Role of Health IT in Implementation Science

Douglas S. Bell, MD, PhD
Associate Professor in Residence
Division of General Internal Medicine,
UCLA School of Medicine
IT as Implementation Tool

◆ Computerized Provider Order Entry (CPOE)
  – A computer application that enables clinicians to order and process medications, lab tests, clinical procedures and other services electronically.

◆ Clinical Decision Support Systems (CDSS)
  – An electronic system designed to aid in clinical decision making, in which characteristics of individual patients are used to generate patient-specific assessments or recommendations that are presented to clinicians for consideration
Patient Safety: Definitions

- **Adverse event**
  - An *injury* caused by healthcare intervention, *not* due to the underlying condition of the patient

- **Error**
  - Use of a bad plan or failure to execute plan properly
Needs Analysis: ADEs

1991: Harvard Medical Practice Study
- 51 NY hospitals
  → 30,121 medical records
- 3.7% of admissions had an adverse event (14% fatal)
- 58% errors, 28% negligent
- Adverse drug events (ADEs) the most common adverse event
Needs Analysis: ADEs

- **1995: ADE Prevention Study**
  - 2 hospitals: prospectively identified med errors
  - 6.5 ADEs/100 admissions
  - 1.8 preventable, 4.7 non-preventable

<table>
<thead>
<tr>
<th>Proximal Cause</th>
<th>Physician Ordering, No. (%)</th>
<th>Transcription and Verification, No. (%)</th>
<th>Pharmacy Dispensing, No. (%)</th>
<th>Nurse Administration, No. (%)</th>
<th>All, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of knowledge of the drug</td>
<td>47 (36)</td>
<td>6 (15)</td>
<td>0 (0)</td>
<td>19 (15)</td>
<td>72 (22)</td>
</tr>
<tr>
<td>Lack of information about the patient</td>
<td>31 (24)</td>
<td>4 (10)</td>
<td>0 (0)</td>
<td>13 (10)</td>
<td>48 (14)</td>
</tr>
<tr>
<td>Rule violations</td>
<td>25 (19)</td>
<td>0 (0)</td>
<td>6 (16)</td>
<td>2 (2)</td>
<td>33 (10)</td>
</tr>
<tr>
<td>Slips and memory lapses</td>
<td>14 (11)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>15 (12)</td>
<td>29 (9)</td>
</tr>
<tr>
<td>Transcription errors</td>
<td>0 (0)</td>
<td>29 (73)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>29 (9)</td>
</tr>
<tr>
<td>Faulty drug identity checking</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>11 (29)</td>
<td>13 (10)</td>
<td>24 (7)</td>
</tr>
<tr>
<td>Faulty interaction with other services</td>
<td>1 (1)</td>
<td>0 (0)</td>
<td>3 (8)</td>
<td>13 (10)</td>
<td>17 (5)</td>
</tr>
<tr>
<td>Faulty dose checking</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>3 (8)</td>
<td>13 (10)</td>
<td>16 (5)</td>
</tr>
<tr>
<td>Infusion pump and parenteral delivery problems</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>16 (13)</td>
<td>16 (5)</td>
</tr>
<tr>
<td>Inadequate monitoring</td>
<td>11 (8)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>4 (3)</td>
<td>15 (4)</td>
</tr>
<tr>
<td>Drug stocking and delivery problems</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>11 (29)</td>
<td>0 (0)</td>
<td>11 (3)</td>
</tr>
<tr>
<td>Preparation errors</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>4 (11)</td>
<td>6 (5)</td>
<td>10 (3)</td>
</tr>
<tr>
<td>Lack of standardization</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>8 (6)</td>
<td>8 (2)</td>
</tr>
<tr>
<td>Unclassified</td>
<td>1 (1)</td>
<td>1 (3)</td>
<td>0 (0)</td>
<td>4 (3)</td>
<td>6 (2)</td>
</tr>
<tr>
<td><strong>Totals‡</strong></td>
<td><strong>130 (100)</strong></td>
<td><strong>40 (100)</strong></td>
<td><strong>38 (100)</strong></td>
<td><strong>126 (100)</strong></td>
<td><strong>334 (100)</strong></td>
</tr>
</tbody>
</table>
CPOE for ADE Prevention

- **Before vs. after CPOE**
  - Preventable ADEs $4.7 \rightarrow 3.9/1000$ pt-days ($17\%$)
  - Non-intercepted potential ADEs $6.0 \rightarrow 1.0$ ($84\%$)
  - Non-intercepted serious errors $10.7 \rightarrow 4.9$ ($55\%$)

- **... vs. CPOE after additional refinements:**
  - Non-intercepted serious errors $\rightarrow 1.1$ ($86\%$)
    - But intercepted 
      - $K^+$ errors initially increased
Some Relation to Performance For Hospitals


### Mortality Rates And Level Of Hospital Use Of Electronic Medication Order Entry, By Condition, 2007

<table>
<thead>
<tr>
<th>Inpatients with electronic medication orders (%)</th>
<th>Unadjusted mortality rate (%)</th>
<th>p value (relative to reference)</th>
<th>Adjusted mortality rate (%)</th>
<th>p value (relative to reference)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HEART ATTACK</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>16.2</td>
<td>—³</td>
<td>16.4</td>
<td>—³</td>
</tr>
<tr>
<td>1-25</td>
<td>16.0</td>
<td>0.01</td>
<td>15.9</td>
<td>0.01</td>
</tr>
<tr>
<td>26-50</td>
<td>16.1</td>
<td>0.47</td>
<td>16.2</td>
<td>0.52</td>
</tr>
<tr>
<td>51-90</td>
<td>16.0</td>
<td>0.07</td>
<td>15.9</td>
<td>0.03</td>
</tr>
<tr>
<td>91-100</td>
<td>15.9</td>
<td>0.004</td>
<td>16.0</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>HEART FAILURE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>11.2</td>
<td>—³</td>
<td>11.2</td>
<td>—³</td>
</tr>
<tr>
<td>1-25</td>
<td>11.1</td>
<td>0.49</td>
<td>10.9</td>
<td>0.22</td>
</tr>
<tr>
<td>26-50</td>
<td>11.0</td>
<td>0.19</td>
<td>10.8</td>
<td>0.21</td>
</tr>
<tr>
<td>51-90</td>
<td>11.1</td>
<td>0.38</td>
<td>10.7</td>
<td>0.05</td>
</tr>
<tr>
<td>91-100</td>
<td>11.0</td>
<td>0.06</td>
<td>10.8</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>PNEUMONIA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>11.5</td>
<td>—³</td>
<td>11.6</td>
<td>—³</td>
</tr>
<tr>
<td>1-25</td>
<td>11.3</td>
<td>0.21</td>
<td>11.3</td>
<td>0.51</td>
</tr>
<tr>
<td>26-50</td>
<td>11.3</td>
<td>0.39</td>
<td>11.0</td>
<td>0.27</td>
</tr>
<tr>
<td>51-90</td>
<td>11.5</td>
<td>0.93</td>
<td>11.6</td>
<td>0.98</td>
</tr>
<tr>
<td>91-100</td>
<td>11.2</td>
<td>0.004</td>
<td>11.3</td>
<td>0.26</td>
</tr>
</tbody>
</table>
Some Major Challenges

- Pediatric ICU CPOE at Pitt:
  - Mortality 2.8% 13 mo. before → 6.6% 5 mo. after
  - Couldn’t write orders until pt. registered in ICU system; delay in starting antibiotics

---

**Unexpected Increased Mortality After Implementation of a Commercially Sold Computerized Physician Order Entry System**
Yong Y. Han, Joseph A. Carcillo, Shekhar T. Venkataraman, Robert S.B. Clark, R. Scott Watson, Trung C. Nguyen, Hülya Bayir and Richard A. Orr
*Pediatrics* 2005;116:1506-1512
DOI: 10.1542/peds.2005-1287

---

**Computerized Provider Order Entry Implementation: No Association With Increased Mortality Rates in an Intensive Care Unit**
Mark A. Del Beccaro, Howard E. Jeffries, Matthew A. Eisenberg and Eric D. Harry
*Pediatrics* 2006;118:290
DOI: 10.1542/peds.2006-0367
CDS: Early Findings

- Reminders printed with encounter note
  - e.g. “BP elevated, suggest med change”
  - Effective (but no learning)
  - 22% adherence without reminder
  - 51% adherence with reminder
  - Return to baseline when reminder off

SPECIAL ARTICLE

PROTOCOL-BASED COMPUTER REMINDERS, THE QUALITY OF CARE AND THE NON-PERFECTABILITY OF MAN

Clement J. McDonald, M.D.

Abstract  To determine whether clinical errors can be reduced by prospective computer suggestions about the management of simple clinical events, I studied the responses of nine physicians to computer suggestions generated by 390 protocols in a controlled crossover design. These protocols dealt primarily with conditions managed (e.g., elevated blood pressure) or caused (e.g., liver toxicity) by drugs. Physicians were instructed to follow the suggestions of the computer. Neither level of postgraduate training (first-year postgraduate or third-year postgraduate) nor the order in which physicians served as study and control subjects had statistically significant overall effect on the results. It appears that the prospective reminders do reduce errors, and that many of these errors are probably due to man’s limitations as a data processor rather than to correctable human
SPECIAL ARTICLE

THE EFFECT ON TEST ORDERING OF INFORMING PHYSICIANS OF THE CHARGES FOR OUTPATIENT DIAGNOSTIC TESTS

WILLIAM M. TIERNEY, M.D., MICHAEL E. MILLER, PH.D., AND CLEMENT J. McDONALD, M.D.

Abstract  We studied the effect of informing physicians of the charges for outpatient diagnostic tests on their ordering of such tests in an academic primary care medical practice. All tests were ordered at microcomputer workstations by 121 physicians. For half (the intervention group), the charge for the test being ordered and the total charge for tests for that patient on that day were displayed on the computer screen. The remaining physicians (control group) also used the computers but received no message about charges. The primary outcomes measured were the number of tests ordered and the charges for tests per patient visit.

In the 14 weeks before the study, the number of tests ordered and the average charge for tests per patient visit were similar for the intervention and control groups. During the 26-week intervention period, the physicians in the intervention group ordered 14 percent fewer tests per patient visit than did those in the control group (P<0.005), and the charges for tests were 13 percent ($6.68 per visit) lower (P<0.05). The differences were greater for scheduled visits (17 percent fewer tests and 15 percent lower charges for the intervention group; P<0.01) than for unscheduled (urgent) visits (11 percent fewer tests and 10 percent lower charges; P>0.3). During the 19 weeks after the intervention ended, the number of tests ordered by the physicians in the intervention group was only 7.7 percent lower than the number ordered by the physicians in the control group, and the charges for tests were only 3.5 percent lower (P>0.3). Three measures of possible adverse outcomes — number of hospitalizations, emergency room visits, and outpatient visits during the study period and the following six months — were similar for the patients seen by the physicians in both groups.

We conclude that displaying the charges for diagnostic tests significantly reduced the number and cost of tests ordered, especially for patients with scheduled visits. The effects of this intervention did not persist after it was discontinued. (N Engl J Med 1990; 322:1499-504.)
CDS Early Findings

- **Utah Antibiotic Advisor**
  - Guideline advice with antibiotic order entry
  - Net use of antibiotics ↓ 23% (time series, adj.)

  [Pestotnik, 1998; Evans, 1998]

<table>
<thead>
<tr>
<th>In ICU</th>
<th>Abx cost</th>
<th>Total cost</th>
<th>LOS</th>
<th>Errors</th>
<th>AEs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year before</td>
<td>$340</td>
<td>$35,283</td>
<td>12.9</td>
<td>405</td>
<td>28</td>
</tr>
<tr>
<td>Followed</td>
<td>$102</td>
<td>$26,315</td>
<td>10.0</td>
<td>87</td>
<td>4</td>
</tr>
<tr>
<td>Not followed</td>
<td>$407</td>
<td>$44,865</td>
<td>16.7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Types of CDS

- **Alerts and Reminders**
  - a pop-up window, highlighted text, etc., to call provider attention to missing or unwise treatment plan

- **Order Sets**
  - Orders grouped for a particular condition.

- **Relevant Data Displays**
  - Aggregation of information highly relevant to the decision-making process at hand. (e.g. overlay of med admin on chart of VS)

- **Infobuttons**
  - Link to provide the user with information about a given item (e.g. disease names) upon request.

- **Documentation Templates**
  - Form to capture clinical data, often related to a guidelines
CDS Effects on Care – Reviews

- 68% of 70 CDS studies showed positive effects on care processes
  - Independent predictors in meta-regression:
    Decision support is...
    - automatically part of clinician workflow
    - recommendations rather than just assessments
    - provided at the time and location of decision making
    - computer based
  - Kawamoto, BMJ 2005

- 25% of 257 HIT studies from 4 institutions (“homegrown” systems)
  - Indiana/Regenstrief
  - LDS Hospital/Intermountain Health Care
  - VA
  - Brigham & Women’s
  - Chaudhry, Annals of IM 2006
Electronic Health Records and Clinical Decision Support Systems

Impact on National Ambulatory Care Quality

Max J. Romano, BA; Randall S. Stafford, MD, PhD

**Background:** Electronic health records (EHRs) are increasingly used by US outpatient physicians. They could improve clinical care via clinical decision support (CDS) and electronic guideline-based reminders and alerts. Using nationally representative data, we tested the hypothesis that a higher quality of care would be associated with EHRs and CDS.

**Methods:** We analyzed physician survey data on 255,402 ambulatory patient visits in nonfederal offices and hospitals from the 2005-2007 National Ambulatory Medical Care Survey and National Hospital Ambulatory Medical Care Survey. Based on 20 previously developed quality indicators, we assessed the relationship of EHRs and CDS to the provision of guideline-concordant care using multivariable logistic regression.

**Results:** Electronic health records were used in 30% of an estimated 1.1 billion annual US patient visits. Clinical decision support was present in 57% of these EHR visits. EHR visits were more likely in the West and in multiphysician settings than in solo practices. In only 1 of 20 indicators was quality greater in EHR visits than in non-EHR visits (diet counseling in high-risk adults, adjusted odds ratio, 1.65; 95% confidence interval, 1.21-2.26). Among the EHR visits, only 1 of 20 quality indicators showed significantly better performance in visits with CDS compared with EHR visits without CDS (lack of routine electrocardiographic ordering in low-risk patients, adjusted odds ratio, 2.88; 95% confidence interval, 1.69-4.90). There were no other significant quality differences.

**Conclusions:** Our findings indicate no consistent association between EHRs and CDS and better quality. These results raise concerns about the ability of health information technology to fundamentally alter outpatient care quality.

Published online January 24, 2011.
Large and Increasing Differences

More Recent Results More Positive

Evaluations Of Outcome Measures Of Health Information Technology A total of 278 outcome measures were evaluated across all studies