Using Medication Safety Technology to Prevent Adverse Drug Events - What’s the Evidence

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## FY 10 Volume Indicators

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Volume Per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medication orders approved</td>
<td>3.9 Million orders</td>
</tr>
<tr>
<td>Inpatient medications</td>
<td>7.2 million doses</td>
</tr>
<tr>
<td>IV admixtures</td>
<td>1.5 million doses</td>
</tr>
</tbody>
</table>
Background: Serious Medication Errors

Leape et al, JAMA 1995
Approaches for Improving Inpatient Medication Safety

- Computerized physician order entry (CPOE)
  - Completeness and traceability of orders
  - Decision Support
  - Standardization
- Decision support for care providers
- Closed loop medication use process (MUP)
  - Medication bar code verification
  - Electronic medication administration records (eMAR)
  - Smart Pumps
- Clinical pharmacists on the units
- Robotic technology in the pharmacy
  - Inpatient
  - Outpatient
  - Compounded Sterile Products
Barcode verification could have prevented Heparin mix-up in Indiana
Medication Administration System

CPOE
Provider Writes Order

Pharmacy System
Pharmacist Approves Order, Assigns Bar Code, Scans and Dispenses Medication

No Transcription
No Paper Record

eMAR

Medication Selection from ADC

Medication Verification

Patient Identification Verification

Medication Administration

Medication Administration Documentation
Bar code Verification is Needed Everywhere Not Just for Inpatient Areas!
Focus on use of Standardized Premixed Safely Labeled and Packaged Products

- Two dimensional bar code
- Tall man lettering
- Unit dose syringes
- Tamper evident caps
Dispensing Process: Ensuring High Reliability with Barcode Technology

Medications Filling by Pharmacy Technician

Checking by Staff Pharmacist

Dispensing Errors Uncovered

Dispensing Error Measured

Medications Sent to Patient Units
Dispensing Errors and Potential ADEs: Before and After Barcode Technology Implementation

Before Period (115164 doses observed)
- Dispensing Error Rate: 0.88%
- Potential ADE Rate: 0.61%

After Period (253984 doses observed)
- Dispensing Error Rate: 0.07%
- Potential ADE Rate: 0.00%

31% reduction*

63% reduction*

* p<0.0001 (Chi-squared test)  
Effect of Barcode Technology on Target Potential ADEs

Before Period (115164 doses observed)

After Period (253984 doses observed)

58% reduction*  53% reduction  100% reduction

* p<0.001 (Chi-squared test)
Potential Medication Safety Impact at Brigham and Women’s Hospital

- The pharmacy barcode verification system currently in use is preventing per year:
  - >13,500 medication dispensing errors (31% reduction)
  - >6,000 errors with potential for harm (63% reduction)
- The eMAR bar code verification system is currently intercepting nearly 7700 potential errors per month:
  - Wrong drug 7107
  - Wrong patient 192
  - Expired med 360
Financial Benefits of Barcode Technology in the Pharmacy

- Medical costs saved through adverse drug event reduction, *per year*
- Increased on-time medication availability on nursing units
- Improved inventory control
- Formal cost benefit analysis showed break-even within first year after go-live
  - 5-year cumulative net benefit = $3.3M

Maviglia, S et al. Archives of Internal Medicine 2007
Barcode/eMAR at the Bedside

- Orders flow electronically from CPOE through pharmacy to an electronic medication administration record (eMAR)
  - Eliminates transcription entirely
  - Nurses have laptops with eMAR and use this to track what medications need to be given (administered)
- Nurses use barcode scanning of the medication and the patient to verify that the drug they are administering matches the physicians’ orders
  - Right drug, right patient, right dose, right time
  - eMAR alerts if any of these is incorrect
  - Potentially reduces administration errors
Real Time Alerts to Nurse

Wrong Medication

Medication is not part of patient's active medication profile.

Product Scanned:
SODIUM BICARB 650 MG TABLET

Please zoom the order to verify Pharmacy approved packages
Real Time Alerts to Nurse

Wrong Patient

The scanned wristband is either the wrong patient's or the wristband was unreadable. Please check to see if this is the correct patient's wristband and re-scan. If this is the correct patient and this continues then select "Manual Patient Entry" on the To Do Screen to record the administrations.

Patient Scanned:
EMARTEST, MAGGIE MRN: 18919027
Evaluating the Impact of Barcode-eMAR on Medication Administration Errors

- **Study Design**
  - Non-randomized, controlled observational study comparing error rates on units with and without bedside barcode scanning

- **Primary Study Outcomes**
  - Directly-observed *medication administration errors*
  - Directly-observed *potential adverse drug events (ADEs)* due to medication administration errors

- **Data Collection**
  - Direct observations of medication administrations by trained research nurses
  - All errors detected adjudicated by 2 members of a multi-disciplinary panel
### Impact of Barcode Scanning on Administration Errors and Potential Adverse Drug Events

<table>
<thead>
<tr>
<th></th>
<th>No Barcode Scanning (n=6712)</th>
<th>Barcode Scanning (n=7314)</th>
<th>Relative Reduction (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medication Administration Errors</td>
<td>11.5%</td>
<td>6.8%</td>
<td>41% (p&lt;0.001)</td>
</tr>
<tr>
<td>Potential Adverse Drug Events</td>
<td>3.1%</td>
<td>1.6%</td>
<td>50.8% (p&lt;0.001)</td>
</tr>
</tbody>
</table>

N Engl J Med 2010;362:36-45
# Impact on Potential Adverse Drug Events of Various Severity

<table>
<thead>
<tr>
<th>Potential Adverse Drug Events</th>
<th>No Barcode Scanning (n=6712)</th>
<th>Barcode Scanning (n=7314)</th>
<th>Relative Reduction (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Significant</strong></td>
<td>1.82%</td>
<td>0.94%</td>
<td>48% (p&lt;0.001)</td>
</tr>
<tr>
<td><strong>Serious</strong></td>
<td>1.30%</td>
<td>0.60%</td>
<td>54% (p&lt;0.001)</td>
</tr>
<tr>
<td><strong>Life-threatening</strong></td>
<td>0.03%</td>
<td>0.01%</td>
<td>54% (p=0.52)</td>
</tr>
</tbody>
</table>

N Engl J Med 2010;362:36-45
## Impact of Barcode eMAR on transcription errors

<table>
<thead>
<tr>
<th></th>
<th>Manual Transcription (n=1799)</th>
<th>Automatic Transcription (n=1283)</th>
<th>Relative Reduction (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transcription Errors</td>
<td>6.1%</td>
<td>0%</td>
<td>100% (p&lt;0.001)</td>
</tr>
<tr>
<td>Potential Adverse Drug Events due to</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>transcription Errors</td>
<td>3.0%</td>
<td>0%</td>
<td>100% (p&lt;0.001)</td>
</tr>
<tr>
<td>Significant</td>
<td>1.6%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>Serious</td>
<td>1.3%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>Life Threatening</td>
<td>0.06%</td>
<td>0%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Admin Error Study - Conclusions

- Barcode scanning technology can significantly reduce the incidence of medication administration and transcription errors and associated potential adverse drug events.
- Significant impact on medication safety:
  - ~50,000 potential ADEs prevented per year during transcription stage
  - ~90,000 potential ADEs prevented per year during administration stage
- Errors not completely eliminated:
  - Still in learning curve at time of study
  - Possibility of new errors being introduced
  - Incomplete compliance with scanning
  - Need for ongoing monitoring and improvements
Impact of eMAR on Nurse Satisfaction

- Pre and post surveys
- Main Results: Nurses feel medication administration is safer and more efficient after implementation of barcode technology

Impact on Nurse Workflow

- 232 two hour observation sessions before and after barcode/eMAR implementation
- Primary Result: Proportion of time spent on medication administration did not change after barcode/eMAR implementation
- Secondary Result: Proportion of time spent in presence of patient increased

What’s the Overall Benefit of Medication Safety Technology?

MD

Medications on Wards

Med Ordering

Pharmacist

Dispensing

Transcription

Transcription Errors (12%)

eMAR: 100% reduction

Medication Admin Record

Ordering Errors (39%)

CPOE: 55% reduction

Dispensing Errors (11%)

Pharmacy Barcode Scanning: 67% reduction

Administration Errors (38%)

Barcode-eMAR: 51% reduction

RN

Patient
The Future?
Automating IV Drug Delivery Platform

“Seamless digital pathway from Computerized Provider Order Entry to the patient vein”
Smart Pump Technology and Bar Code Verification

- The Pump Recognizes Drug Name & Concentration in 2D Bar Code
- Calls up correct Drug Library entry
- Critical for PCA !!!

BAR CODE LABEL CONTENT per HIBCC labeling standard
IV Medication Delivery via Wireless Network or Barcode Scan

IV Med Order

ACD Application

CPOE Application

Pharmacy Application

eMAR Application

Pump Vendor Integration Engine

Infusion Data

Drug Library Updates

CQI Database

DL & CQI Data

RFID Tracking

Back End

Smart IV Pump

WiFi and or Barcode Reader

Barcode Label Printer

Scan IV medication orders at the Pump

WiFi and or Barcode Reader

Application

Wireless Communication

Wired Communication

Manual Intervention

Legend
BWH Strategic Vision for Compounded Sterile Products

- Minimize the number of IV admixture and syringe preparation errors by eliminating human preparation of these products both in the pharmacy and in patient care areas.
- Prepare medications in house that were previously prepared and compounded by outside vendors.
- Utilize the quality and safety features of IV robotic devices to insure that all products are made with the highest degree of accuracy, sterility, and safety.
The Cytocare Robot is designed for preparing chemotherapeutic agents.

The Intellifill syringe robot is designed to prepare bulk batches of ready-to-use syringes for Anesthesia and Nursing staffs.

The IV Station robot is designed to prepare patient specific IV bags and syringes or batch filling.

- This can be centrally located or in high volume hospital areas for on-demand access such as the Emergency Department.
IV Station Robotic Devices for On-site, On-Demand IV Admixture Preparation

- Integration with Pharmacy and eMAR information systems
  - Real time bi-directional interfaces
- Remote verification capability for checking pharmacist
- Medications prepared in under 2 minutes in ISO class 5 environment
- Documentation available for central data warehouse
Some Final Thoughts…

- No one intervention (bar coding, eMAR, CPOE, robotics) will solve all of our problems in the Medication Administration System. We need them all!
- Technology can never replace the critical thinking of clinicians
- Beware new sources of error and user initiated work arounds!
“To err is human but to really mess things up... you need a computer”

Anonymous