
*Based Upon True Events*

- Eliminate all 1,000 mL bags of sterile water for injection from all areas outside of the pharmacy and respiratory therapy departments
  - To prevent accidental mix-ups in storage and infusion of straight water
  - Use 2 L bags of sterile water to prevent mix-ups
  - Implement a policy that only the pharmacy can order sterile water for injection/irrigation
- Eliminate glacial (99.5%) acetic acid from all areas of the hospital
  - To avoid accidental topical application which results in 3rd degree burns/tissue dam age and oral use
  - One case of bilateral amputation
  - Use 0.25% acetic acid or white vinegar (5% acetic acid)

80

## Additional ISMP Advice
*Based Upon True Events (11, 59)*

- Opioids
  - Understand patient controlled analgesia (PCA) dosing in opioid naïve patients
  - Use standardized pain management protocols
  - Limit the number of products and strengths on hospital floors
    - Store naloxone wherever opioids are used
    - Use prefilled 0.5mg syringes of HYDROmorphone
    - Prepare all infusions by the pharmacy
- Insulin
  - Do not store U-500 on the hospital floors
  - Store insulin in designated areas only with limited inventory and only with the smallest vial size possible
  - Use standardized protocols when using smart pumps and with hard stops to avoid overdosing
  - Prepare all infusions and dispenses all long acting insulins by the pharmacy
  - Measure U-500 insulin using a U-500 syringe or a U-500 pen
    - Do not use TB syringes due to calculations errors
  - Re-evaluate in-patient use of insulin pens

81

## Additional ISMP Advice
*Based Upon True Events (11)*

- Vaccines
  - Post and use easy to read age related immunization schedules
  - Use protocols
- Look Alikes/Sound Alikes
  - Use standardized format for TALLman lettering
  - Use different storage bins (separation)
  - Use the word "liposomal" in all entries for such drugs placed before the drug name
    - *Liposomal* amphotericin B vs. "regular" amphotericin B
    - Use separate bins with special labeling in pharmacy for liposomals
- Only use the abbreviations approved by the Joint Commission and ISMP
  - Do not use your own abbreviations!
- Separately store high alert medications
- Double check the entries into the IV compounder machine

82

## Practical Proposals To Preclude Errors

*Calculations, Color Coding, Separation, Storage, Packaging, Labeling, Systems*

## Calculations
*Tips and Advice*

- Recognize that every situation is different
- Do not be intimidated by the prescription!
  - The prescription will clarify along with the calculations
    - Slowly work it through
- Determine what you know and what is "given", what you don't know and where you want to go with each preparation
  - Have a plan first
    - Note: The resultant calculation will be the plan!

84

## Calculations
*Tips and Advice*

- Setup up the equation to give you the desired result/answer
  - mg/mL? mg/hr? mg/kg? mEq/L?
  - Structuring of the equation is critical!
  - Always use dimensional analysis to guide you in creation of the equations
  - Always use the units of measure and keep them straight
  - Never do the calculations in your head; put pen to paper; write it out (40)
- Recognize that the equation will also suggest the formulation process and direction to be used
  - Always ask yourself if the final answer makes sense
    - If not, do the equation and calculations over!

85

## Calculations
*Tips and Advice*

- Keep the calculations as clear and simple as possible (25)
  - Remember: As complexity increases, the chances for errors likewise increases
- Document the calculations
  - Checking can not be done if the calculations are not written down
- Have an independent double check of both the equation and the mathematics
  - Remember: There is no shame in asking for a double check

86

## Color Coding

- Use color coding to differentiate drugs
  - Red and white – high alert drugs
  - Yellow – chemotherapeutic agents
  - Orange – paralytics
  - Green – concentrated high alert medications

87

## Color Coding and Separation
*Chemo Drugs – Yellow in Designated Area (54)*

88

## Separation and Color Coding (55)

- Use covered and colored bins for high alert medications
  - Provides physical separation and color coding
  - Requires a 2 step process
    - Read the warning labels on the outside of the bin
    - Lift the lid to retrieve the drug
  - Requires staff to stop and think
    - Highly noticeable

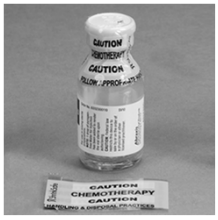
89

## Separation and Color Coding (55)



90

## Shrink Bands (55)




91

## Vial Rings (55)



92

## Bags (55)



93

## Stickers (55)

*Place on Automated Dispensing Cabinets*



94

## Labels (55)



95

## Summary

*Things to Remember*

## Things to Remember

1. Pharmacy errors are preventable
2. Watch out for high alert medications
   - Insulin, heparin, opioids, et.al.
3. Be careful with Look-Alike/Sound-Alike drugs and sound alike verbal orders
   - Slow down, read, check
     - Celexa and Celebrex
     - Glyburide and glipizide
4. Be aware of how our brains can play tricks on us and cause mistakes; the human factors
5. Use caution with abbreviations and directions
   - Never use your own abbreviations
   - Avoid Latin directions (40)
6. Be careful with zero's and decimal points
   - Leading and trailing zero's

97

## Things to Remember

7. Calculations
   - Setting up the equation is critical
   - Write it down
   - Use dimensional analysis
   - Ask yourself if the answer makes sense
   - Use an independent double check of the equation and mathematics

8. Be aware that work place conditions contribute to errors
   - Interruptions; distractions
   - Workload; staffing;
   - Drug shortages

98

## Things to Remember (53, 59)

9. Confirm that the prescription is correct and complete

10. Ensure correct entry of the prescription

11. Organize the workplace

12. Reduce distractions when possible

13. Reduce stress; take breaks and time for a meal

14. Thoroughly check all prescriptions

15. Read back any verbal orders

99

## Things to Remember

16. Use good common sense practices to preclude errors
    - Physical separation, labels, color coding
    - Take time to properly store drugs (53)

17. Stop when in doubt
    - You do not need to know everything all of the time
      - You just need to know what you know and recognize what you don't know and where to get the information
        - Do not guess
        - Look it up
        - Don't be afraid to ask questions
        - Conquer the fear of saying "I don't know" (58)
          - Recognize that this is not an admission of weakness

100

# Parting Caveats

*How to Preclude Errors*

## Parting Caveats on How to Preclude Errors

- If something can go wrong then it will! (56)
- Check and have an independent double check
  - Trust, but verify (57)
- If you are using too much or a fraction of something (e.g., too many vials for a Rx) then something is wrong (56)
- Ask yourself, "Is this going to keep me up at night if we do this?"
  - If you are not comfortable with it, then you really shouldn't do it
- Ask if you don't know; it's OK to ask – no shame (58)
  - Ask someone else if you do not get the expected answer (56)
- Keep the work processes, procedures, documentation and preparations as clear and simple as possible
  - But documents and procedures must also be complete, rugged, robust and reproducible

102

## Acknowledgements


- Special thanks to Darryl Rich, PharmD, MBA, FASHP
  - Medication Safety Specialist, Institute for Safe Medication Practices (ISMP)
  - Administration Coordinator, Medication Safety Officer Society (MSOS)
- Many thanks to the Institute for Safe Medication Practices (ISMP) for their assistance!


103

## Questions

1. Medication errors are usually due to a confluence of multiple simultaneous situations. Common factors that can create the conditions for medication errors to occur can include which of the following:
   a. Sound alike/look alike drugs
   b. Inappropriate use of abbreviations
   c. Calculations and careless use of decimal points and zeros
   c. Working environment
   e. All of the above

2. Which of the following steps can be done to help to reduce pharmacy errors?
   a. Color coding
   b. TALLman lettering
   c. Physical separation
   d. Use of only the metric system
   e. All of the above

104

## Questions

3. Mistakes with high alert medications have a higher risk of causing injury when incorrectly used. Which of the following medication categories include high alert medications:
   a. Narcotics
   b. Insulins
   c. Antithrombotic agents
   d. Chemotherapeutic agents
   e. All of the above

4. What is the best way to avoid calculations errors?
   a. Write down the equation and the calculations
   b. Check top assure that the answer makes sense
   c. Have an independent double check
   d. Keep the calculations clear and simple
   e. All of the above

105

## Questions

5. Name three of the ISMP Best Practices.

a. Always dispense vinca alkaloids in a mini-bag and never in a syringe
b. Segregate, sequester and differentiate all neuromuscular blocking agents (paralyzing agents) from all other medications wherever they are stored in the organization
c. When compounding sterile preparations, perform an independent verification to ensure that the proper ingredients (medications and diluents) are added, including confirmation of the proper amounts and volumes of each ingredient prior to and after addition to the final container
d. All of the above

106

## Suggested Extra Reading


- FDA. Strategies to reduce medication errors: Working to improve medication safety. Available at: https://www.fda.gov/Drugs/ResourcesForYou/Consumers/ucm143553.htm. Accessed Aug 9, 2017.
- Halverson D. Survey results: Compliance challenge. State of pharmacy compounding. Pharmacy Purchasing & Products. Vol. 6. No. 4. April 2009. Available at: https://www.pppmag.com/digitalmag/Main.php?MagNo=43&PageNo=1#page/1. Accessed Aug 9, 2017.
- ISMP. 2017 Medication Safety Self Assessment® for Community/Ambulatory Pharmacy https://www.ismp.org/selfassessments/community/2017/2017_ISMP_CommunityAmbulatory_Pharmacy_Self_Assessment.pdf. Accessed Jul 17, 2017.
- ISMP. Guidelines. Available at: http://www.ismp.org/Tools/Guidelines/. Accessed Aug 9, 2017.
- ISMP. Medication safety tools and resources. Available at: http://www.ismp.org/Tools/. Accessed Aug 9, 2017.
- ISMP. Proceedings from the ISMP sterile preparation compounding safety summit: Guidelines for safe preparation for sterile compounds. Available at: www.ismp.org/Tools/guidelines/IVSummit/IVCGuidelines.pdf. Accessed Aug 7, 2017.


107

## Thank You!

108

## References


1. Makary MA, Daniel M. Medical error – the third leading cause of death in the US. British Medical Journal. 2016; 353:i2139. May 3 2016. Available at: http://www.west-info.eu/pdf/medical-error-the-third-leading-cause-of-death-in-the-us/. Accessed Jul 17, 2017.
2. Rich D. The top ISMP medication safety issues for 2014. ASHP Medication Safety Collaborative. June 2014.
3. Crain's Chicago Business. Walgreen sets sales record on prescription drug growth. Sep 30, 2014. Available at: http://www.chicagobusiness.com/article/20140930/news07/140939998/walgreen-sets-sales-record-on-prescription-drug-growth. Accessed Jul 17, 2017.
4. Saffel, D. Identifying factors that cause medication errors. PharmaCare Strategies, Inc.
5. Darezzo H. Medication errors. Our Lady of Fatima Hospital. Resources. Rhode Island Society Health-System Pharmacists. Available at: http://www.rishp.org/Resources/CE%20Events/MEDICATION%20ERRORS.pdf. Accessed Jul 21, 2017.
6. Francis T. Heparin overdoses hit babies in Texas Hospital. The Wall Street Journal. July 9, 2008. Available at: https://blogs.wsj.com/health/2008/07/09/heparin-overdoses-hit-babies-in-texas-hospital/. Accessed Aug 9, 2017.
7. ISMP. Obesity epidemic and U-500 insulin-related medication errors. Pharmacy Today. May 2016. p. 80.
8. ISMP. List of high-alert medications in acute care setting. Available at: www.ismp.org/tools/highalertmedications.pdf. Accessed Jul 17, 2017.




## References


9. Rich D. The top ISMP medication safety issues for 2014. ASHP Medication Safety Collaborative. June 2014.

10. Morawicz MA. Marion A. Morawicz, Ltd. Attorney at Law. Available at: http://www.morawiczlaw.com/Medical-Malpractice/Drug-Overdose-Medication-Errors.shtml. Accessed Jul 17, 2017.

11. Rich D. Improving medication safety: A national perspective from the ISMP. ASHP Mid-Year Clinical Meeting. Anaheim CA. Dec. 2014.

12. ISMP. Heparin errors continue despite high-profile fatal events. July 17, 2008. Available at: https://www.ismp.org/Newsletters/acutecare/articles/20080717.asp. Accessed Jul 17, 2017.

13. ISMP. List of confused drug names. Available at: www.ismp.org/tools/confuseddrugnames.pdf. Accessed Jul 17, 2017.

14. Rich D. Reducing sterile compounding errors – an ISMP perspective. ASHP Medication Safety Collaborative. Denver, CO. June 2015.

15. Kosiba L. Personal Communication. Sodium Bicarbonate Injections. St. Francis Hospital, Evanston, IL. May 30, 2014.

16. Davis M. Aoccdrinig to rscheearch at Cmabrigde. Available at: https://www.mrc-cbu.cam.ac.uk/personal/matt.davis/Cmabrigde/. Accessed Aug 9, 2017.

17. Fortier C. Medication errors in the hospital pharmacy - Prevalence, causes, and prevention. ASHP Summer Meeting. Las Vegas, NV. 2014.




## References


18. BBC News. Magazine Monitor. What would Wittgenstein say about that dress? Feb 28, 2015. Available at: http://www.bbc.com/news/blogs-magazine-monitor-31662317?print=true. Accessed Jul 17, 2017.

19. Levy P. Oops, too much morphine. Not Running a Hospital. Aug 29, 2014. Available at: http://runningahospital.blogspot.com/2014/08/oops-too-much-morphine.html. Accessed Jul 17, 2017.

20. Joint Commission. Facts about the official "Do not use" list. Available at: https://www.jointcommission.org/facts_about_do_not_use_list/. Accessed Jul 17, 2017.

21. ISMP. List of error prone abbreviations, symbols and dose abbreviations. Available at: www.ismp.org/tools/errorproneabbreviations.pdf. Accessed Jul 17, 2017.

22. Benavides S, Huynh D, Morgan J, et.al. Approach to the pediatric prescription in a community pharmacy. J Pediatr Pharamcol Ther 2011 vol. 16. no. 4. Available at: https://www.ncbi.nlm.nih.gov/pubmed/22768015. Accessed Aug 13, 2017.

23. ISMP. Quarterly Action Agenda. Oct 3, 2013. Available at: https://www.ismp.org/newsletters/acutecare/articles/ActionAgenda1304.doc. Accessed Aug 9, 2017.

24. ISMP. Eliminating error-prone abbreviations, symbols and dose designations.

25. Jackson M. Risk management. Calculation errors. Handbook of Extemporaneous Preparation. July-Sept 2013. pp. 17-18.

26. Schencker L. Jusry awards $3.3 million in Northwestern overdose case. Chicago Tribune. Sec 1. p. 8. Aug 12, 2016. Available at: http://www.chicagotribune.com/business/ct-northwestern-kidney-overdose-0813-biz-20160812-story.html. Accessed Aug 9 2017.


## References


27. Rich D. Reducing sterile compounding errors – An ISMP perspective.

28. Hurley D. After hyponatremia deaths, stronger interventions urged. Pharmacy Practice News, volume 36:10, Oct 2009. Available at: http://www.pharmacypracticenews.com/Clinical/Article/10-09/After-Hyponatremia-Deaths-Stronger-Interventions-Urged/14100/ses=ogst. Accessed Jul 17, 2017.

29. Erickson A. Top medication safety issues for 2014. Pharmacy Today, July 2014. pp. 6-7.

30. Chou J, Lambert G, Hicks RW. Intralipid medication errors in neonatal intensive care unit. Joint Commission Journal on Quality and Patient Safety, USP Medication Safety Forum, 2007, vol. 33, no. 2, pp. 104-111. Available at: http://www.ncbi.nlm.nih.gov/pubmed/17370921. Accessed Aug 13, 2017.

31. Aleccia J. Nurse's suicide highlights twin tragedies of medical errors. msnbc.com. June 27, 2011. Available at: http://www.nbcnews.com/id/43529641/ns/health-health_care/t/nurses-suicide-highlights-twin-tragedies-medical-errors/#.VBBdWMoQO_k. Accessed Jul 17, 2017.

32. Cohen M. Drug shortage tales from the front line – keeping patients safe during the daily scramble. ASPEN Annual Meeting. Jan 19, 2014. Available at: http://www.prolibraries.com/aspen/?select=session&sessionID=1558. Accessed Jul 17, 2017.

33. University of Utah Drug Information Service. Drug shortages. Available at: http://www.nasemso.org/Meetings/annual/Presentations2012/documents/DrugShortages-Fox.pdf. Accessed Jul 23, 2017.

34. ISMP. Medication Safety Alert. A shortage of everything except errors: Harm associated with drug shortages April 19, 2012. Available at: http://www.ismp.org/Newsletters/acutecare/showarticle.aspx?id=20. Accessed Jul 17, 2017.




## References


35. Flynn EA, Pearson RE, Barker KN. Observational study of accuracy in compounding I.V. admixtures at five hospitals. Am J Health Syst Pharm. 1997. Apr 15:54(8):904-912.

36. Associated Press. Eye Drop Injuries Prompt an FDA Warning. The New York Times. Dec 9, 1990. Available at: http://www.nytimes.com/1990/12/09/us/eye-drop-injuries-prompt-an-fda-warning.html. Accessed Aug 9, 2017.

37. Ballor C. Dallas News. Patients lose vision after routine cataract surgeries at Dallas Key-Whitman center. Available at: https://www.dallasnews.com/business/health-care/2017/04/27/patients-lose-vision-routine-cataract-surgeries-dallas-key-whitman-center. Accessed Aug 9 2017.

38. Graham J, Dizikes C. Baby's death spotlights safety risks linked to computerized systems. Chicago Tribune. June 27, 2011. Availkable at: http://www.chicagotribune.com/lifestyles/health/ct-met-technology-errors-20110627-story.html. Accessed Jul 17, 2017.

39. Bury C, Apton D. Deadly dose: Pharmacy Error Kills Infant. ABC News. Feb 18, 2008. Available at: https://abcnews.go.com/Health/print?id=4299616. Accessed Aug 9, 2017.

40. Deng Y, Lin AC, Hingl J. Risk factors for i.v. compounding errors when using an automated workflow management system. Am J Health-Syst Pharm. vol 73, no. 12, June 15, 2016. Available at: http://www.ajhp.org/content/73/12/887. Accessed Aug 9, 2017.




## References


41. O'Donnell JO. Hospitals' digital drug ordering boosts safety but can lead to fatal errors. USA Today. April 9, 2016. Available at: http://www.usatoday.com/story/news/politics/2016/04/07/hospitals-digital-drug-ordering-boosts-safety-but-can-lead-fatal-errors/82669450/. Accessed Jul 21, 2017.

42. Nanji KC. Evaluation of perioperative medication errors and adverse drug events. Anesthesiology 1 2016, Vol. 124. Available at: http://anesthesiology.pubs.asahq.org/article.aspx?articleid=2466532&resultClick=3. Accessed Aug 7, 2016.

43. Sun LH. At top US hospital, almost 50 percent of surgeries have drug-related error. The Washington Post. Oct 28, 2015. Available at: https://www.washingtonpost.com/news/to-your-health/wp/2015/10/28/at-top-u-s-hospital-almost-half-of-surgeries-have-drug-related-error/?utm_term=.8fd974c81223. Accessed Aug 7, 2016.

44. Vivian J. Criminalization of medication errors. US Pharm. 2009. 34(11):66-68. Available at: http://www.uspharmacist.com/content/d/pharmacy%20law/c/16572/. Accessed Jul 17, 2017.

45. Lazar K, Wallack T. 14 executives, staff charges in tainted drug case. Boston Globe. Dec 17, 2014. Available at: https://www.bostonglobe.com/metro/2014/12/17/feds-arrest-tied-necc-closed-pharmacy-blamed-causing-deaths-with-tainted-drugs/24QytISVdaqXDNsSUOsNYJ/story.html. Accessed Jul 17, 2017.

46. FDA. Form 483 Inspection Reports, EIR's, Warning Letters and Responses. New England Compounding Pharmacy. Oct 24, 2012 – Feb 10, 2013. Available at: https://www.fda.gov/aboutfda/centersoffices/officeofglobalregulatoryoperationsandpolicy/ora/oraelectronicreadingroom/ucm325828.htm. Accessed Jul 17, 2017.

## References

47. New York Times. Pharmacy executive face murder charges in meningitis deaths. Dec 17, 2014. Available at: https://www.nytimes.com/2014/12/18/us/new-england-compounding-center-steroid-meningitis-arrests.html. Accessed Jul 17, 2017.

48. CBS News. Judge Approves $200 million settlement over meningitis outbreak. May 20, 2015. Available at: http://www.cbsnews.com/news/judge-approves-200-million-settlement-over-meningitis-outbreak/. Accessed Jul 17, 2017.

49. Department of Justice. Owner of New England Compounding Center Convicted of Racketeering Leading to Nationwide Fungal Meningitis Outbreak. Mar 22, 2017. Available at: https://www.justice.gov/opa/pr/owner-new-england-compounding-center-sentenced-racketeering-leading-nationwide-fungal. Accessed Jul 17, 2017.

50. Lavoie D. Pharmacy Owner Blames for Meningitis Outbreak Sentenced to 9 Years in Prison. Time/Associate Press. Jun 26, 2017. Available at: http://time.com/4834128/barry-cadden-meningitis-prison-sentence. Accessed Jul 17, 2017.

51. Bidgood J. Compounding pharmacy owner not guilty of murder after 60 meningitis deaths. New York Times. Available at: https://www.nytimes.com/2017/03/22/us/meningitis-new-england-compounding-center-barry-cadden.html. Accessed Jul 17, 2017.

115

## References

52. ISMP. 2016-2017 Targeted medication safety best practices for hospitals. Available at: http://www.ismp.org/tools/bestpractices/TMSBP-for-hospitals.pdf. Accessed Jul 17, 2017.

53. Nair RP, Kappil D, Woods TM. 10 strategies for minimizing dispensing errors. Pharmacy Times. Jan 19, 2017. Available at: http://www.pharmacytimes.com/publications/issue/2010/january2010/p2pdispensingerrors-0110. Accessed Aug 13, 2017.

54. Upadjyaya H. Personal Communication. University of Chicago, IL. Sep 18, 2014.

55. Health Care Logistics. Products. Available at: http://shop.gohcl.com/products/HCL/ERROR%20PREVENTION%203.aspx. Accessed Jul 17, 2017.

56. Rajski M. Personal Communication. Advocate Good Samaritan Hospital, Downers Grove, IL. July 11, 2017

57. Buckenmaier C. "Doveryai, no proveryai" (Trust, but verify) – President Ronald Reagan. US Medicine. Available at: http://www.usmedicine.com/editor-in-chief/doveryai-no-proveryai-trust-but-verify/. Accessed Aug 9, 2017.

58. Huppke RW. Conquer the fear of saying 'I don't know' on the job. Chicago Tribune. Section 2. Apr 6, 2015. p. 1. Available at: http://www.chicagotribune.com/business/careers/ct-biz-0406-work-advice-huppke-20150402-column.html. Accessed Jul 17, 2017.

59. Rich D. Personal Communication. ISMP. Aug 15, 2017.

116