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

Jaehoon Lee, PhD

Wendi L. Record, PharmD

Nathan C. Hulse, PhD

Intermountain Healthcare

Intermountain Healthcare

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*

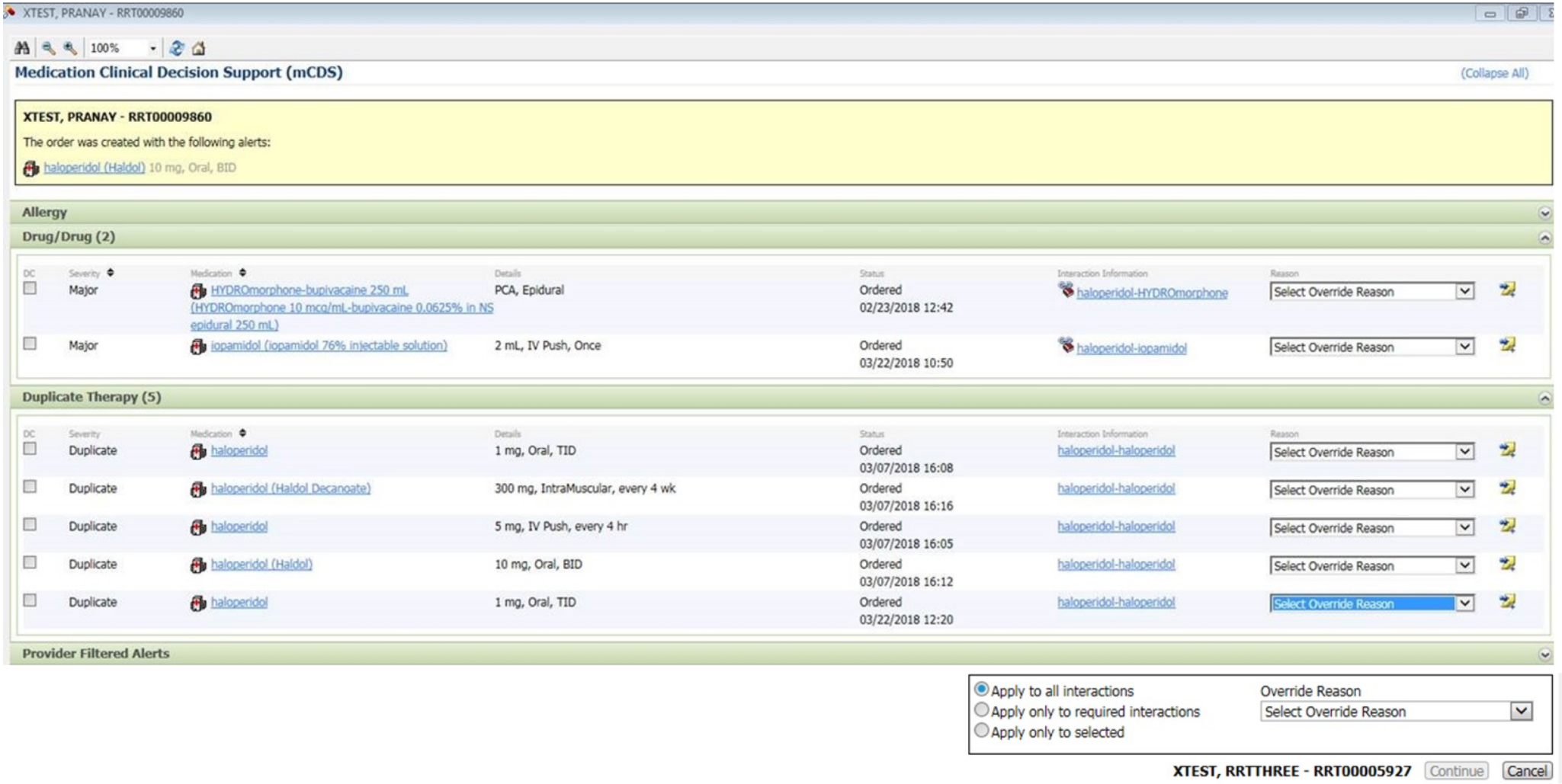
Alert effectiveness

- *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



Intermountain Healthcare

© Cerner Corporation. All rights reserved. This document contains Cerner confidential and/or proprietary information belonging to Cerner Corporation and/or its related affiliates which may not be reproduced or transmitted in any form or by any means without the express written consent

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

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

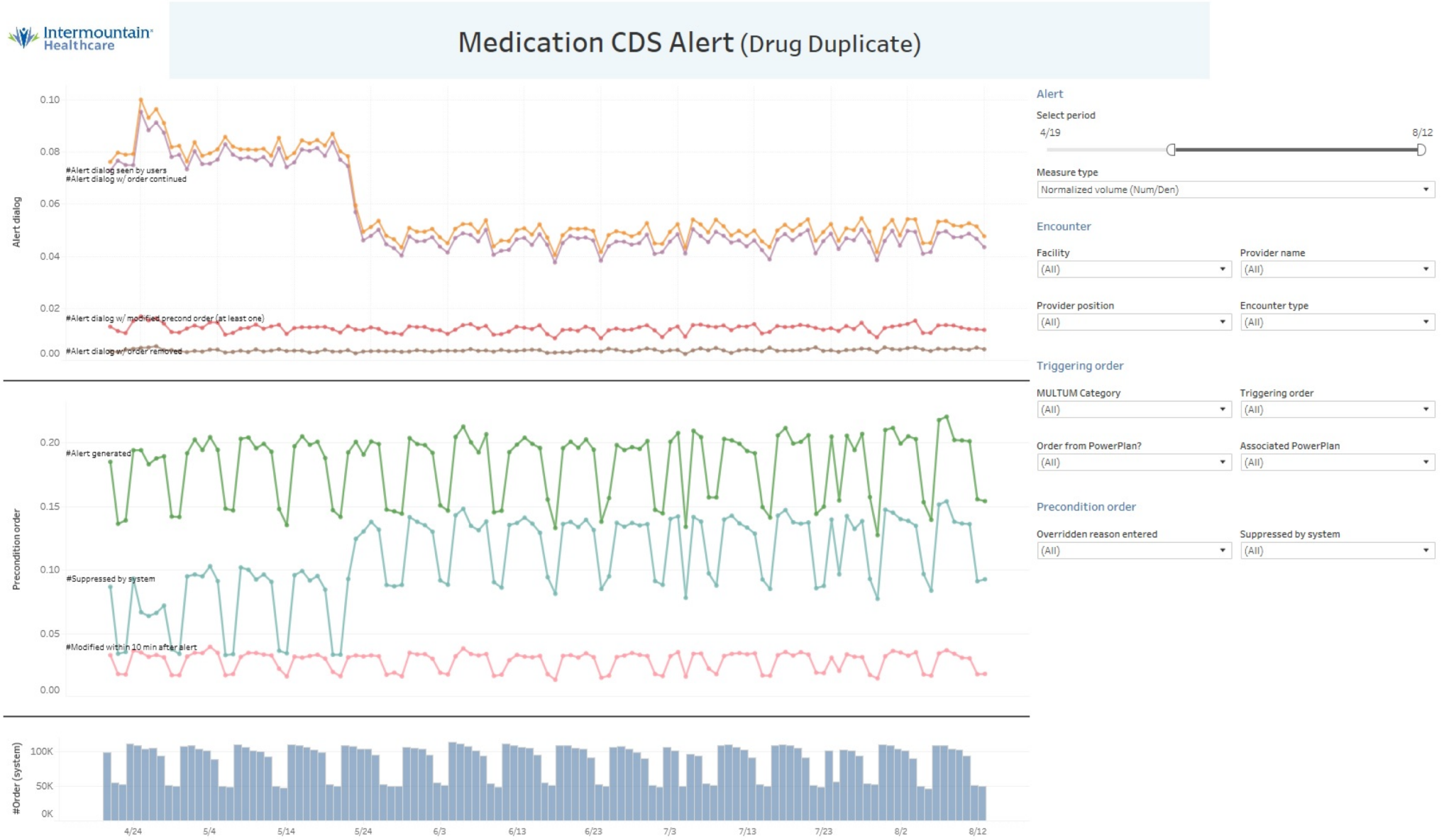
$$\%\ \text{Overridden reason entered} = \frac{\#\ \text{of alert with overriden reason entered}}{\#\ \text{of total alert dialog}}$$

Proof-of-concept implementation

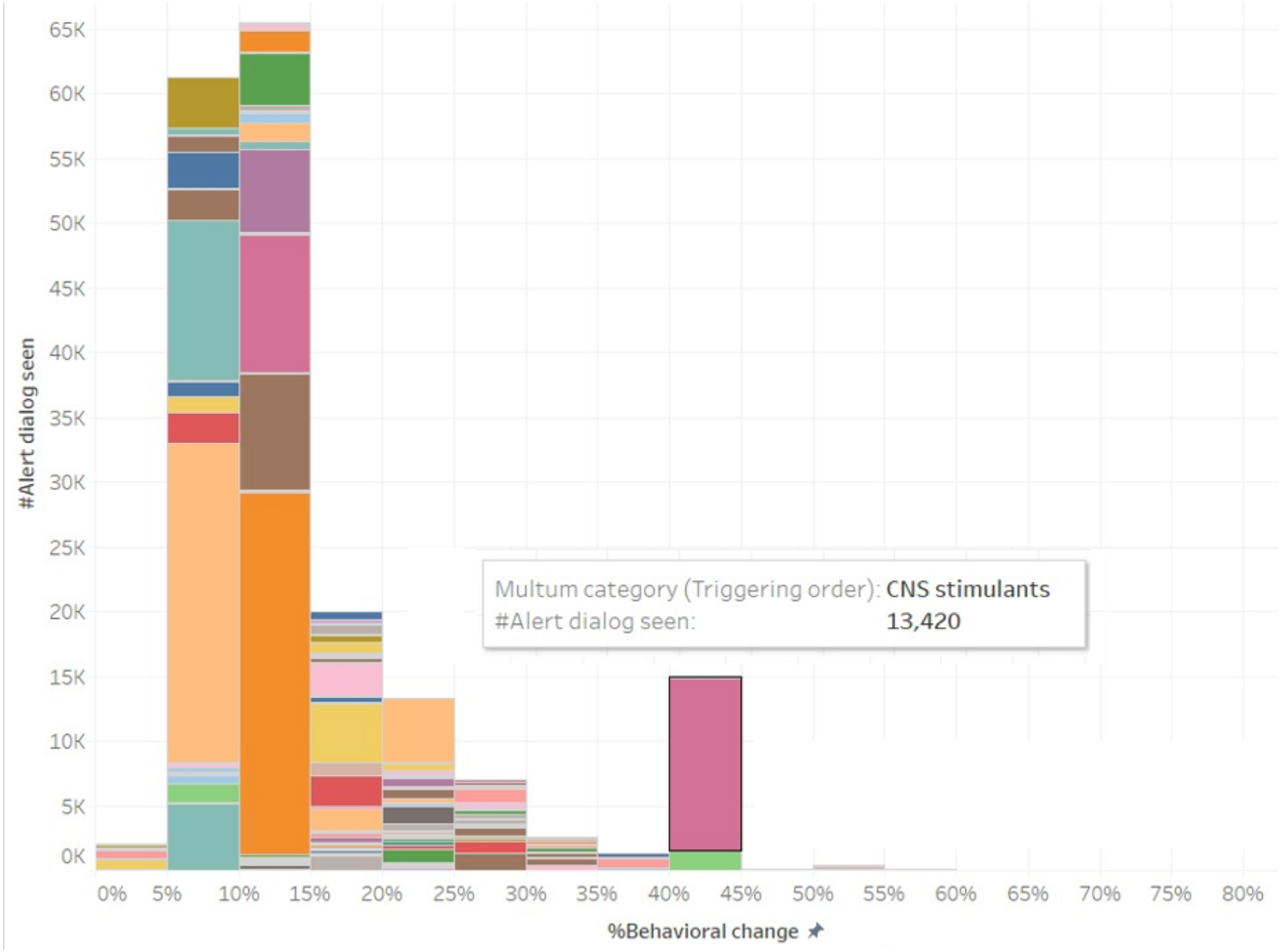
Dashboard

- *EDW*
- *Tableau*
- *6 month*
- *Task force team*

Key metrics


Intermountain Healthcare
Medication CDS Alert (Drug Duplicate)
Alert dialog
0.10
0.08
0.06
0.04
0.02
0.00
#Alert dialog seen by users
#Alert dialog w/ order continued
#Alert dialog w/ modified precond order (at least one)
#Alert dialog w/ order removed
Precondition order
0.20
0.15
0.10
0.05
0.00
#Alert generated
#Suppressed by system
#Modified within 10 min after alert
#Order (system)
100K
50K
0K
4/24
5/4
5/14
5/24
6/3
6/13
6/23
7/3
7/13
7/23
8/2
8/12
Alert
Select period
4/19
8/12
Measure type
Normalized volume (Num/Den)
Encounter
Facility
(All)
Provider name
(All)
Provider position
(All)
Encounter type
(All)
Triggering order
MULTUM Category
(All)
Triggering order
(All)
Order from PowerPlan?
(All)
Associated PowerPlan
(All)
Precondition order
Overridden reason entered
(All)
Suppressed by system
(All)

Effective metrics



Intermountain Healthcare

Effective metrics

Intermountain Healthcare

Effective metrics

Table 2. Descriptive statistics

# of patient	183,448	# of alert dialog	637,071
# of patient visit	253,583	# of alert firing	2,068,790
# of provider alerted	14,621	# of overridden reason entered	213,226
# of facility / clinic	706	# of suppression	1,262,747
# of medication orders	10,916,693	# of alert dialog with behavioral change	41,123

Table 3. Overridden reason entered

Overridden reason type	#Record	Percentage
Prescriber Clinical Judgment	170,285	81%
Prescriber Consulted, OK Received	19,710	9%
Patient Already Tolerating	12,790	6%
Pharmacist Clinical Judgment	7,941	4%
Accept Previous Override Reason	22	0%
Total	210,748	100%

Case #1. reducing nuisance alert individually

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).

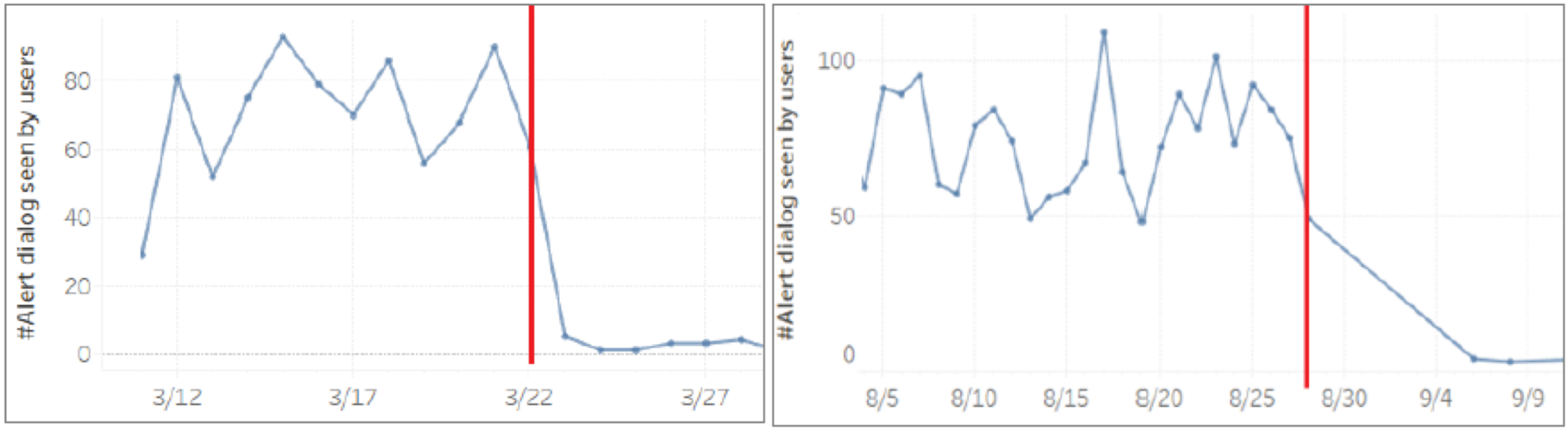
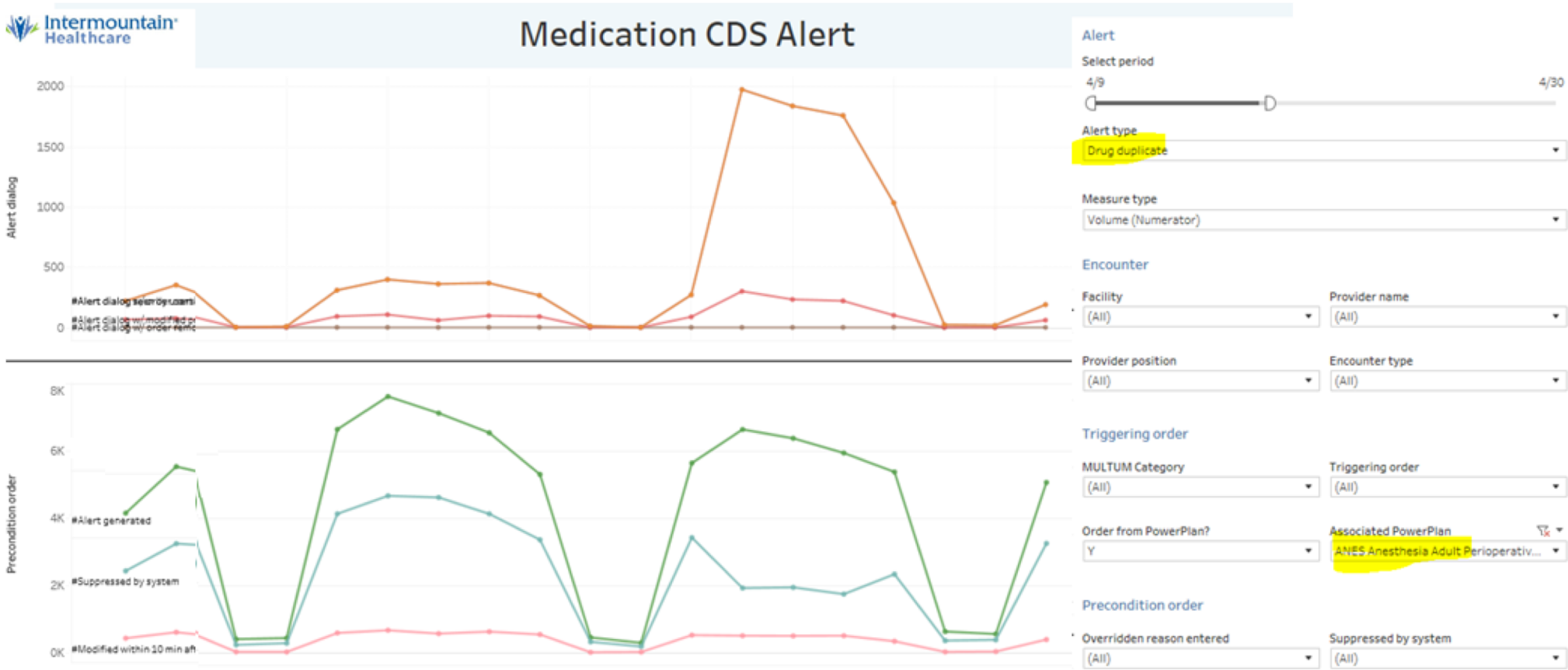
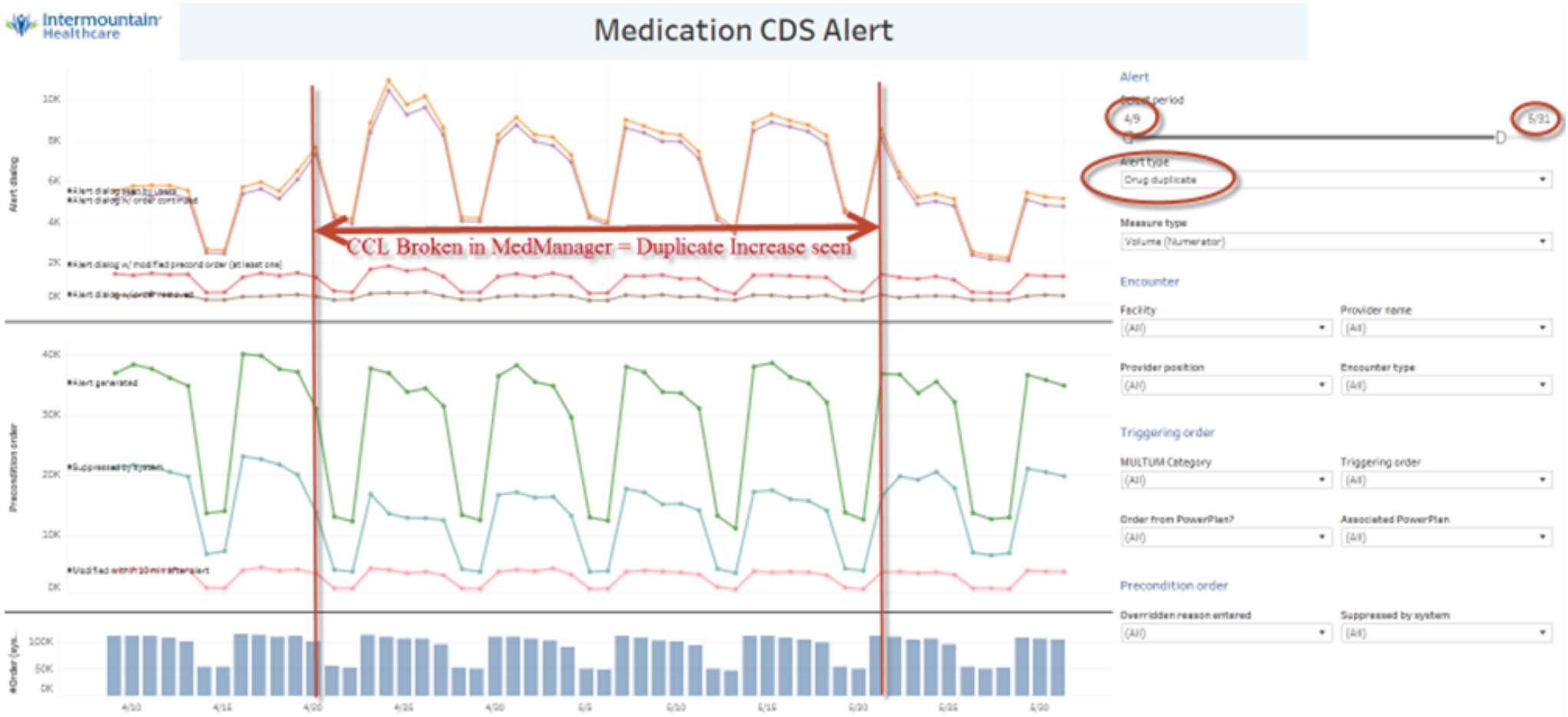


Figure 5. Reduction of duplicate alert: left) Dextrose 10%, 25%, 50% and 70%; right) Humalog (lispro) insulin

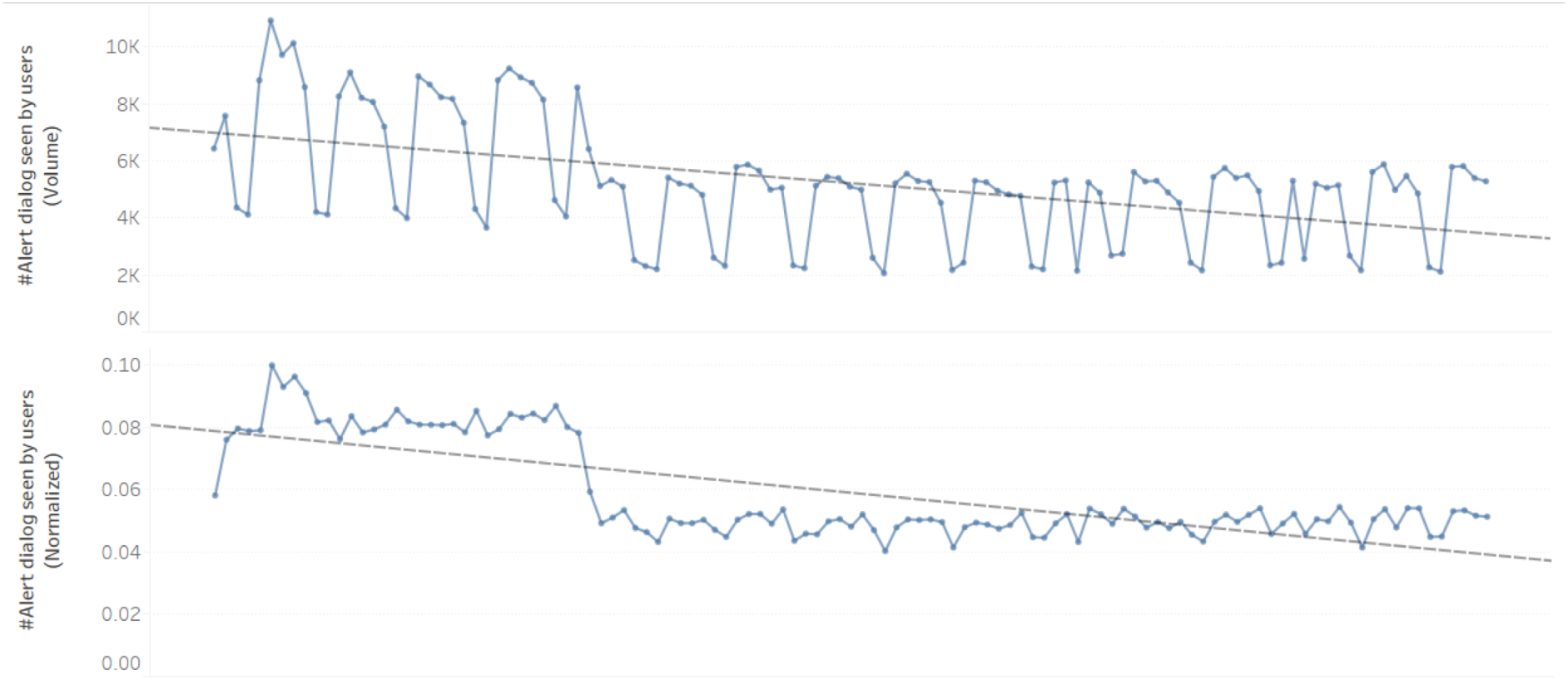
Case #2. Early detection of filtering failure for order set related duplicate alert



Case #3. Detecting broken queries in applications

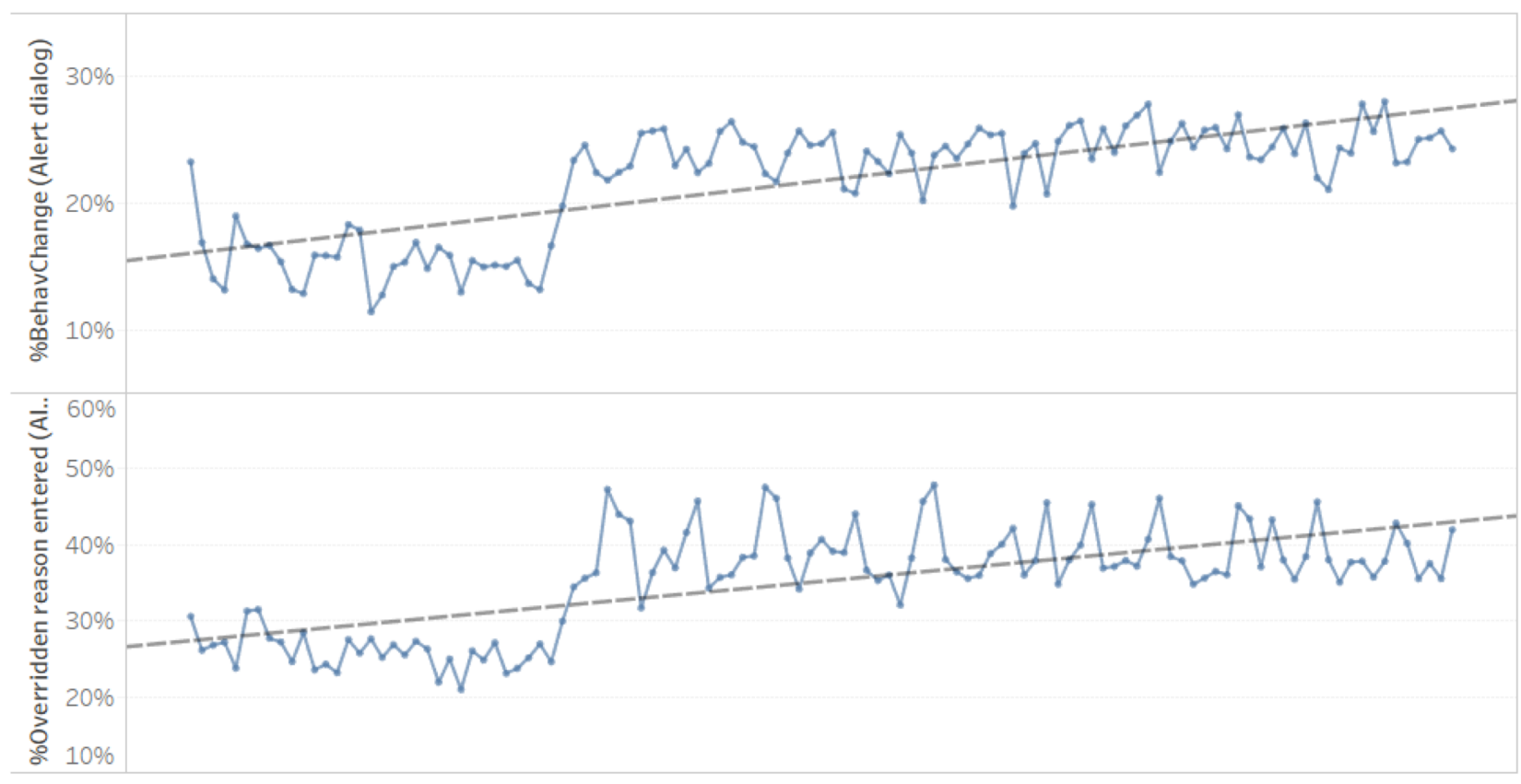


Daily duplicate alert volume trend (top: volume, bottom: normalized volume)



Intermountain Healthcare

Effectiveness metrics (top: % behavioral change, bottom: % overridden reason entered)



Intermountain Healthcare

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 to 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 affects to provider's behaviors and clinical processes.*
- *Machine learning approach to detect abnormal behaviors of mCDS alert*