A Case Study on Visual Analytics for Optimizing Drug Duplicate Alerts in a Medication Clinical Decision Support System

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Disclosure

• We do not have any conflict of interest to report.

• We do not have fancy visualization in this presentation. We only have bar chart and line chart.
mCDS: Medication Clinical Decision Support System

- *Key components in modern electronic health record (EHR) systems*
- *Specialized in preventing and reducing human errors related to drug prescription*
- *Integrated with computerized physician order entry (CPOE)*
- *Known to have a positive impact on preventing adverse drug events in healthcare institutes*
Alert fatigue

- mCDS are delivered to providers as an intervention to recommend change or reconsider of their action, typically as a form of “ALERT”

- ALERT FATIGUE: apathy of providers against alerts resulted by too many alerts

- Alert optimization: minimize the number of alerts presented to users while maintaining or maximizing effectiveness
Alert effectiveness

- **Quantitively measuring frequency of alerts changes a provider’s behavior**
- **Overridden rate**: how many alerts are overridden (acknowledged or ignored)
- **Interpreted differently by various clinical contexts on how and why alerts are generated, clinical settings, whether an alert is accepted or overridden, and characteristics of providers seen by**
Our approach

- **Data-driven approach**
  - Developed metrics representing different perspectives of effectiveness

- **Visual analytics**
  - Human visual perception is the best tool for pattern detection and decision making

- **Statistical process monitoring**
  - Automate data extraction to detect abnormality in real time
mCDS alert dialog
mCDS alert dialog

- **Triggering order**: can be associated with multiple orders already made for a patient (i.e. precondition order) at the time of ordering,
- An alert dialog may consist of multiple alert sections for each represents association between a triggering order and precondition orders.
- A provider can choose to continue or remove a triggering alert.
- **Suppression**: a function to block alerts depending on specific conditions.
- **Overridden reason**: selecting from the list or manually entering free text.
Duplicate alert

- To detect inappropriate duplication of therapeutic groups or active ingredients and are estimated significant proportion of volumes in medication related alerts

- Hard to optimize duplicate alerts, as their nature is related to clinical workflow or logistics processes, such as outpatients receiving prescriptions from different prescribers or early refill sue to holidays
Key metrics

Alert dialog
- # of alert dialog seen by user
- # of alert dialog with continued triggering order
- # of alert dialog with removed triggering order
- # of alert dialog with modification of at least one precondition orders within 10 minutes

Precondition orders
- # of alert generated in an alert dialog
- # of alert overridden reason entered (either selected or typed)
- # of alert suppressed by system
- # of modification of precondition orders
Effective metrics

\[
\% \text{ Behavioral change} = \frac{\# \text{ of alert dialog with triggering order removed} + \# \text{ of alert dialog with precondition order modified within 10 mins}}{\# \text{ of total alert dialog}}
\]

\[
\% \text{ Overridden reason entered} = \frac{\# \text{ of alert with overridden reason entered}}{\# \text{ of total alert dialog}}
\]
Proof-of-concept implementation

Dashboard
- EDW
- Tableau
- 6 month
- Task force team
Key metrics

Medication CDS Alert (Drug Duplicate)
Effective metrics
Effective metrics
### Effective metrics

#### Table 2. Descriptive statistics

<table>
<thead>
<tr>
<th></th>
<th># of patient</th>
<th># of alert dialog</th>
</tr>
</thead>
<tbody>
<tr>
<td># of patient</td>
<td>183,448</td>
<td>637,071</td>
</tr>
<tr>
<td># of patient visit</td>
<td>253,583</td>
<td>2,068,790</td>
</tr>
<tr>
<td># of provider alerted</td>
<td>14,621</td>
<td>213,226</td>
</tr>
<tr>
<td># of facility/clinic</td>
<td>706</td>
<td>1,262,747</td>
</tr>
<tr>
<td># of medication orders</td>
<td>10,916,693</td>
<td>41,123</td>
</tr>
</tbody>
</table>

#### Table 3. Overridden reason entered

<table>
<thead>
<tr>
<th>Overridden reason type</th>
<th>#Record</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prescriber Clinical Judgment</td>
<td>170,285</td>
<td>81%</td>
</tr>
<tr>
<td>Prescriber Consulted, OK Received</td>
<td>19,710</td>
<td>9%</td>
</tr>
<tr>
<td>Patient Already Tolerating</td>
<td>12,790</td>
<td>6%</td>
</tr>
<tr>
<td>Pharmacist Clinical Judgment</td>
<td>7,941</td>
<td>4%</td>
</tr>
<tr>
<td>Accept Previous Override Reason</td>
<td>22</td>
<td>0%</td>
</tr>
<tr>
<td>Total</td>
<td>210,748</td>
<td>100%</td>
</tr>
</tbody>
</table>
Case #1. Reducing nuisance alerts individually: With the combined information of mCDS end-user observation and effectiveness analysis from the dashboards, we added suppression for Dextrose 10%, 25%, 50% and 70% (3/22), and Humalog insulin (8/29). Figure 5 shows duplicate alert volume from the medications were dropped after the actions (red line).

Figure 5. Reduction of duplicate alert: left) Dextrose 10%, 25%, 50% and 70%; right) Humalog (lispro) insulin
Case #2. Early detection of filtering failure for order set related duplicate alert
Case #3. Detecting broken queries in applications
Daily duplicate alert volume trend (top: volume, bottom: normalized volume)
Effectiveness metrics (top: % behavioral change, bottom: % overridden reason entered)
Key findings

• About half of duplicate alerts were seen by pharmacy and the rest by physicians.

• Since nuisance duplicate alerts used to occur between ordering providers and referred pharmacists, the interactive visual analytics approach will be useful to understand such patterns in the clinical processes.
Limitation

- It wasn’t clearly investigated for how much individual actions affected alert effectiveness.
- There have been a number of administrative modifications done in the mCDS system, such as new rule definitions, drugs items, drug categories, and order sets.
- It is challenging to segregate alert reduction only affected by our optimization efforts.
- Did not include clinical context of mCDS alerts into the analysis, such as patient encounter types, clinical condition, facilities, and provider positions.
Future work

• Generalize the proposed approach across other mCDS alert types: drug-drug interaction, allergy, dose checking, etc.

• In addition, we will develop detailed effectiveness metrics to more accurately measure how alerts affect provider’s behaviors and clinical processes.

• Machine learning approach to detect abnormal behaviors of mCDS alert