Optimizing Drug-Dose Checking to Minimize Alert Fatigue

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Conflict of Interest

David Kaelber, MD, PhD, MPH

Consulting Fees: UpToDate North America
Advisory Board

Other: CareSource Board of Directors
Agenda

• Introduction/Background
• What we built
• Summary/Discussion
Learning Objectives

• Define the opportunities and challenges of drug-dose checking

• Design a strategic approach to effective implementation of drug-dose checking

• Identify specific ways to optimize drug-dose checking
STEPS™: An Introduction of How Benefits Were Realized for the Value of Health IT

- Optimizing drug-dose alerts increases CPOE/EHR satisfaction by minimizing alert fatigue
- Preventing adverse events related to dosing errors improves clinical outcomes.
- Avoidance of adverse events reduces care costs
MetroHealth

**System Overview**
- 1 tertiary care academic hospital
- 21 outpatient facilities
- 300+ resident/fellow physicians
- 500 staff physicians
- 1,200 nurses
- 30,000 inpatient stays/year
- 100,000 ED visits/year
- 1,000,000 outpatient visits/yr
- Affiliated with Case Western Reserve University
- Public healthcare system for Cuyahoga County

**Total EHR data**
- 1 million patients
- 15 million visits
- 120 million labs/pathology
- 750,000 imaging studies
- 15 years of data in Epic

**Key Events**
- 1999 - Ambulatory EHR (EpicCare w/ Cadence, Prelude, & Resolute)
- 2004 - EHR in ED (ASAP)
- 2009 - Inpatient EHR (Epic w/ Inpatient Willow and Beacon)
- 2011 - CareEverywhere, e-Rx, MyChart, Nurse Triage
- 2012 - Epic Enterprise Contract, MU Stage 1
- 2013 - BCMA, EpicCare Link, Welcome
- 2014 - ADT, Beaker, Bedtime, OpTime, Research, SBO
- 2015 - Epic 2014 (3/7/15)

1st public healthcare system in US to install Epic in the outpatient setting (1999)!!!
1st public healthcare system in US with Epic to achieve HIMSS Stage 7 EMRAM Ambulatory & Hospital recognition (2014)!!!
1st public healthcare system with Epic to receive Davies Enterprise Award (2015)!!!
Drug-Dose Checking

12 month old girl being given 2 teaspoons of amoxicillin twice a day for 10 days for otitis media

Double dose missed by:
- CPOE
- Med-Peds prescribing physicians
- Dispensing pharmacist
- 2 Med-Peds physician parents
Drug-Dose Checking

- Up to 60% of prescribing errors are dosing errors
- Dosing errors represent the most common type of preventable adverse drug events
- 5-8% of all orders have dosing errors (~1/3 may be clinical significant)

Types of Drug-Dose Checking

- Below minimum daily dose
- Below minimum frequency dose
- Below minimum duration dose
- Below minimum single dose
- Exceeds maximum duration dose
- Exceeds maximum frequency dose
- Exceeds maximum daily dose
- Exceeds maximum single dose
- Exceeds daily prn dose
Drug-Dose Checking Strategy

• Drug-dose clinical decision support should improve patient safety.

• Drug-dose CDS need optimization to be effective.

• Optimized drug-dose CDS should enhance sensitivity and specificity, reducing clinical low risk alerts.
Methods - Strategies

- Turned off incomplete information drug-dose alerts.
- Turned off minimum drug-dose alerts.
- Increased single drug-dose threshold to 125%.
- Increased daily drug-dose threshold to 125%.
- Increased dose frequency drug-dose threshold by 2 doses per day.
- Changed drug specific maximum single and daily drug-dose alert parameters on top 1% of alerting drugs.
Methods - Overview

• Default drug-dose alerts from Epic electronic health record using default Medi-Span® drug data.
• 1st quarter 2013 silent alerts for all drug-dose alerts (single dose, daily dose, dose frequency, and dose duration alerts), in different care settings and patient ages.
• System-wide and drug specific strategies analyzed to optimize drug-dose alerts.

834,911 orders and 104,098 alerts

PSNs - 32 drug-dosing errors (24 wrong dose, 7 wrong frequency, and 1 wrong duration)
Results: Drug-dosing alerts by category, care setting

<table>
<thead>
<tr>
<th>Alert type</th>
<th>Baseline Drug-Dose alerts, % (n)</th>
<th>ED, % (n)</th>
<th>IP, % (n)</th>
<th>OP, % (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below minimum daily dose</td>
<td>24% (24,508)</td>
<td>12% (1684)</td>
<td>24% (12,922)</td>
<td>40% (9,902)</td>
</tr>
<tr>
<td>Below minimum frequency</td>
<td>10% (10,330)</td>
<td>7% (718)</td>
<td>50% (5,163)</td>
<td>43% (4,449)</td>
</tr>
<tr>
<td>Exceeded maximum duration</td>
<td>5% (4,972)</td>
<td>5% (245)</td>
<td>16% (816)</td>
<td>79% (3911)</td>
</tr>
<tr>
<td>Exceeded maximum frequency</td>
<td>16% (16,566)</td>
<td>17% (2,840)</td>
<td>55% (9,143)</td>
<td>28% (4,583)</td>
</tr>
<tr>
<td>Exceeded maximum daily dose</td>
<td>23% (24,183)</td>
<td>15% (3,662)</td>
<td>59% (14,177)</td>
<td>26% (6,344)</td>
</tr>
<tr>
<td>Exceeded maximum single dose</td>
<td>23% (23,539)</td>
<td>20% (4,594)</td>
<td>54% (12,760)</td>
<td>26% (6,171)</td>
</tr>
<tr>
<td>Total</td>
<td>100% (104,098)</td>
<td>13% (13,743)</td>
<td>53% (54,981)</td>
<td>34% (35,371)</td>
</tr>
</tbody>
</table>
Results: Drug-dosing alerts by patient population type

<table>
<thead>
<tr>
<th>Alert type</th>
<th>Baseline Drug-Dose alerts, % (n)</th>
<th>Pediatrics, % (n)</th>
<th>Non-Pediatrics Only Populations, % (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below minimum daily dose</td>
<td>24% (24,508)</td>
<td>7% (1,787)</td>
<td>93% (23,814)</td>
</tr>
<tr>
<td>Below minimum frequency</td>
<td>10% (10,330)</td>
<td>5% (559)</td>
<td>95% (9,772)</td>
</tr>
<tr>
<td>Exceeded maximum duration</td>
<td>5% (4,972)</td>
<td>4% (208)</td>
<td>96% (4,764)</td>
</tr>
<tr>
<td>Exceeded maximum frequency</td>
<td>16% (16,566)</td>
<td>5% (634)</td>
<td>95% (15,93)</td>
</tr>
<tr>
<td>Exceeded maximum daily dose</td>
<td>23% (24,183)</td>
<td>10% (2,307)</td>
<td>90% (21,87)</td>
</tr>
<tr>
<td>Exceeded maximum single dose</td>
<td>23% (23,539)</td>
<td>9% (2,206)</td>
<td>91% (21,333)</td>
</tr>
<tr>
<td>Total</td>
<td>100% (104,098)</td>
<td>7% (7,701)</td>
<td>93% (96,397)</td>
</tr>
</tbody>
</table>
# Results: Impact

<table>
<thead>
<tr>
<th>System Level Drug-Dose Alerts</th>
<th>Optimization of drug-dose alerts, % (n)</th>
<th>Optimized drug-dose alerts per hundred orders</th>
<th>Decrease in drug-dose alerting, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum drug-dose daily dose alerts (removed)</td>
<td>0% (0)</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>Minimum drug-dose frequency alerts (removed)</td>
<td>0% (0)</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>Maximum drug-dose duration alerts (removed)</td>
<td>0% (0)</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>Maximum drug-dose single dose alerts (increased to 125% of threshold)</td>
<td>42% (19,503)</td>
<td>2.3</td>
<td>17%</td>
</tr>
<tr>
<td>Maximum drug-dose daily dose alerts (increased to 125% of threshold)</td>
<td>45% (21,052)</td>
<td>2.5</td>
<td>13%</td>
</tr>
<tr>
<td>Maximum drug-dose dose frequency alerts (increased to more than 2 dose/day of threshold)</td>
<td>14% (6,433)</td>
<td>0.8</td>
<td>61%</td>
</tr>
<tr>
<td><strong>Sub-Total System Level Drug-Dose Alerts</strong></td>
<td><strong>100% (46,988)</strong></td>
<td><strong>5.6</strong></td>
<td><strong>45%</strong></td>
</tr>
</tbody>
</table>
Results: Impact

<table>
<thead>
<tr>
<th>Drug-Dose Alert Category</th>
<th>Optimization of drug-dose alerts, % (n)</th>
<th>Optimized drug-dose alerts per hundred orders</th>
<th>Decrease in drug-dose alerting, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual Level Drug-Dose Alerts</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Maximum drug-dose single dose alerts (top 22 individual dose adjustment customized)</td>
<td>0% (0)</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>Maximum drug-dose daily dose alerts (top 22 individual dose adjustment customized)</td>
<td>0% (0)</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>Sub-Total Individual Drug-Dose Alerts</td>
<td>0% (0)</td>
<td>0</td>
<td>100%(^1)</td>
</tr>
<tr>
<td>Total</td>
<td>25,455</td>
<td>0.030</td>
<td>76%</td>
</tr>
</tbody>
</table>

1. Approximate
Discussion

• Out of the box drug-dosing alerts produces high (~12%) alerting rates.

• Primary, system approaches decreased drug-dose alerting to 5% (46,988/834,911) of orders.

• Secondary, drug-specific approaches decreased drug-dose alerting to 3% (25,455/834,911).

• Simple approaches significantly decrease drug-dose alerts, while maintaining drug-dose alerts for potentially clinically significant drug-overdoses.
Outline

• Introduction/Background

• What we built

• Summary/Discussion
Where do dose warnings come from?

- Medication Database Vendors
- Medi-Span or First DataBank
Initial Rollout

• Pharmacists as guinea pigs
• Too many warnings
• Had to turn it off
• New in 2014 - In-line Dose Warnings
• 4 Strategies to Turn Down the Noise
Interactions Settings Editor (FIS)

- 9 Categories of Filtering
- We un-filtered 4
- Dose Allowance Percentage
- Admin > Med Warnings Admin > Interactions Setting Editor
## Dose Checking

<table>
<thead>
<tr>
<th>Category</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent allowance for min dose</td>
<td></td>
</tr>
<tr>
<td>Percent allowance for max dose</td>
<td>25</td>
</tr>
<tr>
<td>Filter warnings for improperly configured medications?</td>
<td>Yes</td>
</tr>
<tr>
<td>Filter no data warnings?</td>
<td>Yes</td>
</tr>
<tr>
<td>Show warnings if default gestational age is used?</td>
<td></td>
</tr>
<tr>
<td>Filter lifetime dose calculation error warnings?</td>
<td></td>
</tr>
</tbody>
</table>

### Filter the following types/ranges:

<table>
<thead>
<tr>
<th>Types/Ranges</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Daily-Low</td>
</tr>
<tr>
<td>2</td>
<td>Duration-Exceed</td>
</tr>
<tr>
<td>3</td>
<td>Duration-Low</td>
</tr>
<tr>
<td>4</td>
<td>Frequency-Low</td>
</tr>
</tbody>
</table>

### Filter the following missing condition warnings:

<table>
<thead>
<tr>
<th>Condition Type</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Creatinine Clearance</td>
</tr>
<tr>
<td>2</td>
<td>Age</td>
</tr>
<tr>
<td>3</td>
<td>Body Surface Area</td>
</tr>
<tr>
<td>4</td>
<td>Problem List Diagnosis</td>
</tr>
</tbody>
</table>
Dose Warning Analysis

• Report from Willow Menu
• Started when all warnings still filtered
• Save in Excel, narrow down to warnings you plan to un-filter
• Use pivot tables to target most frequent warnings for deeper analysis
Dosing Rule Editor

- From Medication Database Vendor
- Multiple Rules per Medication
- Factors Considered - Age, ICD-9 codes, Maintenance VS One-time
- Custom Rules Go to the Top of the List
- Admin > Med Warnings Admin > Dosing Rule Editor

Ex: Bivalirudin in Cath lab, inc daily dose limit to 42 mg/kg
RXR Record

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Single Dose</th>
<th>Daily Dose</th>
<th>Frequency</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age: 13 week old–18 year old (90–6,569 day old)</td>
<td>≤ 0 mg/kg</td>
<td>≤ 0 mg/kg</td>
<td>0 mg/kg</td>
<td>0 mg/kg</td>
</tr>
<tr>
<td>Dx: 040.89, CrCl ≤ 5.00 mL/min, Dose Type: ONE-TIME</td>
<td>≤ 0 mg/kg</td>
<td>≤ 0 mg/kg</td>
<td>0 mg/kg</td>
<td>0 mg/kg</td>
</tr>
<tr>
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<td>0 mg/kg</td>
<td>0 mg/kg</td>
</tr>
<tr>
<td>Dx: 040.89, CrCl ≤ 5.00 mL/min, Dose Type: MAINTENANCE</td>
<td>≤ 0 mg/kg</td>
<td>≤ 0 mg/kg</td>
<td>0 mg/kg</td>
<td>0 mg/kg</td>
</tr>
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<td>0 mg/kg</td>
</tr>
</tbody>
</table>
SmartGroup (OSQ)

• Smart Groups used to build Smart Sets (Order Sets)
• Can set single dose maximum within the Smart Group
• Can’t override Frequency or Daily Max Warnings
• Can’t use for Mixture Records

Ex: Cefazolin 3gm Preop Doses
SmartGroup
Frequencies (EFQ)

- PRN Frequencies can calculate number of doses per day
- Every 5 min PRN = 288 doses/day
- Remove the Schedule Settings
- No Effect on Dispensing or MAR
- Can effect BPA for dose too soon, exclude the EFQ

Ex: Sublingual nitroglycerin tab every 5 minutes PRN
Frequencies (EFQ)
Project Roll-out

• 2013 – Silent alert data analysis

• 2014 – Turn on for inpatient pharmacists (part of HIMSS Stage 7 effort)

• 2015 – Turn on for all prescribing providers in all settings (inpatient, outpatient, ED)
Outline

• Introduction/Background
• What we built
• Summary/Discussion
Lessons Learned

• Do not turn on “out of the box” drug-dose checking
• Conduct “silent” drug-dose checking analysis
• Develop system level setting strategy
• Develop sustainable individual drug strategy
• Role out to inpatient pharmacists first

Implement drug-dose checking to help our patients (and in the way not to drive prescribers or pharmacist crazy)!
Outcomes/Impact

- Decreased inappropriate doses to patients
- Physicians and pharmacists saw more alerts (true positive and false positive)
- No direct impact to nurses
STEPS™: A Summary of How Benefits Were Realized for the Value of Health IT

- Increased CPOE/EHR satisfaction due to optimized drug-dose alerts and minimized alert fatigue.
- Avoidance of adverse events, reduced care costs, and increased ROI.
- Drug-dose CDS optimized alert sensitivity and specificity based on patient-specific criteria.
I would like to acknowledge and thank Wolters Kluwer (www.wolterskluwer.com) for contributing its Medi-Span® data to this study and presentation.