**Electronic Medical Record**
**Does it really improve medication safety? What is the evidence?**

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**Objectives**
- Describe the implications of the current state of health information technology initiatives within the United States
- Understand the importance of and processes for distinguishing between levels of evidence when evaluating research studies
- Using the HIMSS EMR adoption model, describe the literature focusing on the impact of the EMR on the medication use process
- Describe factors contributing to successful EMR adoption

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**Agenda**
- Environmental scanning
- Why?
- Levels of evidence
- Literature discussion
  - CDSS
  - CPOE + CDSS
  - Bar code dispensing
  - ADCs
  - Conclusions
- BCMA
- Smart pumps
- Auto ADE surveillance
- Advanced EMR

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Enterprise approach preferred
- CPOE challenges continue
- Other providers now face CDSS challenges well known to pharmacy
- BCMA requires strong infrastructure and impacts workflow
- CPOE before BCMA in 400+ bed hospitals
- Role of IT pharmacists predicted to expand with increased number of implementations — while not increasing dedicated FTEs
**Most Important Applications (Next Two Years)**

(2008 vs. 2007 Results)

<table>
<thead>
<tr>
<th>Application</th>
<th>2008 %</th>
<th>2007 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical Information Systems</td>
<td>46%</td>
<td>46%</td>
</tr>
<tr>
<td>Computer Based Prescriptions Order Entry (CPOE)</td>
<td>45%</td>
<td>67%</td>
</tr>
<tr>
<td>Electronic Medical Record (EMR)</td>
<td>11%</td>
<td>15%</td>
</tr>
<tr>
<td>Enterprise-Wide Clinical Information Storage</td>
<td>68%</td>
<td>47%</td>
</tr>
<tr>
<td>Closed Loop Medication Management</td>
<td>15%</td>
<td>29%</td>
</tr>
<tr>
<td>Clinical Data Repository</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>Point-of-Care Data Generation</td>
<td>1%</td>
<td>8%</td>
</tr>
<tr>
<td>Clinical Portal</td>
<td>1%</td>
<td>21%</td>
</tr>
</tbody>
</table>


**Status of Electronic Medical Record Implementation**

(Comparison of 2008, 2007, and 2006 Results)

<table>
<thead>
<tr>
<th>Status</th>
<th>2006 %</th>
<th>2007 %</th>
<th>2008 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully Operational System</td>
<td>14%</td>
<td>24%</td>
<td>46%</td>
</tr>
<tr>
<td>Installation Begun</td>
<td>72%</td>
<td>32%</td>
<td>39%</td>
</tr>
<tr>
<td>Signed Contract</td>
<td>24%</td>
<td>32%</td>
<td>26%</td>
</tr>
<tr>
<td>Developed Plan to Implement</td>
<td>14%</td>
<td>21%</td>
<td>24%</td>
</tr>
<tr>
<td>No Plans Yet</td>
<td>20%</td>
<td>10%</td>
<td>5%</td>
</tr>
<tr>
<td>Don't Know</td>
<td>1%</td>
<td>12%</td>
<td>1%</td>
</tr>
</tbody>
</table>


**Why Are We Here?**

- Helicobacter pylori and ulcers
- Human papillomavirus and cervical cancer
- HRT is good for every woman
- Vitamins C and E prevent heart disease
- Beta blockers are contraindicated in heart failure (?)
- MMR vaccine and autism
- National Academies Computational Technology for Effective Health Care: Immediate Steps and Strategic Directions (1/09)
Biomedical Literature: Levels of Evidence

1a. Multiple RCTs
1b. Single RCT
2. Cohort
3. Case Control
4. Case Series
5. Expert Opinion


Setting the Stage...

- The *most salient* articles were selected
- Every article - volume
- Terminology is not consistent across articles
- Adoption model and available data
- Work and publication bias
- You may disagree
  - With me
  - With each other
- Honest disagreement is often a good sign of progress. <Mahatma Gandhi>
System Failures: Preventable ADEs and Potential ADEs

Ordering 49% (48%)
Transcribing 11% (23%)
Dispensing 14% (37%)
Administering 26% (0%)


Many others.
CPOE + CDSS: Prescribing Practices

- others

CPOE + CDSS: MES, PADES, ADES

- Prospective time series, 4 periods
- Paper med ordering vs CPOE with DS capabilities across periods
- 2 Gen Med & 1 MICU for 7-10 week periods in 4 different years
- Paper orders → complete electronic orders → drug allergy checking → K ordering, drug-drug interaction checking
- Incidents identified by RPh review, voluntary report, & interview
- Non-missed dose error ↓ 81% (SS)
- Non-intercepted serious error ↓ 86% (SS)
CPOE + CDSS: MEs, FADES, ADES

- Australia, UK, Belgium, others

Role of Physician in Fact

- Types of Provider

- 5 separate hospitals with successful CPOE implementations using different systems; differing size, location; academic & nonacademic
- Observation of interaction with CPOE: infrequent, impromptu interviews of observed clinicians and semi-structured interviews with 32 individuals with historical perspective
- 9 major types of unintended consequences identified: more/new work for clinicians, workflow issues, never ending system demands, paper persistence, changes in communication, emotions, changes in power structure, overdependence on technology, new errors

CPOE + CDSS: MEs, FADES, ADES

- Qualitative and quantitative analysis of interactions with commercial CPOE application
- Found 23 medication error sources (in two broad categories) facilitated by CPOE:
  - Information errors due to fragmentation of data and failure to integrate information systems
  - Human machine interface flaws that do not reflect workflow

Computerized Provider Order Entry Implementation - National Intensive Care

- Pre-post retrospective review of pediatric patients transported to a regional pediatric referral center: 13 mths pre, 5 mths post-CPOE
- 28 day CPOE implementation; 1394 patients pre, 548 patients post CPOE: ↓ in mortality after CPOE (OR: 1.71, CI: 2.13-6.46, p < 0.001)
- Causality?
- CPDE-induced workflow changes and other workflow changes

- Some CPOE system as Han et al.; tertiary referral center serving a large geographic area in NW US
- 13 mths post (1232), 5 (7) and 13 (1301) mths post-CPOE
- More involvement, training & support; 14 hour conversion to CPOE
- CDSS beyond allergy, dose, and rules; order sets
- All patients: 13 mths post: NS ↓ mortality (OR: 0.82, CI: 0.55-1.21, p=0.32)
- Transfers 13 mths post: NS ↓ mortality (OR: 0.66, CI: 0.29-1.47, p=0.31)
- Transfers 5 mths post: NS ↓ mortality (OR: 0.6, CI: 0.2-1.8)
Keypoints
- Large volume of literature
- "Political" focus
- Some well-designed trials
- Adults and pediatrics
- Generalizability
  - 4 institutions
  - Home grown vs. commercial
- Organizational and workflow factors

Bar Coding

Ordering 39%
Transcribing 12%
Dispensing 11%
Administering 38%


Bar Code Dispensing
**Automated Dispensing Cabinets**

- Klein EG et al. Medication cart filling times, accuracy, and cost with an automated dispensing system. AJHP. 1994;51:1193-1196.
- Dean BS et al. Comparison of medication errors in an American and a British hospital. AJHP. 1995;52:2543-2549.
- Shirley KL. Effect of an automated dispensing system on medication administration time. AJHP. 1999;56:1542-1549.
- Botwin KJ et al. Restricted access to automated dispensing machines for surgical antimicrobial prophylaxis. AJHP. 2001;58:797-799.
Bar Coding

Ordering: 39%
Transcribing: 12%
Dispensing: 11%
Administering: 38%


Bar Code Medication Administration

This report focuses on grants in AHRQ’s health IT portfolio that are implementing or evaluating bar coding technologies to improve care for patients, increase efficiency, and contain costs. The analysis presented here provides a snapshot of these funded activities. The scope of this discussion is limited to challenges faced by grantees in developing, implementing, or evaluating bar coding interventions. The report does not include an evaluation of the projects’ final outcomes. AHRQ has encouraged individual grantees to disseminate information about the final results of their work through peer-reviewed journals, trade publications, and other vehicles.
Initial pilot in Eastern Kansas Health Care System (8/95)

Nationwide BCMA rollout in 1998

Colmery-O'Neal VAMC

Cohort study
• 22.7 incidents/100,000 units (1993)
• 3 incidents/100,000 units (2001)
• Overall 88% decrease in errors (75% wrong med, 62% wrong dose, 93% wrong patient, 87% wrong time, 76% med not given)


Case study describing BCMA developed in conjunction with a vendor in a 243 bed regional referral center

Report of averted errors (near misses) identified by the BCMA vs reported by staff

Incident reports vs BCMA log

Nonsignificant 18% increase in errors after BCMA


Small volume of literature
Many descriptive reports
External drivers
Experience in other industries - logical

"Smart" Pumps

Prospective, randomized time-series test of "smart" pump with (intervention) and without (control) decision support in cardiac SICU & step-down units:
- Four 8-wk data collection periods: Ctrl (1st, 3rd), INT (2nd, 4th)
- Real-time DS = reminders, drug library, dose & rate limit alerts; hard limits were not used
- NS ↓ preventable ADEs, ↑ nonintercepted potential ADEs, ↑ serious ME rate;
- Bypassing drug library, alert overrides, undocumented verbal orders
- What if?

Pre/post comparison of reported continuous infusion medication errors; incident report; pre - retrospective; post - ?
- Intervention: standardized concentrations, modifications to med label, smart syringe pump (drug library, rate calc, range alerts, display)
- SS 73% ↓ from 3.1 to 0.8/1000 doses (absolute RR: 2.3, CI: 1.1-3.4, p=0.001)
- Admin errors ↓ 28 to 8; number of ≥10x overdose ↓ 5 to 1
- Error definition? ADE measured? Change in reporting emphasis, process, etc? Hard stops?
Impact of Infusion Pump Technology on Medication Errors (Fanikos et al., JACEP, 2007;23(Suppl 1):41-45).

Insights from the sharp end of intravenous medication errors: implications for infusion pump technology (Husch et al., Qual Saf Health Care. 2005;14:80-86).

• Retrospective chart review to identify PADEs before and after infusion pump implementation; surgical, trauma/burn, and medical ICUs
• Academic and nonacademic hospital
• Pumps contained dosing libraries; overrides allowed
• 100 PADEs identified; 92 PADEs in each period matched pump capabilities (duplicate and excessive dosing)

Conclusions
• PADEs identification, boluses
• Observational, prospective study using point prevalence approach
• Defined & categorized (MCC, MERP) med errors; 9 hr study period
• Errors: 285 of 426 medications for 286 patients had >1 errors
• 67 rate deviations: 1 deemed preventable by pump (underdose); remainder not due to programming or not significant enough to be detected
• Importance of interfacing to medical record, CPOE, BCMA, PHS

Smart Pumps, cont.

• Wetterneck TB et al. Using failure mode and effects analysis to plan implementation of smart i.v. pump technology. AJHP. 2006;63:1528-1538.
Keypoints
- Narrow therapeutic index
- "Political" focus
- Small volume of literature
- Importance of hard vs soft stops
- Value of logs
- Identification of incidents where pumps are anticipated to help: beyond programming

Automated ADE Surveillance

Amarasingham R et al. Clinical information technologies and inpatient outcomes. A multiple hospital study. AIM.

http://www.himssanalytics.org/PDFFiles/UHC25.pdf

Cutting The Advanced Automated “Smart” pumps

BCMA

Automated Bar Code Dispensing

CPOE + CDSS

CDSS

Bar code dispensing

Automated dispensing cabinets

BCMA

“Smart” pumps

Automated ADE surveillance

Advanced EMR stages

The importance of teams

Cutting room floor: robotic dispensing, carousels, robotic IV automation, ePrescribing, eMed Rec, process improvement, satisfaction, etc.
Conclusion:
Parachutes appear to reduce the risk of injury after gravitational challenge, but their effectiveness has not been proven with randomized controlled trials.

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