CDS Malfunctions: Causes, Detection and Prevention

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Background

• Clinical Decision Support (CDS) has a number of potential benefits when working properly\(^1\)
  ▫ Increased quality of care and health outcomes
  ▫ Avoidance of errors and adverse events
  ▫ Improved efficiency, cost-benefit, and provider and patient satisfaction
Background

- Despite the promise of CDS, many safety issues and unintended consequences have been reported
- Investigators from the ONC-funded SAFER project have cataloged a number of these failures
Reminders

- Patient 65 yrs or older, may be due for Pneumococcal. Please verify historical entries.
- Patient due for seasonal influenza vaccination
- Recommend bone densitometry every 2 years and appropriate treatment for patients at high risk for osteoporosis.
- Pt on Thiazide for > 365 consecutive days. Checking K+ is recommended.

Pt on Amiodarone for > 365 consecutive days. Checking TSH level is recommended.
Pt on Amiodarone for > 365 consecutive days. Checking ALT is recommended.

- No documented height in last year. Please enter height in flowsheet.
- No documented weight in past year. Please enter weight in flowsheet.
if patient is on drug [40]
with start date > [365] days ago

and

most recent lab [tsh] not found
or > [365] days ago

then

suggest lab [tsh]
Poisson Change-point Analysis

Poisson Distribution:
\[ \Pr(X = k) = \frac{\lambda^k e^{-\lambda}}{k!} \]

Does \( \lambda \) change?

Distribution graph source: http://en.wikipedia.org/wiki/Poisson_distribution
- Patient due for repeat pneumovax.
- Patient age 18-65 with high risk medical condition, due for Pneumovax.
- Patient due for repeat Pneumovax (very high risk medical condition).
- Pt is overdue for mammogram (rec: q 1 year). FHx indicates mod risk for breast cancer.
- Patient is overdue for mammogram (rec: q 1 year). FHx indicates average risk for breast cancer.
- Patient is due for mammogram by [redacted] (rec: q 1 year). FHx indicated moderate risk for breast cancer.
- Patient is due for mammogram by [redacted] (rec: q 1 year). FHx indicated average risk for breast cancer.
- Patient is overdue for pap smear (rec q 3 years).
- Patient is due for pap smear by [redacted] (rec q 3 year).
- Patient has CHF, BP >140/90, and ACEI is not on the med list. Recommend ACE inhibitor.
- Patient has Renal Dysfunction, BP >140/90, and ACEI is not on the medication list. Recommend ACE inhibitor.
- Recommend thiazide diuretic in patients with BP >140/90.
- Patient overdue for total cholesterol and LDL cholesterol (rec q 5 years).
- Patient overdue for total cholesterol and LDL cholesterol (rec q 5 years).
- Patient overdue for total cholesterol and LDL cholesterol (rec q 5 years).
- Patient overdue for total cholesterol and LDL cholesterol (rec q 5 years).
- Patient almost due for total cholesterol and LDL cholesterol by [redacted] (rec q 5 years).
- Patient almost due for total cholesterol and LDL cholesterol by [redacted] (rec q 5 years).
- Patient has an incomplete Advance Directive profile. Click to complete documentation.
- This high risk Medicaid patient is eligible for telephonic health coaching.
AMDIS Survey Results
Overview

- The Association of Medical Directors of Information Systems (AMDIS) is the professional organization for CMIOS and other physicians responsible for health information technology

- Survey conducted in April, 2014

- 29 responses from members of AMDIS
Which types of CDS are currently in use at your site?

- Drug-drug interaction alerts
- Allergy alerts
- Screening / preventive care reminders
- Renal dose adjustments
- Alerts about abnormal test results
- Drug-pregnancy alerts
- Reminders to patients
How often has your site experienced CDS malfunctions?

- Never: 7%
- Less than once a year: 27%
- 1-3 times a year: 28%
- 4 or more times a year: 38%
Did any of these factors contribute to CDS malfunctions that you found?

- Upgrade of your EHR software
- Changes to underlying codes or data fields
- Inadvertent disabling or enabling of a rule
- Upgrade of another clinical information system
- Database corruption or another system malfunction
How confident are you that your existing processes and procedures are sufficient to prevent or detect all CDS malfunctions before they reach the user?

- Not at all confident: 22%
- Not very confident: 45%
- Somewhat confident: 26%
- Very confident: 7%
- Totally confident: 0%
How did you find the malfunctions?

- Report from users: 80%
- Noticed in my own use of the system: 50%
- Ongoing system testing: 30%
- Reviewing reports of CDS performance: 20%
Summary

- CDS usage is widespread among AMDIS members; > 70% have basic CDS
- 2/3 report 1 or more CDS malfunctions/year
- EHR upgrades and changes to underlying codes are most common causes of failure
- Confidence in existing prevention strategies is low
- Over 80% of malfunctions are reported by users; current prevention strategies are not working
CDS Anomaly Detection Project
CDS Anomaly Objective

Develop and evaluate an innovative approach to proactively identify CDS failures, drawing from the field of anomaly detection.
Specific Aims

• **Aim 1:**
  ▫ Inventory CDS failures and issues that have occurred at three core medical centers and conduct root cause analyses (RCA) on these failures
  ▫ Use this information to develop best practices for preventing andremediating CDS failures
Specific Aims

• **Aim 2:**
  ▫ Develop and validate portable anomaly detection models for identifying CDS failures

• **Aim 3:**
  ▫ Evaluate and generalize CDS anomaly detection models to the community hospital setting
  ▫ Update CDS anomaly taxonomy and best practices, release software and disseminate findings
Aim 1

Site Visits
Taxonomy of CDS Anomalies
Aim 1: Site Visits

- **Objective:** Inventory CDS failures at core medical sites and analyze their causes

- **Conducted interviews at BWH and OSU**
  - Clinicians, software developers, analysts, corporate managers, CMIOs

- **Coded interview transcripts**
  - Each new site builds off the pre-existing codes

- **Next steps**
  - Conduct interviews at other sites
  - Conduct root cause analyses on catalog of CDS failures
Aim 1: Site Visits

- Brigham and Women’s Hospital (BWH)
- University of Texas Health Science Center at Houston (UTH)
- The Ohio State University Medical Center (OSUMC)
- Holy Spirit Hospital
- Baptist Health
Aim 1: Taxonomy of CDS Anomalies

Conditions
- Correctly functioning
- Incorrectly functioning

Causes
- Poor communication
- Version problem
- Software upgrade
- Error in rule logic
- Database corruption

Patterns
- Never fired
- Abrupt stop
- Abrupt spike
- Gradual decline
- Spurious firing

Impacts
- Care delayed
- Patient harmed
- Physician annoyed
- Patient died
Aim 2

Anomaly Detection Algorithm
CDS Alerts Dashboard Viewer
Aim 2: Anomaly Detection Algorithm

- Goal: Develop and validate portable anomaly detection models for identifying CDS failures
- Different types of anomalies are amenable to different methods of detection
- Multi-faceted approach
  - Change point detection
  - Seasonal Trend Decomposition with Loess (STL)
  - Outlier Scores
Aim 2: Anomaly Detection Algorithm

Baseline drift (Undocumented smoking status)
Baseline drift (Amiodarone)
Baseline shift (Lead screening)
Burst/Spike (Aspirin for CAD)
Anomaly Detection Model
Upstream Anomaly Detection
Aim 2: CDS Alerts Dashboard

CDS Alerts Viewer

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<th>Chart</th>
<th>Anomaly rating</th>
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Aim 3
Dissemination to the Community
Aim 3: Community Dissemination

- Apply the results of Aim 1 and Aim 2 to the community hospital setting (Holy Spirit Hospital, Baptist Health)
- Use the information gathered from this application to update CDS anomaly taxonomy and best practices
- Package and disseminate software developed from this process
Lessons Learned / Process Improvements

- Additional knowledge management tools and processes
- Frequent testing, including in the production environment
- Proactive monitoring
- Dependency checking
- Improvements in reliability of interrelated systems
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