Health IT Detection of Medication Errors in US Hospitals – Implications for the VA Health Care System

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Unexpected Increased Mortality After Implementation of a Commercially Sold Computerized Physician Order Entry System

Scott Watson, Trung C. Nguyen, Hülya Bayir and Richard A. Orr

Yong Y. Han, Joseph A. Carcillo, Shekhar T. Venkataraman, Robert S.B. Clark,Richard A Orr.

Pediatrics 2005;116;1506-1512

High Rates of Adverse Drug Events in a Highly Computerized Hospital

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Background: Numerous studies have shown that specific computerized interventions may reduce medication errors, but few have examined adverse drug events (ADEs) across all stages of the computerized medication process. We describe the frequency and type of inpatient ADEs that occurred following the adoption of multiple computerized medication ordering and administration systems, including computerized physician order entry (CPOE).

Methods: Using explicit standardized criteria, pharmacists classified inpatient ADEs from prospective daily reviews of electronic medical records from a random sample of all admissions during a 20-week period at a Veterans Administration hospital. We analyzed ADEs that necessitated a changed treatment plan.

Results: Among 937 hospital admissions, 483 clinically significant inpatient ADEs were identified, accounting for 52 ADEs per 100 admissions and an incidence density of 70 ADEs per 1000 patient-days. One quarter of the hospitalizations had at least 1 ADE. Of all ADEs, 9% resulted in serious harm, 22% in additional monitoring and interventions, 32% in interventions alone, and 11% in monitoring alone; 27% should have resulted in additional interventions or monitoring. Medication errors contributed to 27% of these ADEs. Errors associated with ADEs occurred in the following stages: 61% ordering, 25% monitoring, 13% administration, 1% dispensing, and 0% transcription. The medical record reflected recognition of 76% of the ADEs.

Conclusions: High rates of ADEs may continue to occur after implementation of CPOE and related computerized medication systems that lack decision support for drug selection, dosing, and monitoring.

Arch Intern Med. 2005;165:1111-1116

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Financial Disclosure: None.

MULTIPLE BROAD-BASED studies during the past 15 years have demonstrated that adverse drug events (ADEs) account for up to 41%[1] of all hospital admissions and more than $2 billion annually in inpatient costs.[2-4] Several of these studies have also estimated that as many as a quarter of inpatient ADEs may be preventable through interventions such as computerized physician order entry (CPOE) and related systems.[3-7] On the basis of these projections and the proven success of these systems in identifying ADEs and reducing medication errors,[8-11] computerized medication processes have been widely promoted as essential to preventing actual ADEs.[9,12,13]

Recently, some researchers have questioned the extent to which currently available CPOE and related systems are preventing ADEs.[14-16] There are concerns that features of commercial CPOE products vary widely and that few can match the sophistication of custom systems developed at institutions that have successfully reduced targeted ADEs.[13,17-21] Moreover, broad-based surveys of ADEs in institutions that have implemented multiple computerized medication systems have not been published; it is unclear how these interventions together have affected the occurrence of ADEs linked to problems across stages of medication processing (ie, ordering, transcription, dispensing, administration, and monitoring).[5]

The Veterans Administration (VA) Healthcare System, one of the largest integrated delivery systems in the country, is a leader in patient safety and has actively sought to reduce medication errors using multiple computerized interventions such as CPOE,[22-26] bar code–controlled medication delivery,[9,27,28] a complete electronic medical record,[1,29-31] automated drug-drug interaction checking,[32-35] and computerized allergy tracking and alerting.[36-38] The White House has

Recommendation 1 (continued)

b. The Office of the National Coordinator for Health IT (ONC) should expand its funding of processes that promote safety that should be followed in the development of health IT products, including standardized testing procedures to be used by manufacturers and health care organizations to assess the safety of health IT products.

c. ONC and AHRQ should work with health IT vendors and health care organizations to promote post-deployment safety testing of EHRs for high prevalence, high impact EHR-related patient safety risks.

d. Health care accrediting organizations should adopt criteria relating to EHR safety.

e. AHRQ should fund the development of new methods for measuring the impact of health IT on safety using data from EHRs.

The Office of the National Coordinator for Health Information Technology

SAFER Guides:
Safety Assurance Factors for EHR Resilience

Kathy Kenyon, JD MA, Office of the National Coordinator
Joan Ash, PhD MLS, MS, MBA, Oregon Health & Science University
Hardeep Singh, MD MPH, Houston VA and Baylor College of Medicine
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January 30, 2014

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  - High Priority Practices
  - Organizational Responsibilities
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  - System Configuration
  - System Interfaces
  - Contingency Planning
- **Clinical Process Guides**
  - Patient Identification
  - Computerized Provider Order Entry with CDS
  - Test Results Reporting and Follow-up
  - Clinician Communication

SAFER Self Assessment Computerized Provider Order Entry with Decision Support

Recommended Practice 22 Worksheet

Phase 2 — Using Health IT Safely

Recommended Practice

22 CPOE and CDS functionality are tested to ensure proper operation before go-live and with test patients in the production system before clinical use.

HIPAA

» Checklist

Implementation Status

Off

Principle: Complete/Correct EHR Use

Rationale for Practice or Risk Assessment

Appropriate testing reduces the risk of errors associated with inappropriate CDS or CPOE system behavior.

Suggested Sources of Input

Clinicians, support staff, and/or clinical administration

EHR developer

Health IT support staff

Examples of Potentially Useful Practices/Scenarios

- The Leap Frog test is taken to ensure the safety of CDS.[77-79]
- CDS interventions are evaluated to ensure correct firing of alerts and reminders.[80]

Assessment Notes

Follow-up Actions

Person Responsible for Follow-up Action

reset page

Click on a link below to view the topic online:

SAFE PRACTICE 16: SAFE ADOPTION OF COMPUTERIZED PRESCRIBER ORDER ENTRY

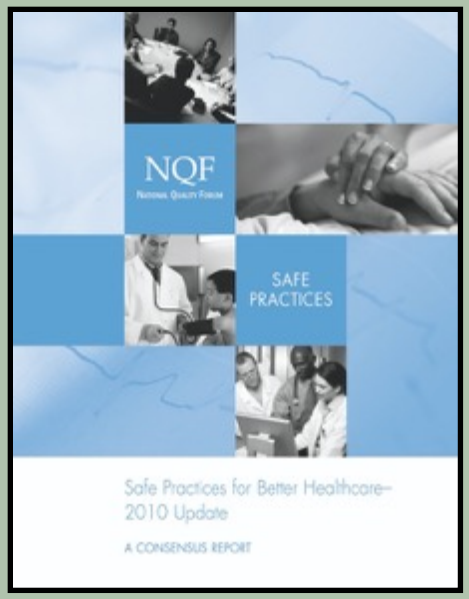
The Objective

Promote the safe use of medications, tests, and procedures through the successful implementation of integrated clinical information technologies that reduce preventable harm to patients.

The Problem

Medical errors related to medication and other clinical ordering errors are common. The majority of such events are preventable. In 2006, the Institute of Medicine (IOM) estimated that 400,000 preventable drug-related injuries occur in hospitals and that an additional 800,000 injuries occur in long-term care settings each year. [IOM, 2007]

The frequency of such errors is alarming: More than 500,000 Medicare recipients experience a medication-related injury during visits to outpatient clinics each year. A recent study estimated that 1 of every 10 adult patients suffers a serious medication-related adverse event. [Adams, 2008] The rate for pediatric patients is estimated to be three times higher than the rate for adults. [Kaushal, 2001]



Information Transfer and Clear Communication

-Excerpt-

CPOE may be adopted with a stage approach once integrated information systems are in place to support safety and effective CPOE systems…

The CPOE system is tested against The AHRQ/NQF Inpatient CPOE Testing Standards…developed to provide organizations that are implementing CPOE with appropriate decision support about…

Example Implementation Approaches

- Providing training early in the development of a CPOE system will increase user familiarity and enhance safety and efficiency. [Ghahramani, 2009; Niazkhani, 2009]
- During the pre-implementation phase, address concerns of staff to ensure better user receptivity and effectiveness with the CPOE system. [Georgiou, 2009]
- CPOE may be adopted with a staged approach once integrated information systems are in place to support safe and effective CPOE systems. At least 75 percent of all inpatient medication orders should be entered directly by a licensed prescriber:
  - Stage 1: CPOE is in place on at least one ward/unit in the hospital.
  - Stage 2: CPOE is in place on three or more wards/units in the hospital.
  - Stage 3: CPOE is in place on more than 50 percent of the wards in the hospital.
  - Stage 4: Full compliance with at least 75 percent of all medications entered through the CPOE system by the prescriber.
- The CPOE system is tested against The Leapfrog Group Inpatient CPOE Testing Standards. These standards were developed to provide organizations that are implementing CPOE with appropriate decision support about alerting levels; these alerting levels need to be carefully set to avoid overalerting and underalerting. [Anderson, 2009] One way to ensure effective alerting is through

Relationship between medication event rates and the Leapfrog computerized physician order entry evaluation tool

Alexander A Leung,[1] Carol Keohane,[1] Stuart Lipsitz,[1] Eyal Zimlichman,[1] Mary Amato,[1,2] Steven R Simon,[1] Michael Coffey,[3] Nathan Kaufman,[3] Bismarck Cadet,[4] Gordon Schiff,[1] Diane L Seger,[1] David W Bates[1]

ABSTRACT

Objective The Leapfrog CPOE evaluation tool has been promoted as a means of monitoring computerized physician order entry (CPOE). We sought to determine the relationship between Leapfrog scores and the rates of preventable adverse drug events (ADE) and potential ADE.

Materials and methods A cross-sectional study of 1000 adult admissions in five community hospitals from October 1, 2008 to September 30, 2010 was performed. Observed rates of preventable ADE and potential ADE were compared with scores reported by the Leapfrog CPOE evaluation tool. The primary outcome was the rate of preventable ADE and the secondary outcome was the composite rate of preventable ADE and potential ADE.

Results Leapfrog performance scores were highly related to the primary outcome. A 43% relative reduction in the rate of preventable ADE was predicted for every 5% increase in Leapfrog scores (rate ratio 0.57; 95% CI 0.37 to 0.88). In absolute terms, four fewer preventable ADE per 100 admissions were predicted for every 5% increase in overall Leapfrog scores (rate difference −4.2; 95% CI −7.4 to −1.1). A statistically significant relationship between Leapfrog scores and the secondary outcome, however, was not detected.

Discussion Our findings support the use of the Leapfrog tool as a means of evaluating and monitoring CPOE performance after implementation, as addressed by current certification standards.

Conclusions Scores from the Leapfrog CPOE evaluation tool closely relate to actual rates of preventable ADE. Leapfrog testing may alert providers to potential vulnerabilities and highlight areas for further improvement.

in the rates of preventable ADE and potential ADE—is an arduous and expensive process.[1 9–12] Therefore, for practical reasons, most hospitals seeking to evaluate the effectiveness of a CPOE system are limited to indirect, surrogate measures.

To this effect, the Leapfrog Group has developed an independent, inexpensive, and standardized tool for assessing the performance of a hospital's CPOE system by using simulation cases. In essence, the Leapfrog CPOE evaluation tool estimates the potential benefit of a CPOE system by testing how it handles a variety of dangerous medication ordering scenarios.[1 8 13] Accordingly, performance scores are presumed to be linked to actual outcomes.[1]

Objective

The Leapfrog CPOE evaluation tool, presently the only instrument of its kind, has been quickly adopted into practice for monitoring purposes.[8 13 14] However, it still remains uncertain whether Leapfrog performance scores are related to outcomes in real-world settings as empirical evidence is currently lacking.[8] Addressing this evidence gap, we sought to determine the relationship between test scores and actual rates of preventable ADE and potential ADE.

MATERIALS AND METHODS

We performed a cross-sectional study to compare the rates of preventable ADE and potential ADE with scores reported by the Leapfrog CPOE evaluation tool. This study was conducted independently of the Leapfrog Group and was approved by the institutional review boards at each hospital site.

AHRQ EHR Flight Simulator

Principles Behind the Evaluation Methodology

- **Principle #1: Target the Harm**
  - Common sources of ADEs (not errors)
  - Sources of severe harm (existing literature and expert consensus)
- **Principle #2: Encourage Quality Improvement**
  - Categorize test set by type of error
  - Provide feedback to the provider organization for each category
  - Provide advice about nuisance alerting
- **Principle #3: Accentuate the positive**
  - Encourage quality, as well as harm reduction (ADE's)
    - **Address errors of commission and omission**
    - **Include corollary orders and duplicate interventions**

Many Research Databases Used

Research background, combined with the practical experience of the EHR pioneers, was first used to define the focus.

Preventable ADEs in 10.4/100 admissions to six community hospitals

Types of CPOE-preventable ADEs	Percentage*
Patient Diagnosis	1
Duplicate Med Check	1
Drug-drug	2
Drug Frequency	3
Drug Allergy	4
Drug-specific Guidelines+	7
Drug-age	9
Drug dose Suggestion (typical)	9
Renal Check	19
Drug-lab Check	27

* All sites
\+ Ondansetron

Source: Bates et al. "Saving lives, Saving money: The Imperative for Computerized Physician Order Entry in Massachusetts Hospitals." The Clinical Baseline and Financial Impact Study. MTC and NEHI. February 2008.

Simulations of EHR Use with CPOE

The assessment pairs medication orders that would cause a serious adverse drug event with a fictitious patient.

A physician enters the order …

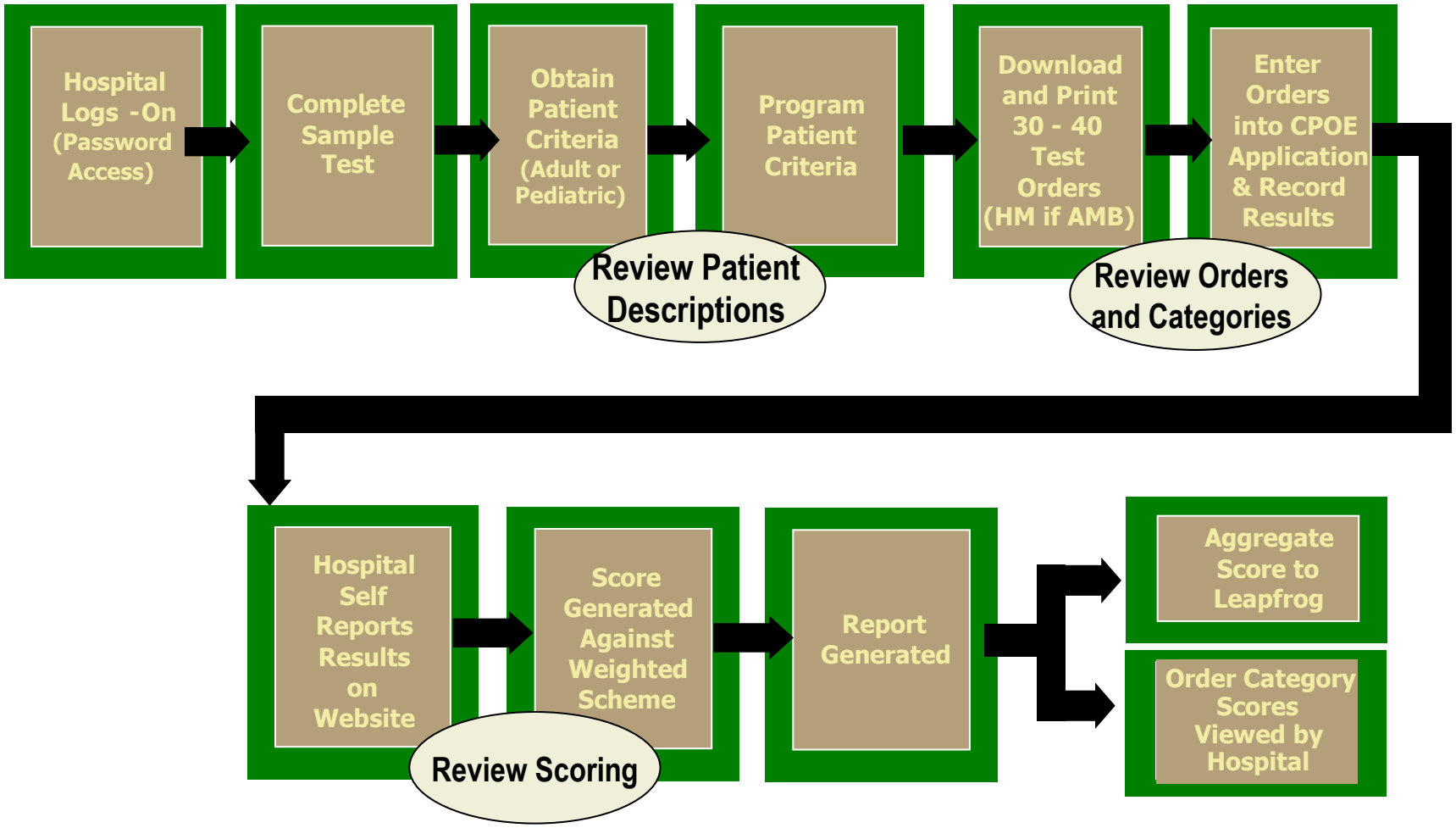
Patient AB

Female
52 years old
Weighs 60 kg
Allergy to morphine
Normal creatinine

and observes and records the type of CDS-generated advice that is given (if any).

Coumadin (Warfarin) 5 mg po three times a day.

Web-Based Evaluation Tool



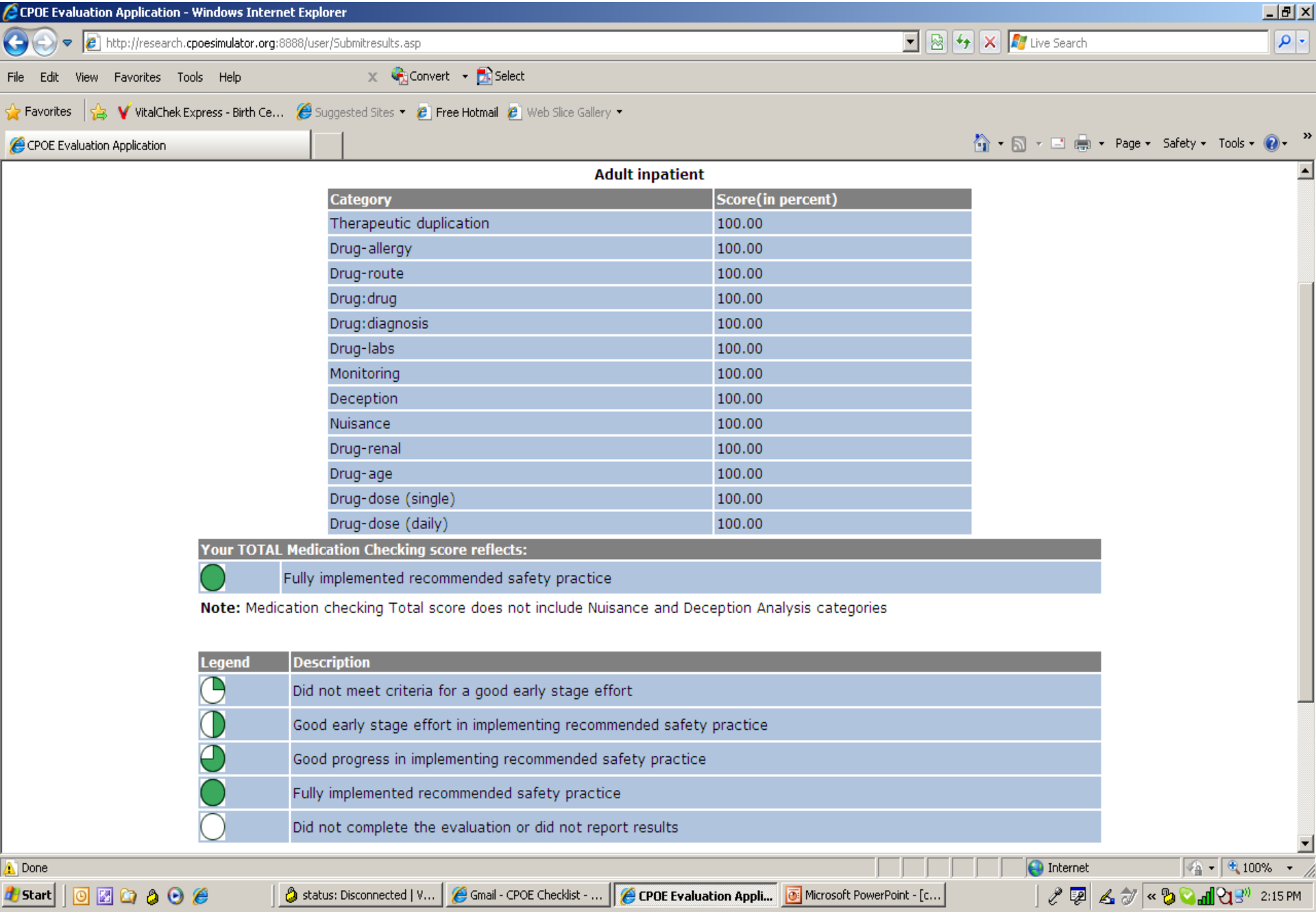
The team of advisors helped to define the order categories in the assessment to reflect the sources of common, preventable ADEs identified in research.

Order Category	Description	Example
Therapeutic duplication	Medication with therapeutic overlap with another new or active order; may be same drug, within drug class, or involve components of combination products	Codeine ***AND*** Tylenol #3
Single and cumulative dose limits	Medication with a specified dose that exceeds recommended dose ranges or cumulative dose	Ten-fold excess dose of methotrexate
Allergies and cross-allergies	Medication (or medication class) for which patient allergy has been documented	Penicillin prescribed for patient with documented penicillin allergy
Contraindicated route of administration	Order specifying an inappropriate route of administration (e.g., oral, intramuscular, intravenous)	Tylenol to be administered intravenously
Drug-drug interaction	Medication that results in known, dangerous interaction when used in combination with a different medication in a new or existing order for the patient	Digoxin ***AND*** Quinidine

The team of advisors helped to define the order categories in the assessment to reflect the sources of common, preventable ADEs identified in research. cont.

Order Category	Description	Example
Contraindication/dose limits based on patient diagnosis	Medication either contraindicated based on patient diagnosis or diagnosis affects appropriate dosing	Nonspecific beta blocker in patient with asthma
Contraindication dose limits based on patient age and weight	Medication either contraindicated for this patient based on age and weight or for which age and weight must be considered in appropriate dosing	Adult dose of antibiotic in a newborn
Contraindication/dose limits based on laboratory studies	Medication either contraindicated for this patient based on laboratory studies or for which relevant laboratory results must be considered in appropriate dosing	Normal adult dose regimen of renally eliminated medication in patient with elevated creatinine
Corollary	Intervention that requires an associated or secondary order to meet the standard of care	Prompt to order drug levels when ordering Dilantin

Print your results and sign-out.



Intermountain Medical Center

5121 South Cottonwood Street
Murray, UT 84157

This Hospital's Grade

C

FALL 2017

Learn how to use the Leapfrog Hospital Safety Grade

► Show Recent Past Grades

Detailed table view

Infections | Problems with Surgery | Practices to Prevent Errors | Safety Problems | Doctors, Nurses & Hospital Staff

Click Each Measure to Learn More

Hospital Performs Below Average — Above Average

Doctors order medications through a computer	Handwashing	Communication about medicines	Communication about discharge	Staff work together to prevent errors
				

This Hospital's Score:
5

Best Hospital's Score:
100

Hospital's Score:
78.21

Worst Hospital's Score:
5

Doctors order medications through a computer

Hospitals can use Computerized Physician Order Entry (CPOE) systems to order medications for patients in the hospital, instead of writing out prescriptions by hand. Good CPOE systems alert the doctor if they try to order a medication that could cause harm, such as prescribing an adult dosage for a child. CPOE systems help to reduce medication errors in the hospital.

Hospitals can earn up to 100 points for using a well-functioning CPOE system in most areas of the hospital. Timing of the data.

What safer hospitals do:

Hospitals use CPOE systems in all areas of the hospital and regularly test those systems to ensure they are alerting doctors to potential ordering errors.

By Jane Metzger, Emily Welebob, David W. Bates, Stuart Lipsitz, and David C. Classen

Mixed Results In The Safety Performance Of Computerized Physician Order Entry

DOI: 10.1377/hlthaff.2010.0160
HEALTH AFFAIRS 29,
NO. 4 (2010): 655–663

ABSTRACT **Computerized physician order entry is a required feature for hospitals seeking to demonstrate meaningful use of electronic medical record systems and qualify for federal financial incentives. A national sample of sixty-two hospitals voluntarily used a simulation tool designed to assess how well safety decision support worked when applied to medication orders in computerized order entry. The simulation detected only 53 percent of the medication orders that would have resulted in fatalities and 10–82 percent of the test orders that would have caused serious adverse drug events. It is important to ascertain whether actual implementations of computerized physician order entry are achieving goals such as improved patient safety.**

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Emily Welebob is an independent consultant in Indianapolis, Indiana.

David W. Bates is division chief for general internal medicine at Brigham and Women's Hospital in Boston, Massachusetts.

Stuart Lipsitz is a researcher at Brigham and Women's Hospital.

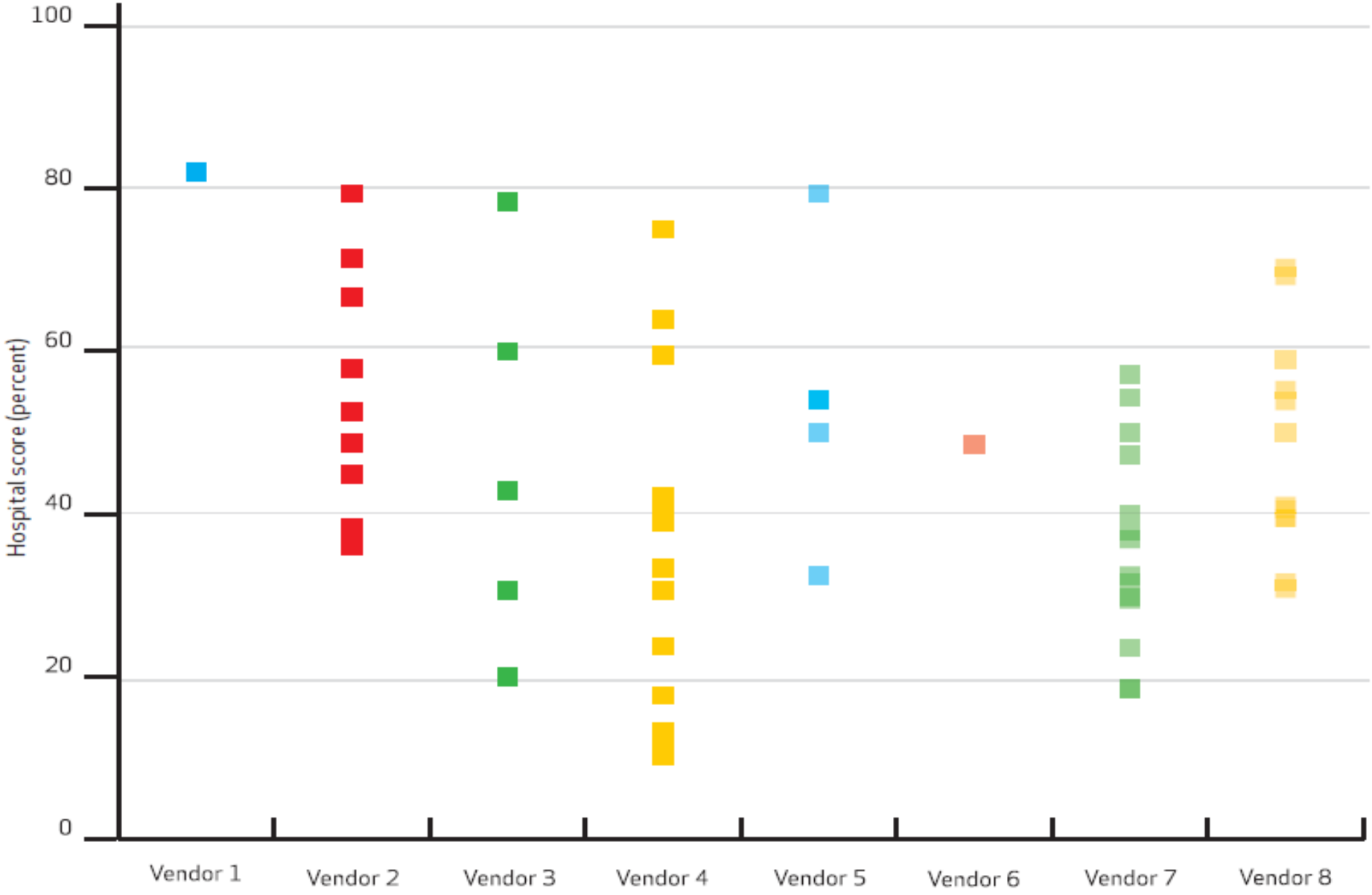
David C. Classen is an associate professor of medicine at the University of Utah in Salt Lake City, and is also with CSC Healthcare.

Many people have suggested that electronic health records represent essential infrastructure for the provision of safe health care in the United States. For several years, the Institute of Medicine, the Leapfrog Group, the National Quality

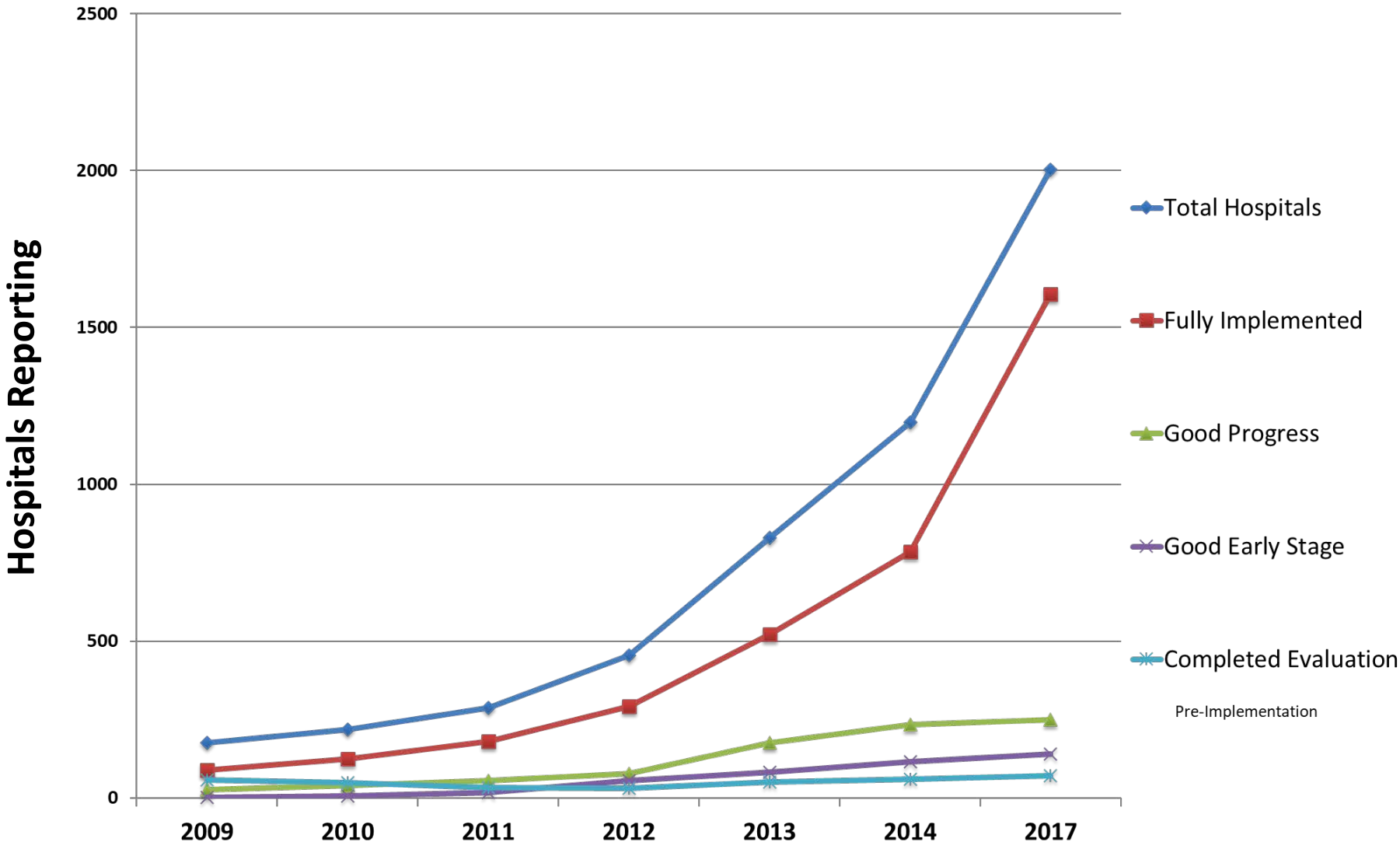
In this application of clinical decision support, physicians are made aware of potential safety issues that can result—for example, when ampicillin is given to a patient with a known allergy to penicillin, or the dose being ordered for a pediatric patient is much higher than the therapeutic range for a child of this age and weight. Prescrib-

EXHIBIT 2

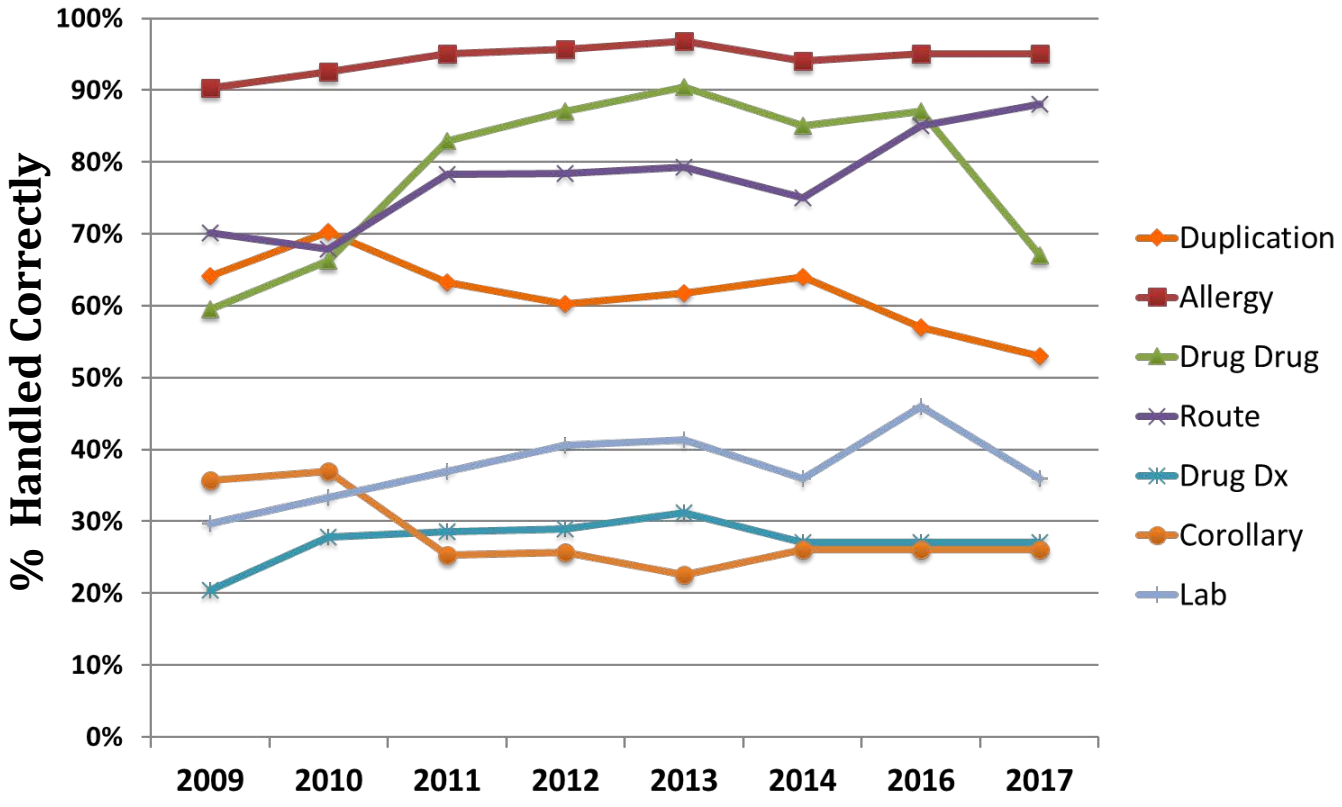
Hospital Scores For Detection Of Test Orders That Would Cause An Adverse Drug Event In An Adult Patient According To The Software Product (Vendor) Implemented



Growth in Participation and Performance



Handled Correctly by Checking Category - 1



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National Trends in the Safety Performance of Electronic Health Record Systems From 2009 to 2018

David C. Classen, MD, MS; A. Jay Holmgren, MHI; Zoe Co, BS; Lisa P. Newmark, BA; Diane Seger, RPh; Mellissa Danforth, BA; David W. Bates, MD, MSc

Abstract

IMPORTANCE Despite the broad adoption of electronic health record (EHR) systems across the continuum of care, safety problems persist.

OBJECTIVE To measure the safety performance of operational EHRs in hospitals across the country during a 10-year period.

DESIGN, SETTING, AND PARTICIPANTS This case series included all US adult hospitals nationwide that used the National Quality Forum Health IT Safety Measure EHR computerized physician order entry safety test administered by the Leapfrog Group between 2009 and 2018. Data were analyzed from July 1, 2018 to December 1, 2019.

EXPOSURE The Health IT Safety Measure test, which uses simulated medication orders that have either injured or killed patients previously to evaluate how well hospital EHRs could identify medication errors with potential for patient harm.

MAIN OUTCOMES AND MEASURES Descriptive statistics for performance on the assessment test over time were calculated at the overall test score level, type of decision support category level, and EHR vendor level.

RESULTS Among 8657 hospital-years observed during the study, mean (SD) scores on the overall test increased from 53.9% (18.3%) in 2009 to 65.6% (15.4%) in 2018. Mean (SD) hospital score for the categories representing basic clinical decision support increased from 69.8% (20.8%) in 2009 to 85.6% (14.9%) in 2018. For the categories representing advanced clinical decision support, the mean (SD) score increased from 29.6% (22.4%) in 2009 to 46.1% (21.6%) in 2018. There was considerable variation in test performance by EHR vendor and associated variation in national hospital quality reporting metrics by vendor as well.

CONCLUSIONS AND RELEVANCE These findings suggest that despite broad adoption and optimization of EHR systems in hospitals, wide variation in the safety performance of operational EHR systems remains across a large sample of hospitals and EHR vendors. Hospitals using some EHR vendors had significantly higher test scores. Overall, substantial safety risk persists in current hospital EHR systems.

JAMA Network Open. 2020;3(5):e205547. doi:10.1001/jamanetworkopen.2020.5547

Key Points

Question How did safety performance of electronic health record systems (EHRs) change in the US from 2009 to 2018?

Findings In this case series using 8657 hospital-year observations from adult hospitals nationwide that used the National Quality Forum Health IT Safety Measure, a computerized physician order entry and EHR safety test, from 2009 to 2018, mean scores on the overall test increased from 53.9% in 2009 to 65.6% in 2018. There was considerable variation in test performance by hospital and EHR vendor.

Meaning These findings suggest that, despite broad adoption and optimization of EHR systems in hospitals, wide variation in the safety performance of operational EHR systems remains across a large sample of hospitals and EHR vendors, and serious safety vulnerabilities persist in these operational EHRs.

+ Invited Commentary

+ Supplemental content and Audio

Author affiliations and article information are listed at the end of this article.

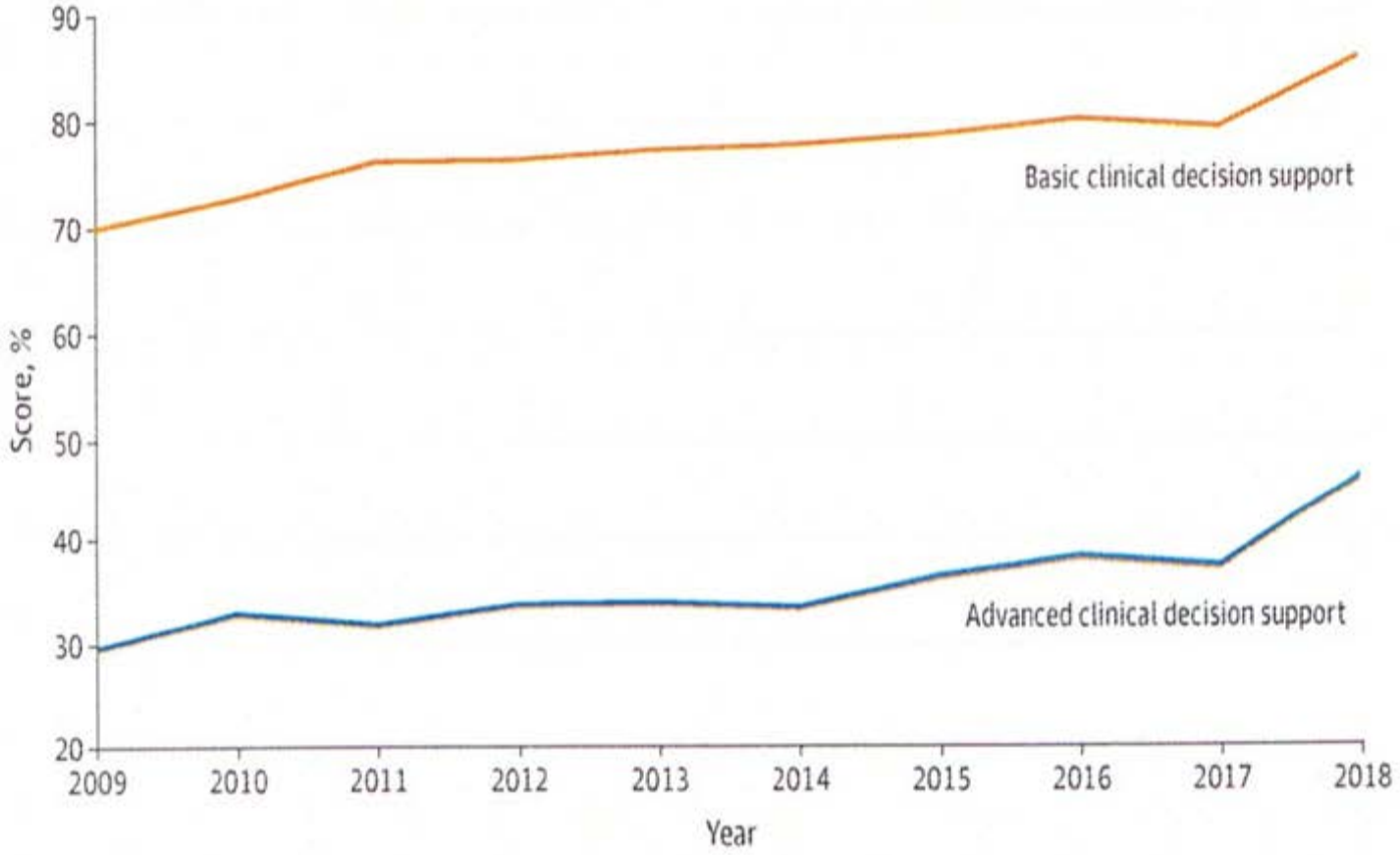
CPOE EHR Assessment Scores Over Time

The overall mean (SD) total score increased from 53.9% (18.3%) in 2009 to 65.6% (15.4%) in 2018. Mean (SD) hospital score for the categories representing basic CDS increased from 69.8% (20.8%) in

Table 1. Hospital Characteristics

Characteristic	Hospital-year observations, No. (%)
EHR vendor	
A	2620 (30.7)
B	2199 (25.7)
C	1996 (23.4)
D	514 (6.0)
E	352 (4.1)
F	225 (2.6)
G	141 (1.7)
H	111 (1.3)
Other	386 (4.6)
Hospital size (beds)	
Small (<100)	1501 (17.3)
Medium (100-399)	4429 (51.2)
Large (≥400)	2727 (31.5)
Organizational characteristics	
Member of a health care system	6117 (70.7)
Teaching hospital	3813 (44.0)
Location	
Rural	2613 (30.2)
Urban	6044 (69.8)
Ownership	
Private nonprofit	5326 (61.5)
Private for-profit	1494 (17.3)
Public nonfederal	780 (9.0)
Geographic region	
Northeast	1548 (17.9)
West	1870 (21.6)
Midwest	1484 (17.1)
South	2698 (31.2)

Figure 1. Basic and Advanced Clinical Decision Support Test Scores Over 10 Years



JAMA Network Open. 2020;3(5):e205547. doi:10.1001/jamanetworkopen.2020.5547

Figure 2. Category Test Scores Over Time

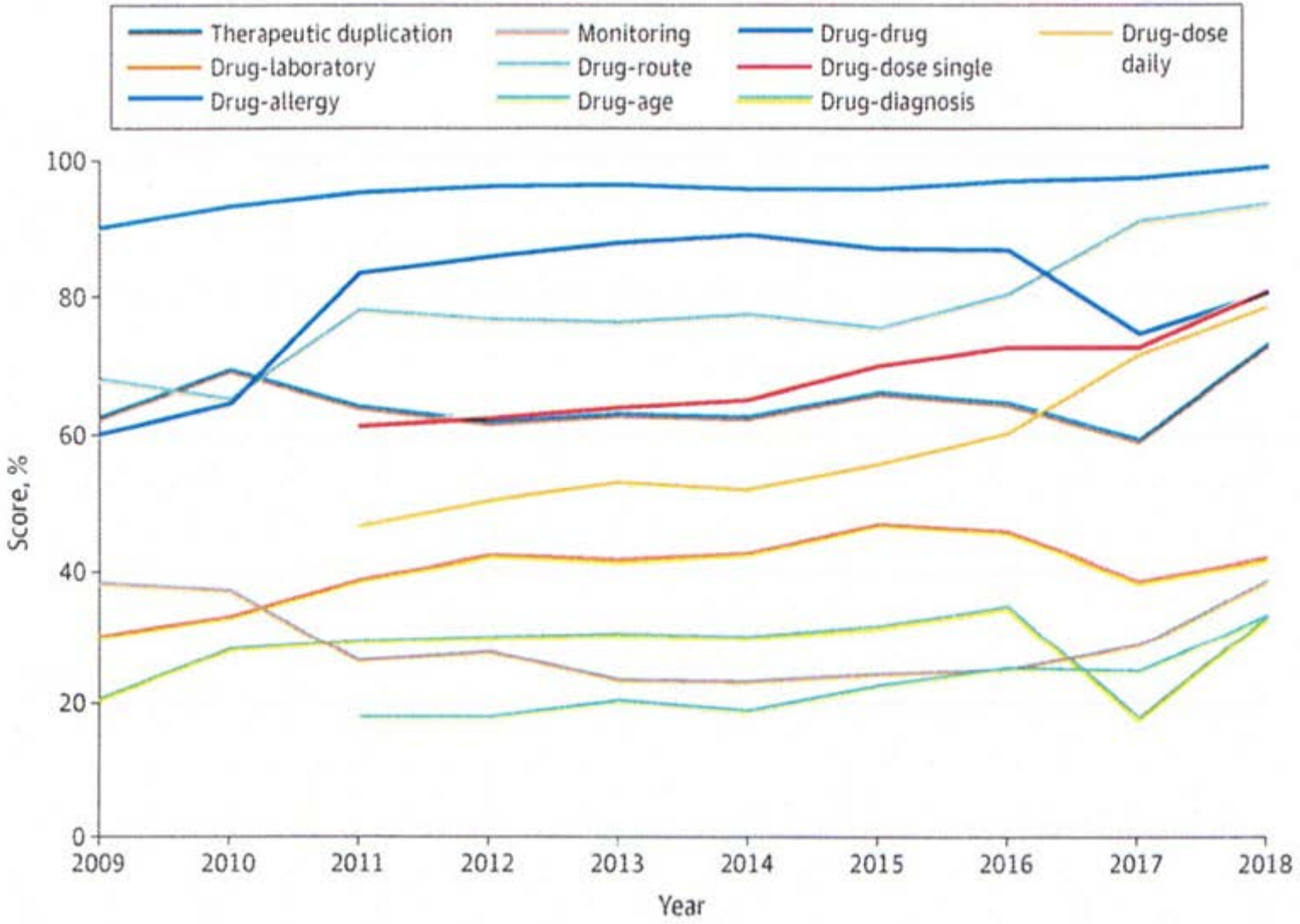
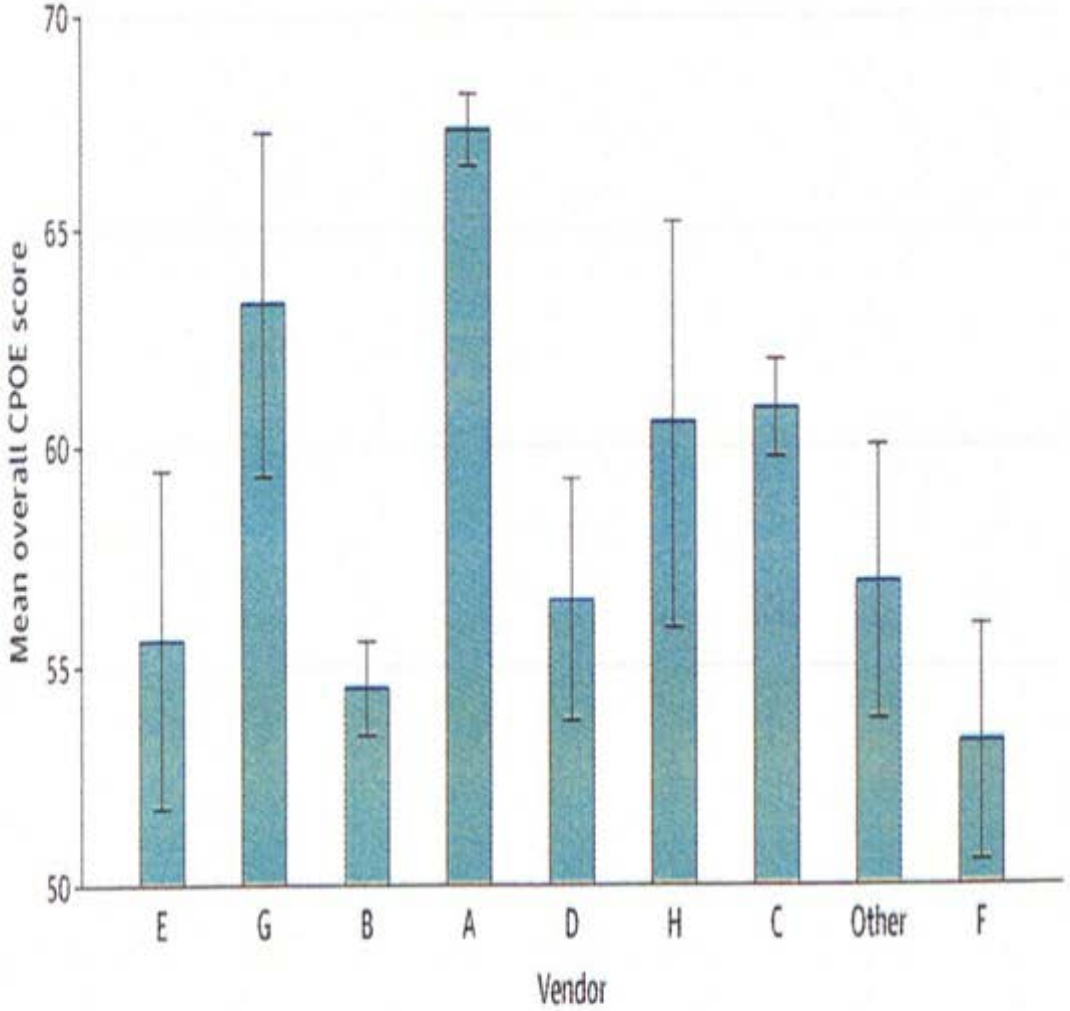


Figure 3. Summary of Hospital Overall Scores by Electronic Health Record Vendor



CPOE indicates computerized physician order entry; Whiskers, SD.

Table 2. Hospital and EHR Vendor Correlations

Variable	β (95% CI)	*P* value
EHR vendor		
Other	[Reference]	NA
A	11.26 (8.10 to 14.42)	<.001
B	-2.21 (-0.54 to 0.99)	.18
C	3.57 (0.32 to 6.81)	.03
D	0.47 (-3.59 to 4.52)	.82
E	-1.41 (-5.97 to 3.15)	.55
F	-3.38 (-7.45 to 0.68))	.10
G	5.49 (0.77 to 10.20	.02
H	2.41 (-2.98 to 7.81)	.38
Vendor only partial R^2	0.099	NA
R^2 including hospital characteristics controls	0.146	NA

Abbreviations: EHR, electronic health record; NA, not applicable.

Table 2. Hospital and EHR Vendor Correlations with Hospital Quality Measures

	Hospital Overall Score		CMS Hospital Compare Star Rating		CMS HAC Rating		CMS HRRP Ratio*	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
EHR Vendor								
Other Vendors	Ref							
Vendor A	**11.26**	**0.00**	**1.05**	**0.00**	-0.04	0.69	**0.02**	**0.01**
Vendor B	-2.21	0.18	**0.62**	**0.00**	-0.02	0.85	0.02	0.07
Vendor C	**3.57**	**0.03**	**0.73**	**0.00**	-0.01	0.92	0.01	0.48
Vendor D	0.47	0.82	0.34	0.15	0.07	0.60	0.02	0.11
Vendor E	-1.41	0.55	**0.51**	**0.03**	0.00	1.00	0.01	0.53
Vendor F	-3.38	0.10	0.28	0.69	0.24	0.41	0.00	0.94
Vendor G	**5.49**	**0.02**	**1.08**	**0.00**	-0.34	0.11	**0.04**	**0.03**
Vendor H	2.41	0.38	**0.91**	**0.00**	-0.25	0.31	**0.03**	**0.02**

* HRRP dependent variable is reverse scored, so positive coefficient is interpreted as lower (better) readmissions ratio

NEW CATEGORIES

Order Category	Description	Example
CHOOSING WISELY	INAPPROPRIATE ORDERING OF MEDICATIONS, LABORATORY TEST, RADIOLOGIC TESTS	ORDERING OF VIT D LEVELS IN LOW RISK PATIENTS
PREVENTION OF COMMON HOSPITAL COMPLICATIONS	APPROPRIATE ORDERING OF INTERVENETIONS TO PREVENT HOSPITAL COMPLICATIONS -- CLABSI OR DVT	ORDERING OF APPROPRIATE INTERVENTIONS FOR PATIENTS WITH CENTRAL LINES IN PLACE
USABILITY OF CLINICAL DECISION SUPPORT	EVALUATION OF USABILITY OF COMMON DECISION SUPPORT CAPABILITY	USE OF THE IMEDESA TOOL
MEDICATION RECONCILIATION	EVALUATION OF EHR AUTOMATED MEDICATION RECONCILIATION	PATIENT FOLLOWED IN CLINIC WITH RECENT HOSPITAL DISCHARGE AND DISCORDANT MEDICATION LIST

AMBULATORY EHR ASSESSMENT TOOL

Expert Panel Meeting

February 5, 2020

GORDON AND BETTY MOORE FOUNDATION

CHPSO
A division of the Hospital Quality Institute

HEALTH
UNIVERSITY OF UTAH

Institute for Healthcare Improvement
NPSF
TOGETHER FOR SAFER CARE

BWH BRIGHAM AND WOMEN'S HOSPITAL

A Chicago Tribune investigation targets a health problem that sends thousands of Americans to the hospital each year: Life-threatening interactions between prescription medications.

DANGEROUS DOSES DEC. 14, 2010

Part 3: Pharmacies miss half of dangerous drug combinations

Pharmacists should tell patients about drug interactions that could cause severe harm or death. But testing of 255 pharmacies found that many failed to say a word about the risks. CVS, Walgreens, Wal-Mart and others are promising reforms. MORE

DANGEROUS DOSES FEB. 11, 2010

Part 1: Finding dangerous drug interactions

The Chicago Tribune teamed with data scientists and pharmacologists to identify pairs of drugs that may increase the risk of a fatal heart condition.

DANGEROUS DOSES FEB. 11, 2010

Part 2: Drug mix leaves woman fighting for life

Flint Beckli Caraway had a sore throat and cough. Then a rash. Soon, her skin peeled off in sheets.

The New York Times https://nyti.ms/30wt3e

How Chaos at Chain Pharmacies Is Putting Patients at Risk

Pharmacists across the U.S. warn that the [illegible] mistakes are more likely. "Lat[illegible]

By [illegible]

Jan. 31, 2020

For Alyssa Watrous, the medication mix-up meant a pounding headache, nausea and dizziness. In September, Ms. Watrous, a 17-year-old from Connecticut, was about to take another asthma pill when she realized CVS had mistakenly given her blood pressure medication intended for someone else.

Edward Walker, 38, landed in an emergency room, his eyes swollen and burning after he put drops in them for five days in November 2018 to treat a mild irritation. A Walgreens in Illinois had accidentally supplied him with ear drops — not eye drops.

For Mary Scheuerman, 85, the error was discovered only when she was dying in a Florida hospital in December 2018. A Publix pharmacy had dispensed a powerful chemotherapy drug instead of the antidepressant her doctor had prescribed. She died about two weeks later.

Results: By Categories

Order Category	Description
Therapeutic duplication	Medication with therapeutic overlap with new or current medication
Drug-dose (single)	Specified dose that exceeds recommended dose ranges for single dose
Drug-dose (daily)	Specified dose that exceeds recommended dose ranges for daily dose
Drug-allergy	Medication for which a patient allergy has been documented
Drug-pregnancy	Medication is contraindicated in pregnant patient
Drug-drug	Medication that results in potentially dangerous interaction when administered in combination with another new or current medication
Drug-diagnosis	Medication contraindicated based on electronically documented diagnosis
Drug-age	Medication contraindicated based on electronically documented patient age
Drug-renal	Medication contraindicated or requires dose adjustment based on patient renal status as indicated in laboratory test results
Drug-lab	Medication contraindicated or requires dose adjustment based on patient metabolic status (other than renal) as indicated in laboratory test results
Monitoring	Medication requires an associated order for monitoring to meet the standard of care
Nuisance	Medication order triggers advice or information that physicians consider invalid or clinically insignificant
Deception	Used to detect testing irregularities

RESULTS

	Vendor A	Vendor B	Vendor C	Vendor D	Vendor E	Vendor F	Vendor G	
Category	**Score**	**Score**	**Score**	**Score**	**Score**	**Score**	**Score**	**Mean**
Drug allergy	100%	100%	100%	100%	100%	100%	100%	**100.0%**
Drug-drug interaction	75.0%	100%	75.0%	100.0%	100.0%	100.0%	75%	**89.3%**
Drug Pregnancy	100.0%	100%	75.0%	75.0%	75.0%	100.0%	0%	**75.0%**
Drug dose (daily)	100.0%	0%	100.0%	75%	100.0%	100.0%	75%	**78.6%**
Drug diagnosis	0.0%	100%	50.0%	100.0%	100.0%	100.0%	0%	**64.3%**
Drug dose (single)	50.0%	0%	100.0%	25%	50.0%	100.0%	75%	**57.1%**
Drug age	0.0%	0%	0.0%	100%	75.0%	100.0%	0%	**39.3%**
Therapeutic duplication	0.0%	75%	0.0%	0%	75.0%	100.0%	25%	**39.3%**
Drug laboratory	0.0%	0%	0.0%	0.0%	0.0%	0.0%	0%	**0.0%**
Drug monitoring	0.0%	0%	0.0%	0.0%	0.0%	0.0%	0%	**0.0%**
Overall	**42.5%**	**47.50%**	**52.5%**	**57.5%**	**67.5%**	**80%**	**32.5%**	**54.3%**
Deception	100%	100%	100%	100%	100%	100%	100%	100%
Nuisance	100%	50%	100%	100%	25%	0%	75%	64%

VA Experience – Evaluating Health IT Detection Methods

HSR&D Cyber Seminar

October 28. 2020

Presenter: Jeanie Scott, MS, CPHIMS, FAMIA

Our Project Objectives

- Embarked on this project to understand methods for detecting vulnerabilities within VHA HIT systems.
  - How do we know at enterprise, facility, user-level Health IT systems are working correctly?
- Given scale of VA, how do we accomplish this using an approach that is both valid and practical?

These goals are consistent with our strategic objective for achieving high reliability:

- ✓ Commitment to being a learning organizing and addressing vulnerabilities
- ✓ Being mindful of all the system factors that may contribute to deviations
- ✓ Maintaining a big picture awareness of CPOE performance across the enterprise
- ✓ Engaging relevant expertise

Our Project Team

- David Classen, MD, MSc
- Aaron Dietz, PhD
- Danielle Kato, PharmD
- Angela Laurio, DrPH, RN
- Jeanie Scott, MS, CPHIMS
- Samantha Zybak, BS (contractor to Informatics Patient Safety program)

Evaluation of CPOE Assessment Tool

- Applied the tool within our own test account to learn more about evaluation process and establish scoring expectations (Facility 0).
- Applied CPOE Assessment Tool at 6 VA medical centers
- Entire process includes three phases :
  - Introduction and sample assessment (1-1.5 hrs)
  - Actual assessment (2.5 – 4 hrs) -
  - Debriefing (~1 hr)
- Facility personnel needed:
  - Clinical Application Coordinator/other staff to enter patient data into test system (15-30min for sample assessment; 30min-1.5hrs for actual assessment)
  - Facility POC (introduction/sample assessment, debriefing, actual assessment, debriefing)
  - Licensed provider (1.5-2hrs)
  - Does not account for resources to set up test patients***

Approx. facility time: 4.5 - 6.5hrs + Prep

Results – (simple version)

Category	Facility 0	Facility 1	Facility 2	Facility 3	VA Expected	2017 Leapfrog (Co et al., 2018)
Drug Dose (Single)	100%	100%	100%	100%	100%	70.8%
Drug Dose (Daily)	100%	100%	100%	100%	100%	69.8%
Drug-Drug Interaction	100%	75%	100%	100%	100%	65.9%
Therapeutic Duplication	100%	0%	100%	100%	100%	52.0%
Drug-Allergy	100%	75%	100%	100%	100%	92.3%
Drug Route	0%	0%	0%	0%	--	85.5%
Drug Laboratory	0%	0%	0%	0%	--	34.2%
Drug Monitoring	0%	0%	0%	0%	25%	27.0%
Drug Diagnosis	0%	0%	0%	0%	--	19.1%
Drug Age	0%	0%	0%	0%	--	16.7%
Alert fatigue orders missed?	No	No	No	No	None	11%
Fatal orders missed?	No	No	No	No	None	25%

Findings and Insights

Configuration Settings Influence System Behavior "Under the Hood" Results

		Facility 1					Facility 2					Facility 3				
Order Check Category	**Type of Order Check**	**Score**	**Package**	**System**	**User**	**Editable**	**Score**	**Package**	**System**	**User**	**Editable**	**Score**	**Package**	**System**	**User**	**Editable**
Drug Dosage (daily and single)	Drug dosage	100%	Enabled	Null	Enabled	**No**	100%	Enabled	Null	Null	No	100%	Enabled	Null	Enabled	**No**
Drug-drug interaction	Critical drug interaction	75%	Enabled	Enabled	Enabled	Null	100%	Enabled	Null	Null	Null	100%	Enabled	Null	Enabled	Null
	Significant drug interaction		Enabled	Null	Disabled	Null		Enabled	Null	Null	Null		Enabled	Enabled	Enabled	Null
Therapeutic Duplication	Duplicate drug therapy	0%	Enabled	Enabled	Disabled	Null	100%	Enabled	Enabled	Null	Null	100%	Enabled	Null	Enabled	Null
	Duplicate opioid medication		Disabled	Null	Disabled	Null		Disabled	Null	Null	Null		Disabled	Null	Enabled	Null
Drug allergy	Allergy-drug interaction	75%	Enabled	Enabled	Enabled	Null	100%	Enabled	Null	Null	Null	100%	Enabled	Enabled	Enabled	Null
	No allergy assessment		Disabled	Enabled	Enabled	Null		Disabled	Null	Null	Null		Disabled	Enabled	Enabled	Null
Drug Laboratory	Estimated creatine	0%	Enabled	Enabled	Enabled	Null	0%	Enabled	Null	Null	Null	0%	Enabled	Enabled	Enabled	Null
	Aminoglycoside ordered		Enabled	Enabled	Disabled	Null		Enabled	Null	Null	Null		Enabled	Enabled	Enabled	Null
	Glucophage-lab results interactions		Enabled	Null	Disabled	Null		Enabled	Null	Null	Null		Enabled	Enabled	Enabled	Null
Drug Age	Renal functions over 65	0%	Enabled	Enabled	Disabled	Null	0%	Enabled	Null	Null	Null	0%	Enabled	Disabled	Enabled	Null
	Dangerous meds for pt > 64		Null	Enabled	Disabled	Null		Null	Null	Null	Null		Enabled	Enabled	Enabled	Null
Drug route	Not supported	0%	N/A	N/A	N/A	N/A	0%	N/A	N/A	N/A	N/A	0%	N/A	N/A	N/A	N/A
Drug monitoring	Not supported	0%	N/A	N/A	N/A	N/A	0%	N/A	N/A	N/A	N/A	0%	N/A	N/A	N/A	N/A
Drug Diagnosis	Not supported	0%	N/A	N/A	N/A	N/A	0%	N/A	N/A	N/A	N/A	0%	N/A	N/A	N/A	N/A

More prescriptive feedback may help facilities redress shortcomings

Overall Assessment Results

Table 1 outlines the performance of your CPOE system in relation to (1) expected scores based on the VA's VistA CPRS order checking capabilities for the simulated orders that were tested, (2) national averages for other medical centers taking the exact test, and (3) the system's order check settings at the time the assessment was conducted. We denoted instances where order check settings may have influenced scores or could be a vulnerability even if a perfect score was obtained for an order checking category. Order checks that are enabled at the system level and not editable by the user will ensure they are triggered as expected. System level settings supersede package level settings in terms of order checking precedence; package level settings are not specific to a facility, whereas system settings are. User settings supersede package and system level settings. For instance, if an order check is enabled at the package and system level, but disabled by the user, the order check will not be triggered.

Table 1 Overall CPOE System Performance

CPOE Category	Your Score	VistA Expected Score[1]	National Averages[2]	Type of Order Check	Order Check Settings			
					Package	System	User	Editable
Drug Dose Single	100%	100%	70.8%	Drug Dosage	Enabled ✓	Null	Enabled ✓	No ✓
Drug Dose Daily	100%	100%	69.8%	Drug Dosage	Enabled ✓	Null	Enabled ✓	No ✓
Drug-Drug Interaction	75%	100%	65.9%	Critical Drug Interaction	Enabled ✓	Enabled ✓	Enabled ✓	Null
				Significant Drug Interaction	Enabled ✓	Null	Disabled x	Null
Therapeutic Duplication	0%	100%	52.0%	Duplicate Drug Therapy	Enabled ✓	Enabled ✓	Disabled x	Null
				Duplicate Opioid Medications	Disabled x	Null	Disabled x	Null
Drug Allergy	75%	100%	92.3%	Allergy-drug Interaction	Enabled ✓	Enabled ✓	Enabled ✓	Null
				No Allergy Assessment	Disabled x	Enabled ✓	Enabled ✓	Null
Drug Monitoring	0%	25%	27.0%	Aminoglycoside Ordered	Enabled ✓	Enabled ✓	Disabled x	Null
Drug Age	0%	0%	16.7%	Renal Functional Over 65	Enabled ✓	Enabled ✓	Disabled x	Null
				Dangerous Meds for Pt > 64	Null	Enabled ✓	Disabled x	Null
Drug Laboratory	0%	0%	34.2%	Estimated Creatinine	Enabled ✓	Enabled ✓	Enabled ✓	Null
Drug Route	0%	0%	85.5%	Not Supported by VistA	N/A	N/A	N/A	N/A
Drug Diagnosis	0%	0%	19.1%	Not Supported by VistA	N/A	N/A	N/A	N/A
Alert Fatigue Orders Triggered?	None	None	National average: 11% of alert fatigue orders were triggered					
Fatal Orders Missed?	None	None	National average: 25% of fatal orders were missed					

Enabled ✓ = Parameter is established
Null = Parameter is not established
Disabled x = Parameter is turned off
No ✓ = Users are not able to edit order check settings

Feedback by CPOE Category

Drug Dose (Single) – 100% (100% Expected)

Your CPOE system scored 100% in this category. Although there was a perfect score in this category, the *Drug Dosage* order check was set to enabled at the package level and not set at the system level (i.e., "null"), which could present a vulnerability as described in the section outlining the overall assessment results.

Drug Dose (Daily) – 100% (100% Expected)

Your CPOE system scored 100% in this category. Although there was a perfect score in this category, the *Drug Dosage* order check was set to enabled at the package level and not set at the system level (i.e., "null"), which could present a vulnerability as described in the section outlining the overall assessment results.

Drug-Drug Interaction – 75% (100% Expected)

Your CPOE system missed one of the four drug-drug interaction alerts. This missed alert was for ordering ondansetron and haloperidol together (Figure 1). This was most likely due to the user having *Significant Drug Interaction* disabled. The other three drug-drug interaction alerts fired as expected as these were *Critical Drug Interaction* to which the user had the setting enabled. For both *Significant* and *Critical Drug Interaction* order checks, the *Editable by User* parameter was not set (i.e. null). Setting *Editable by User* to "no" will prevent individual users from disabling drug-drug interaction order checks.

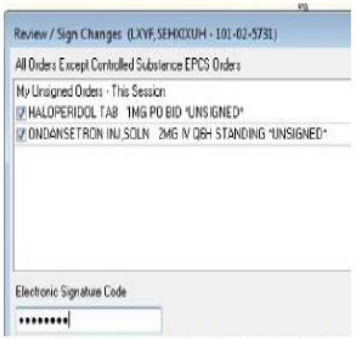


Figure 1. Signing Haloperidol and Ondansetron Order

Therapeutic Duplication – 0% (100% Expected)

Your CPOE system scored a 0% in this category. The first missed therapeutic duplication alert may have been missed due to ordering celecoxib as a non-formulary medication request (Figure 2). The remaining alerts were likely missed due to the user having *Duplicate Drug Therapy* disabled (Figure 3, Figure 4, Figure 5). The *Editable by User* parameter was also not set (i.e., null). Setting *Editable by User* to "no" will prevent individual users from disabling therapeutic duplication order checks.

Differences in content displayed for the same CDS

Order Checking

(1 of 1) ALENDRONATE 70MG TAB: Total dose amount of 70 MILLIGRAMS/DAY exceeds the maximum daily dose amount of 11 MILLIGRAMS/DAY.

Order Checking

(1 of 3) Remote Order Checking not available - checks done on local data only

(2 of 3) ALENDRONATE 70MG TAB: Total dose amount of 70 MILLIGRAMS/DAY exceeds the maximum daily dose amount of 11 MILLIGRAMS/DAY.

(3 of 3) Recommended frequency of ALENDRONATE 70MG TAB is every 7 days.

Order Checking

(1 of 2) ALENDRONATE 70MG TAB - ONCE WEEKLY: Total dose amount of 70 MILLIGRAMS/DAY exceeds the maximum daily dose amount of 11 MILLIGRAMS/DAY.

(2 of 2) Recommended frequency of ALENDRONATE 70MG TAB - ONCE WEEKLY is every 7 days.

Human factors observations

o cancel an order select the order by checking the checkbox and press the "Cancel Checked Order(s)" button.

If the order check description is cut short, hover over the text to view the complete description.

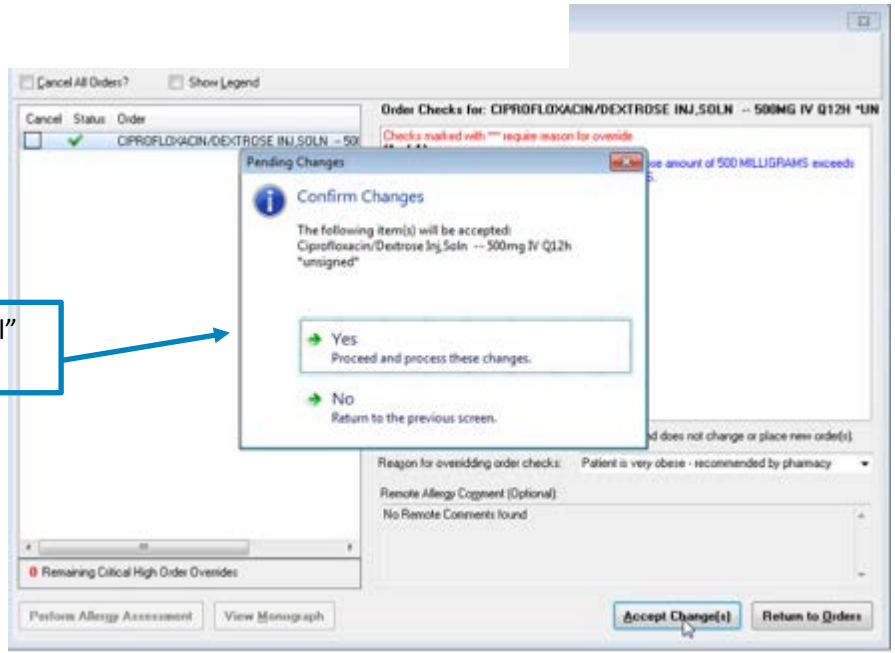
Cancel	Order/Order Check Text
Cancel? ☐	DOXYCYCLINE CAP/TAB 500MG PO DAILY *UNSIGNED*

*Order Check requires Reason for Override
(1 of 1) DOXYCYCLINE CAP/TAB: Single dose amount of 500 MILLIGRAMS exceeds the maximum single dose amount of 300 MILLIGRAMS.

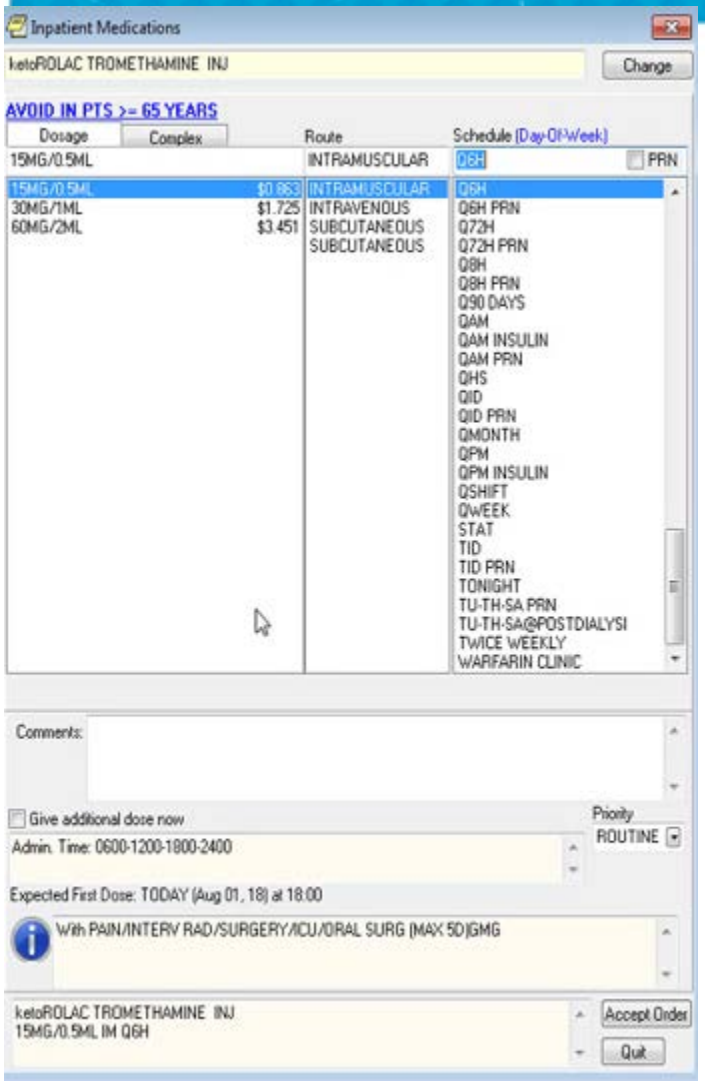
Measurement unit emphasized, not "exceeds"

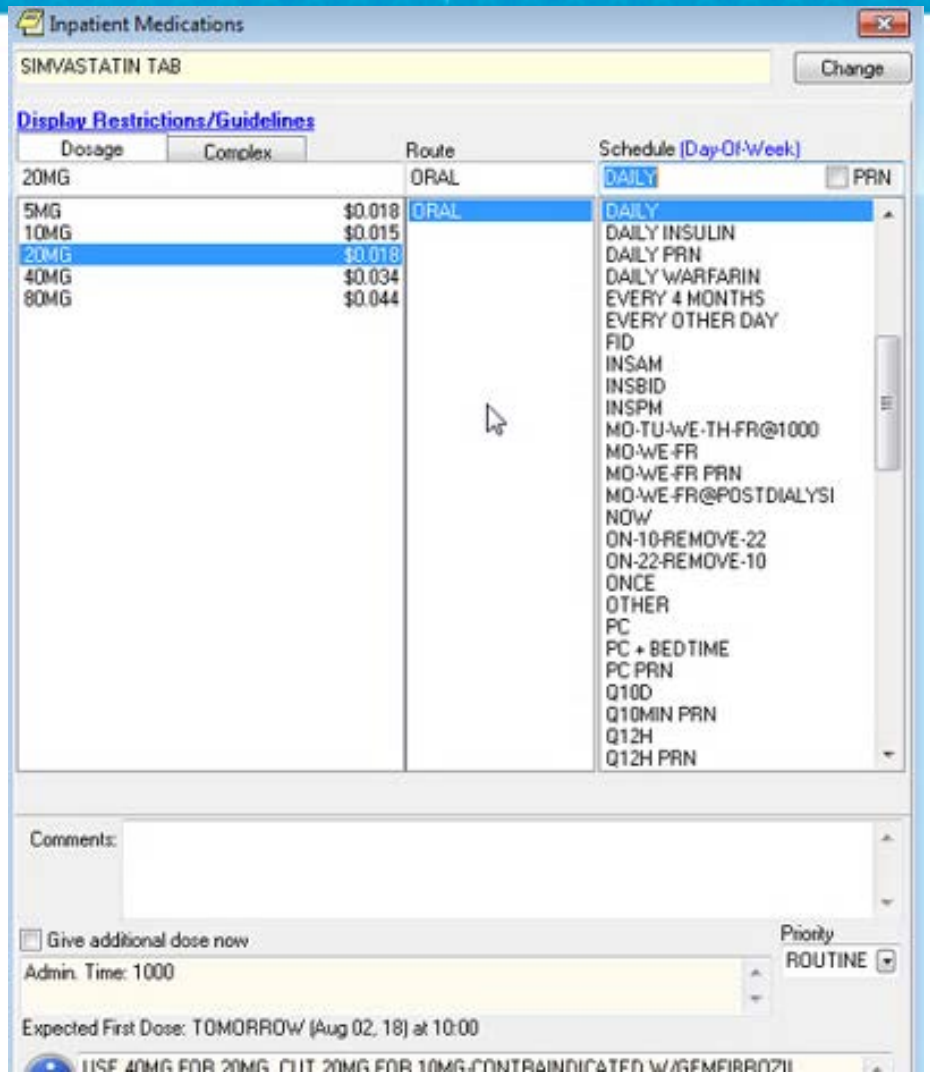
Red font paired with blue font
(Shneiderman et al., 2017)

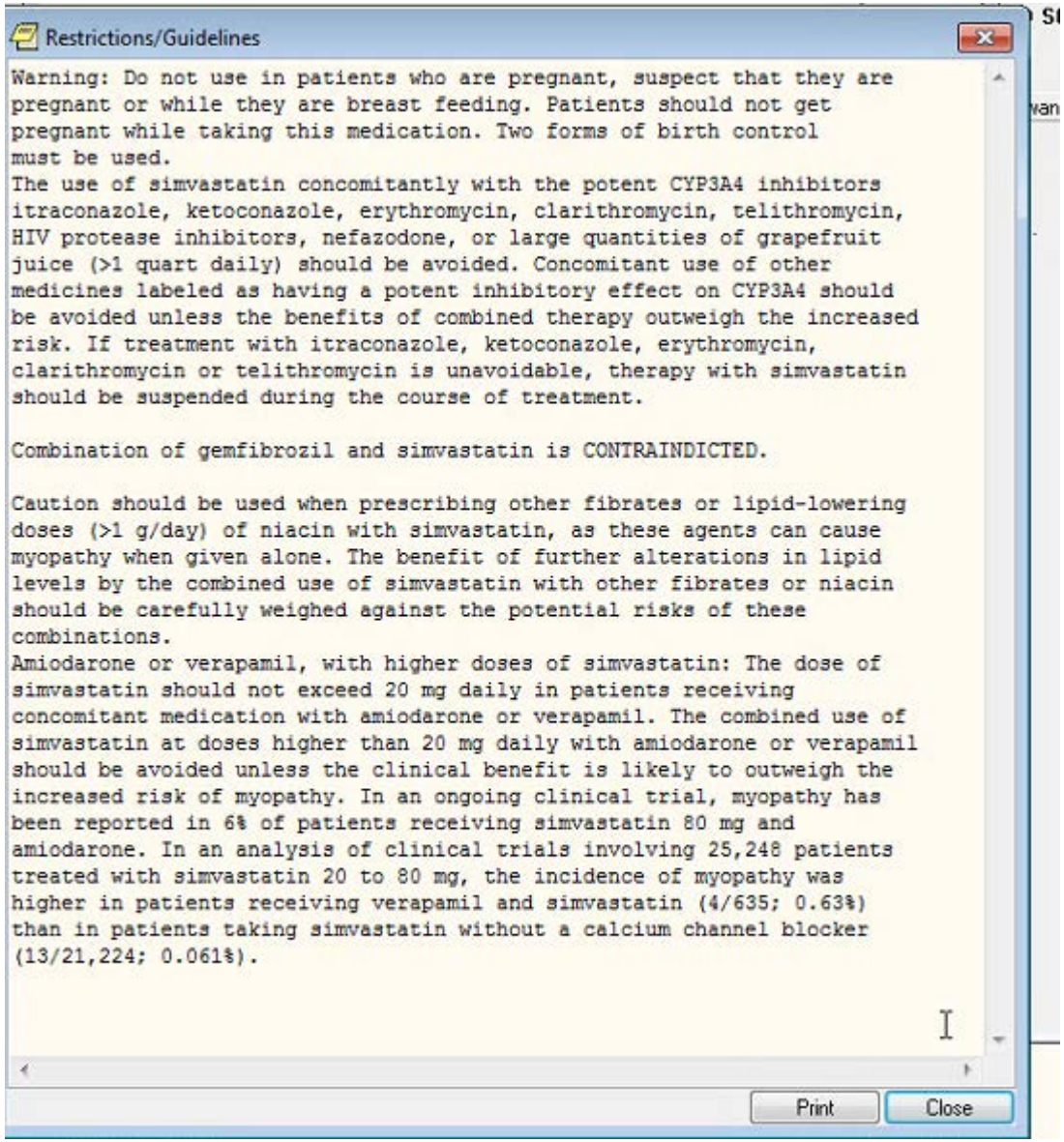
MS Word "look and feel" at one facility



Additional Formats for CDS Guidance

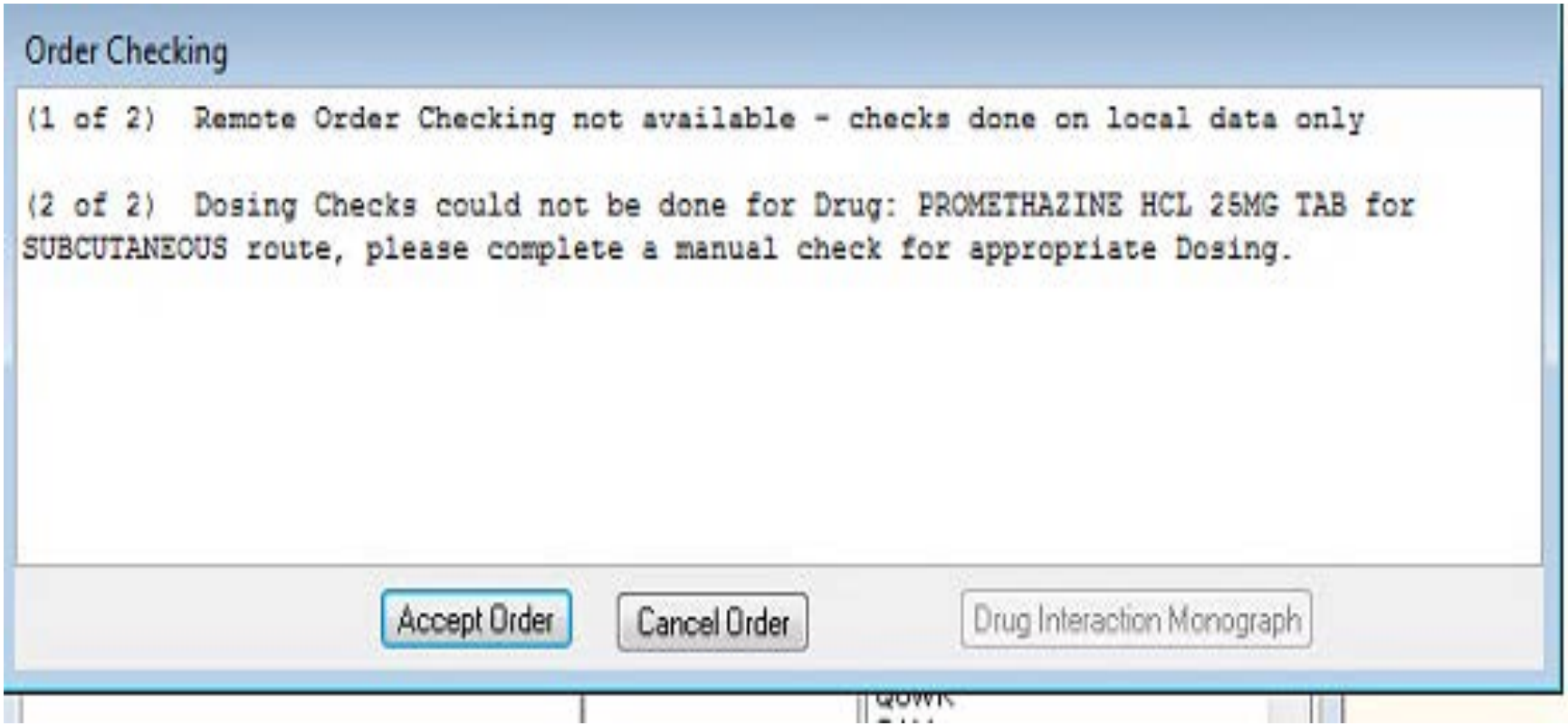




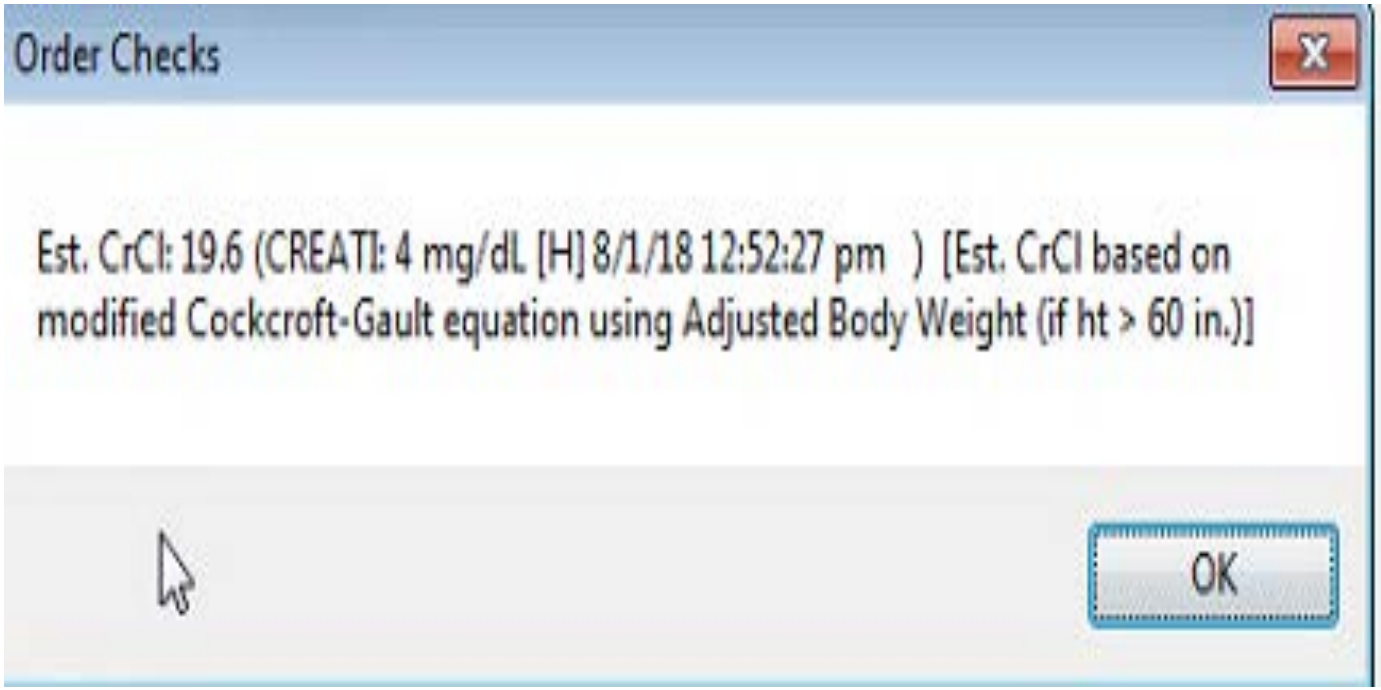

Restrictions/Guidelines
Warning: Do not use in patients who are pregnant, suspect that they are pregnant or while they are breast feeding. Patients should not get pregnant while taking this medication. Two forms of birth control must be used.
The use of simvastatin concomitantly with the potent CYP3A4 inhibitors itraconazole, ketoconazole, erythromycin, clarithromycin, telithromycin, HIV protease inhibitors, nefazodone, or large quantities of grapefruit juice (>1 quart daily) should be avoided. Concomitant use of other medicines labeled as having a potent inhibitory effect on CYP3A4 should be avoided unless the benefits of combined therapy outweigh the increased risk. If treatment with itraconazole, ketoconazole, erythromycin, clarithromycin or telithromycin is unavoidable, therapy with simvastatin should be suspended during the course of treatment.
Combination of gemfibrozil and simvastatin is CONTRAINDICTED.
Caution should be used when prescribing other fibrates or lipid-lowering doses (>1 g/day) of niacin with simvastatin, as these agents can cause myopathy when given alone. The benefit of further alterations in lipid levels by the combined use of simvastatin with other fibrates or niacin should be carefully weighed against the potential risks of these combinations.
Amiodarone or verapamil, with higher doses of simvastatin: The dose of simvastatin should not exceed 20 mg daily in patients receiving concomitant medication with amiodarone or verapamil. The combined use of simvastatin at doses higher than 20 mg daily with amiodarone or verapamil should be avoided unless the clinical benefit is likely to outweigh the increased risk of myopathy. In an ongoing clinical trial, myopathy has been reported in 6% of patients receiving simvastatin 80 mg and amiodarone. In an analysis of clinical trials involving 25,248 patients treated with simvastatin 20 to 80 mg, the incidence of myopathy was higher in patients receiving verapamil and simvastatin (4/635; 0.63%) than in patients taking simvastatin without a calcium channel blocker (13/21,224; 0.061%).
Print
Close

	Facility 1	Facility 2	Facility 3
		Refer to Formulary/Protocol or Service Guidelines/Approval	
Ibuprofen	NSAIDS may be associated with an increased risk of CV thrombotic events		Avoid chronic use in pts>=65 years or use w/gastroprotective agent
Metoprolol tartrate		Refer to PBM/MAP Hypertension treatment and CHF treatment guidelines	
Hydrochlorothiazide		Refer to PBM/MAP Hypertension treatment and CHF treatment guidelines	
			Avoid in pts>= 65 years
Oxycodone			Look alike/sound alike
		Refer to PBM/MAP Hypertension treatment and CHF treatment guidelines	
Sumatriptan		Restricted to Neurology	
Ketorolac tromethamine			
	No new starts, simvastatin or pravastatin preferred	Refer to VA/DoD Hyperlipidemia treatment guidelines	
Clarithromycin		Refer to Formulary/Protocol or Service Guidelines/Approval	
Haloperidol	PRN orders MUST include the indication		
Chlorpromazine hydrochloride		Look alike/sound alike	
			Use with caution in pts >= 65 years
			Use with caution in pts >= 65 years
			Look alike/sound alike
Enoxaparin	Restricted to PVAMC anti-coag guidelines		
Hydroxyzine		Look alike/sound alike	Look alike/sound alike
Aspirin	Order in multiples of 100 only		
		Refer to PBM/MAP Hypertension treatment and CHF treatment guidelines	
Glipizide			Look alike/sound alike
Gentamicin	Requires renal dosing		
Omeprazole			
			Avoid in pts >= 65 years for treatment of

Understand how system functionality influences Assessment Tool scoring - is this a valid response for “credit”?



Understand how system functionality influences Assessment Tool scoring - is this valid for "credit"?



Future directions – Evaluating Impact

- ✓ **Reactions**: Perceptions of utility
- ✓ **Learning**: Did facilities learn any new about their CPOE system as a result of the evaluation?

Behavior: Did these lessons learned transfer to organizational changes?

Results: How did this evaluation process improve safety?

- Simulated retest (6 months or 1 year following initial test)
- Additional sources of data available from Corporate Data Warehouse (ONC, CPOE SAFER Guide, 3.1, p. 38):
  - Rates of preventable ADEs, CPOE use rate, Frequency (i.e., volume of orders that generate an alert, Override rate in comparison to alert volume, Median turnaround time for STAT laboratory or radiology results, Percent of all orders requiring modification by someone other than the ordering provider, Alerts with the highest percent of overrides, usage of evidence-based order sets
  - IHI Trigger Tool (IHI, 2004; Classen et al., 2018)
- Does the clinical data support results of evaluation? What is confidence of reliably achieving stated result?

Adapted from Kirkpatrick, 1976

Future directions – Explore Activity Traces

- Analyze variation in CPOE with CDS settings within and across VHA facilities related to drug-allergy, drug-dose, therapeutic duplication, drug-drug interaction, drug age (where appropriate) from the Corporate Data Warehouse (CDW).
- Compare results using CPOE evaluation tool and CDW data.
- Outline the ideal CDS settings in order to achieve 100% (guidance document).

Using EHR Data to Evaluate CPOE Safety

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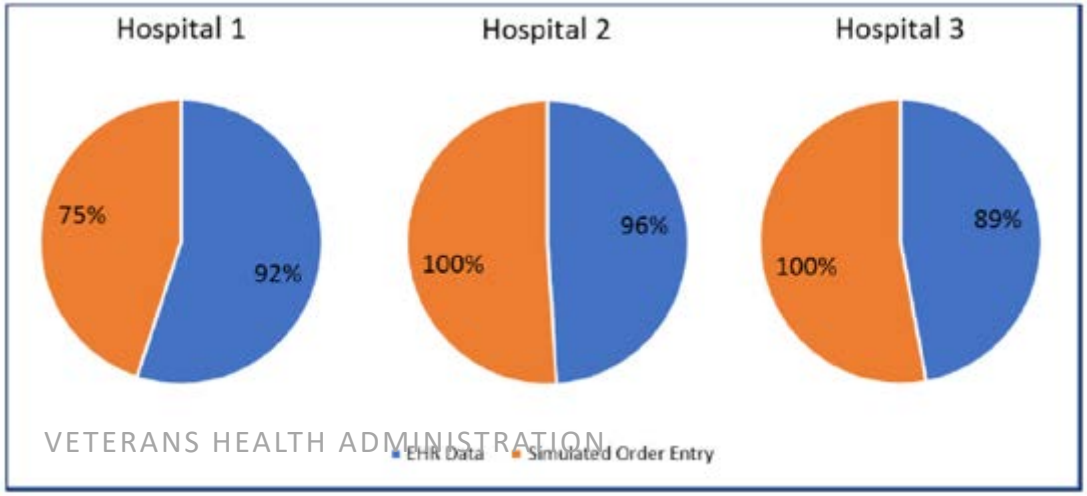

SUMMARY

The CPOE Assessment Tool is a snapshot of EHR system safety.

- ✓ Opportunity to understand more about CDS systems by observing user & system behavior.
  - Clinical domains for risk assessment
- ✓ What are the impacts of completing the assessment
  - Are facilities making changes?
  - What is the impact on safety?
  - Unintended consequences – such as alert fatigue or alert overrides?
- ✓ Untapped potential of exploring activity traces related to simulated orders
- ✓ Measuring effectiveness between evaluations
  - How do we get to 365/24/7 reliability?

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