Computerized Provider Order Entry (CPOE) Using Systems Engineering

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Loyola Marymount University
Topics

- Background
- Project Goals
- Integrating Systems Engineering
- Ethics
- Success Stories
- Conclusion
Background
The Need

- Institute of Medicine Report (1999) stated ~ 44,000 - 98,000 hospital deaths per year due to medical errors
- Adverse Drug Events (ADE) refers to serious injury caused by the drug or medication and any harm associated with the use of the drug
- And...if systems exist that enhance patient safety, don’t they deserve the very best?

Top 10 Causes of Death 1998

1. Heart Disease 724,269
2. Cancer 538,947
3. Stroke 158,060
4. Lung Disease 114,381
5. Medical Errors 98,000*
6. Pneumonia 94,828
7. Diabetes 64,574
8. Motor Vehicle 41,826
9. Suicide 29,264
10. Kidney Disease 26,295

* Estimated

Source: The Err Is Human: Building a Safer Health System, 1999

Patient safety is increasingly recognized as a critical differentiator in the care delivery process

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Medication Management Process: Origin of Adverse Drug Events

Majority of the errors occurs in the ordering steps

Source: JAMA 1995: 274-29-34
1991 Harvard Medical Practice Study was the first to capture data on the epidemiology of medical injury:

- Adverse events occurred in 3.7% of the hospitalizations; 58% of were attributable to preventable Adverse Drug Events (ADE); 13.6% of these ADE leading to death

- Physician ordering errors accounted for 56%-78% of all preventable ADE

- Cost of a single preventable ADE is $4700 per admission or about $2.8 million annually for a 700-bed hospital

Source: Bates and others 1997

Adverse Drug Events (ADEs) are only the visible element of a much bigger incidence of medication errors and ADEs are only one component of the errors in health care today!!
Physician drug ordering errors are most often due to one of two causes:

1. Lack of knowledge about drug
   - Wrong dose
   - Wrong frequency
   - Drug-drug interaction

2. Incomplete patient information
   - Documented allergies
   - Recent lab results

Adverse Drug Events (ADEs) – while a large problem in the health care industry – can be resolved through the appropriate deployment of computerized physician order entry systems!!

Traditional Physician Order Entry Process

**Order is acted on**

- Potential Sources of Error:
  - No validation that order was received
  - Nurse faxes the incorrect order for the patient
  - Transcription/reading error

**Physician writes order of treatment on a paper order sheet**

- Potential Sources of Error:
  - No height/weight dosage checks
  - Allergic reaction to medication ordered
  - Drug-to-drug interactions

**Nurse faxes order to Pharmacy, Lab or department resp. for action**

**Nurse attaches Order to paper patient chart**

- Potential Sources of Error:
  - Order attached to incorrect patient's chart
  - Order not faxed in a timely manner
  - Previous errors are carried over

* Error Prone Step

Traditional approach has been to identify the persons making the errors and punish. Modern approach aims to fix the errors in the process by which care is provided

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CPOE a Close-Loop Process

![Figure 3. CPOE – Eight-Step Physician Workflow](image)

- Successful CPOE utilization requires careful attention to Physician Workflow
- System must encourage physician usage by leading with positive enhancements versus imposing on them a foreign system
- Utilization must be addressed from the perspective of the physician user to achieve value from implementation of the system

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CPOE - What It Does

- Provides Decision Support
  - Display of patient's medical history and lab results
  - Evidence based and best practice medicine guidelines

- Warns of Drug Interactions
  - Drug-Drug
  - Drug-Allergy
  - Drug-Food

- Checks Dosing
  - Real-time patient identification, drug dose recommendations, adverse drug reaction reviews, and checks on allergies and test or treatment conflicts.

- Reduces Transcription Error
  - Orders standardized across the organization
  - Orders are communicated real-time to responsible departments, improving response time and lag time

- Reduces number of lost orders
- Reduces duplicative diagnostic testing
- Recommends cost effective, therapeutic alternatives

Source: CPOE 8 steps to optimization, Journal of Healthcare Information Management Eisenber & Barbell
CPOE – How it makes a difference

Attributes of a CPOE that makes a difference in care:

- Evidence-based clinical guidelines to support treatment decisions
- Enhances patient safety
- Creates more time for care of the patient
- Provides easy access to relevant information
- Enhances documentation and coding for billing compliance

CPOE improve the standards of care, resulting in better therapeutic delivery and outcomes at lower cost
Efficiency Gained

- Initially CPOE added less than 1 minute to the time physicians spent on writing task and 1-2 minutes per overall patient encounter.

- As physicians gained experience with the system, the time for writing tasks and overall task actually decreased, leaving more time for the doctor-patient interaction.


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CPOE Challenges

- It changes the way physicians do their work and they don’t understand the benefits of the change
  - Ultimate goals of the project never explained to clinicians
  - Training of CPOE application can be time consuming
  - Lack of collaborative clinical process redesign

- Redesign efforts impact the entire clinical team – physicians, nurses, pharmacists, and other ancillary personnel
  - IT leads the effort without adequate clinical involvement

- CPOE systems not perceived as reliable, responsive or user-friendly
  - Cumbersome interfaces
  - Integration with legacy EMR systems incomplete or inadequate

- Initial investment inadequate and ongoing costs underestimated
  - Insufficient investment in resources to support the initiative
Key Factors of CPOE Implementation

People
- Lean Leadership - Aligned Leadership and Organization
- Collaborative Structure (Kaizen)
- Communication is vital
- Proper Coordination at all levels
- Commitment to Change & Results

Knowledge
- Training for highly skilled employees
- Proper follow-on IT support
- Management of Clinical Knowledge: Evidence Based Guidelines, Order Sets, Alerts
- Learning focus, not penalties

Process
- Redesign improves, streamlines and eliminates non-value added work
- Value must be defined as improving patient care and safety
- Clinical workflow standardization to reduce variability
- Workflow redesign is an iterative process for continual improvement

Technology
- Data is standardized and supports a common goal
- Applications are integrated
- Infrastructure is interconnected for care continuum
- Security of patient information
Project Goals
Project Goals

- Demonstrate how to integrate SE in the complex development of CPOE

- Presents success stories on how CPOE has been used to manage complexity, lower risk, increased patient safety, lower healthcare cost and offer greater system usability
SE Methodologies

- SE in CPOE development and implementation
- The "illities"
- Lean Thinking and Holistic Engineering
Systems Engineering and CPOE
HITECH 15 "Core" Requirements

- Health Information Technology for Economic and Clinical Health Act (HITECH), apart of the 2009 Federal Stimulus Package, allocated $27 billion dollars for adoption of electronic medical records within clinical organizations

- HITECH defined 15 "core" requirements

- CPOE usage is a major requirement for eligibility of provisions of the HITECH Act

<table>
<thead>
<tr>
<th>Core Req</th>
<th>&quot;Meaningful Use&quot; Core Requirements</th>
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<tbody>
<tr>
<td>#</td>
<td></td>
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<tr>
<td>1</td>
<td>Use Computerized Provider Order Entry (CPOE) for medication order directly entered by any licensed health care professional who can enter orders into the medical record per state, local and professional guidelines.</td>
</tr>
<tr>
<td>2</td>
<td>Implement drug-drug and drug-allergy checks</td>
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<td>3</td>
<td>Generate and transmit permissible prescriptions electronically.</td>
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<tr>
<td>4</td>
<td>Record demographics: preferred language, gender, race, ethnicity, date of birth.</td>
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<tr>
<td>5</td>
<td>Maintain an up-to-date problem list of current and active diagnoses.</td>
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<tr>
<td>6</td>
<td>Maintain active medication list.</td>
</tr>
<tr>
<td>7</td>
<td>Maintain active medication allergy list.</td>
</tr>
<tr>
<td>8</td>
<td>Record and chart changes in vital signs: Height, weight, blood pressure, calculate and display BMI, plot and display growth charts for children 2-20 years, include BMI.</td>
</tr>
<tr>
<td>9</td>
<td>Record smoking status for patients 13 years old or older.</td>
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<tr>
<td>10</td>
<td>Protect electronic health information created or maintained by the certified HER technology through the implementation of appropriate technical capabilities.</td>
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Core Req #1: Use Computerized Provider Order Entry (CPOE) for medication order directly entered by any licensed health care professional who can enter orders into the medical record per state, local and professional guidelines

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Source: American Medical Association, 2010
From Needs to Architecture

Needs
- What needs are we trying to fill?
- What is wrong with the current situation?
- Is the need clearly articulated?

Operations Concept
- Who are the intended users?
- How will they use our products?
- How is this different from the present?

Functional Capabilities
- What specific capability will we provide?
- To what level of detail?
- Are element interfaces well defined?

Architecture
- What is the overall plan of attack?
- What elements make up the overall approach?
- Are these complete, logical, and consistent?

Source: SELP 530, Session #4 Charles C. Tang, 2010
Execution Roadmap

**Structure**
- Apply Systems Engineering to the CPOE development and implementation process within the confines of
  1. People
  2. Process
  3. Knowledge
  4. Technology

**Process**
- Apply ISO/IEC Technical Process within the context of
  1. Define
  2. Design
  3. Develop
  4. Deploy

**Outcome**
- Manages Complexity
- Lowers Risk
- Increased Patient Safety
- Lowers Cost
- Long Term Usability

(Substantiated in Conclusion chart)

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DEFINE
- Stakeholders Requirements Definition
- Requirement Analysis Process

DESIGN
- Architectural Design Process
- Implementation Process

DEVELOP
- Integration Process
- Verification & Validation

DEPLOY
- Transition Process
- Operation and Maintenance Process

Technical Process

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Technical Process applied to CPOE Implementation

Stakeholders Requirements
Definition:
- Definition
- Objectives
- Requirements

Architectural Design:
- CPOE vendor is chosen
- Value stream analysis
- Current state
- Gap analysis to the future
- Define process priorities
- Data collection of existing order sets
- Re-design of order sets
- Define interfaces between EMR modules
- Training Requirements

Implementation:
- Certification
- Comissioned System Operations and Maintenance
- System Validation Plan
- System Verification Plan
- Verification and Validation:
  - Testing: 3 levels which system build to build upon each other 
  - (1) Unit testing
  - (2) System testing
  - (3) Integration testing "day in the life" testing
  - Validation is the Proof of Design Review Concept
  - Training Plans

Operation and Maintenance
- Framework for ongoing support
- Transition:
  - CPOE Monitoring
  - Problem identification method
  - Piloted CPOE conversion throughout the rest of the facility
  - "Go Live" conversion
  - Facility training

Increased Benefits in Safety and Quality

Source: The MITRE, 2012

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Value of Value Stream Mapping

- Value Stream Mapping identifies the value and highlights waste in the flow
- Redesigning operations for minimum waste
- Clinical organizations must perform Value Stream Mapping for clinical workflows in order to:
  - Specify the "value" in any flow
  - Critically examine existing ways of doing business
  - Help clarify current process and identify the desired future state workflows
- Also organization must plan to make all imperfections visible in implementation

Value Stream Mapping **MUST** be done early on in the CPOE implementation


- *Gap Analysis* determines where the technology can improve upon the existing clinical workflows

- Examines weakness in the current environment and asks how it should work for improving patient information flow

- One major mistake that clinical organizations make during this study is trying to force their existing processes into the Electronic Medical Record (EMR) environment

- The most successful organizations approach workflow redesign as an iterative process for continual improvement

*Source: How to Architect the Best CPOE Approach*

*LMU|LA Loyola Marymount University*
- CPOE capabilities range from very basic edits that check for required fields, to highly complex systems that provide knowledge-based rules.

- Integrated EMR systems provide vital patient information at the point of care.

- A major focus during implementation is on the key interfaces and interoperability of CPOE systems with other existing EMR systems.

System integration is vital to the success of CPOE usability.
CPOE system "ilities"...

Reliability...Scalability...Interoperability...
The "ilities"

<table>
<thead>
<tr>
<th>Elements</th>
<th>Considerations</th>
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<tbody>
<tr>
<td>Reliability</td>
<td>Is the CPOE system reliable to manage data flow? Growing number of users, throughput?</td>
</tr>
<tr>
<td>Scalability</td>
<td>How does the system allow for more users? How does the system allows for more networks of providers? What about additional clinical organizations?</td>
</tr>
<tr>
<td>Interoperability</td>
<td>Is the CPOE system interoperable with existing EMR systems? Are there standard messaging protocols or data formats to ease data sharing between systems? What other</td>
</tr>
</tbody>
</table>
Designing for Reliability

- **Reliability**  – *Closely related to maintainability*

> "The ability of a system to consistently perform its required function or mission, on demand and without degradation or failure”

- **Reliable infrastructure** to prevent against loss of critical data in the case of major disruptions
  - Back-up networks on-site, remote data centers and encrypted networks

- **Reliable, secure systems** to protect patient data in the case of major disruptions
  - Technical standards, Antivirus/Spyware prevention and encrypted data

- Ensure **reliability** of the current system and the system in the future
  - Proper training and ensuring software builds are kept up-to-date

Source: Weck and Roos, 2011, pg 79
Designing for Scalability

- **Scalability** – *Closely related to evolvability*

“*The ability of a system to handle usage and service levels with no significant drop in cost effectiveness, functionality, performance, or reliability.*”

- **Evolvable** to allow for more users and greater **data flow**
  - Common protocols and open source system in development

- **Evolvable** design to be flexible to change to allow for more interfaces or functionality in the future
  - OpenEMR, Health Level 7 (data transfer)

*Source: Weck and Roos, 2011, pg 79*
Designing for Interoperability

- Interoperability – *Closely related to compatibility and modularity*

*"The ability of a system to effectively interact with other systems"*

- **Interoperable** with legacy **EMR systems** to merge patient information from various places at the point-of-care
  - common message formats such as HL7 and open source architectures such as COBRA and OLE/COM

Source: Weck and Roos, 2011, pg 79
Lean Thinking and Holistic Engineering
## Lean Thinking in Healthcare

### Leadership
- Commitment to Lean must start from top management
- Management must be visible champions of Lean
- Two-way communication between leadership and the rest of the organization
- Readiness to hear and act on input from the organization

### Culture
- Whole-system strategy rather than single computer fix
- Eliminate organizational structure. Eliminating hierarchical layers and organizing staff into operational teams based on services
- Foster an environment of teamwork and cooperation
- Hold people to higher standards and encourage them to do the right thing

### Process
- The primary process serves health care and patients
- The internal process serves the clinical staff in support of the primary purpose
- Health care has been slow to identify who the customer really is because of the complexity of the health care systems
Holistic Engineering

- Cross disciplinary, whole system approach
- Ability to lead team-centered projects
- Communication across disciplines
- Fostering collaborative environments
- Envisioning creative solutions
Acceptance of Change

Most clinical staff are probably here

Not everyone is at the same pace with respect to his or her acceptance of change

AND...

Communication is the key to shifting from shock to connection

Source: CPOE Success Factors and Implementation Issues
Communication

- Communication is extremely important but can be very time consuming
- Communication Plan is vital and should include updates of the CPOE project at all levels of the organization including:
  - Board meetings by the physician CPOE leader
  - Medical Staff meetings
  - Clinical Department meetings
  - Hospital Departmental Manager meetings
  - Hospital Newsletter
- Lean Visual Signs: develop a device to communicate with the organization on progress of the project
  - Example: "thermometer" method used to show ongoing achievement of the goal
Ethics
Ethical Component: Saving Lives

- American Medical Association defined Codes of Ethics which physicians must abide as part of their duties in providing care:
  - AMA Code of Ethics, Costs: "While physicians should be conscious of costs and not provide or prescribe unnecessary medical services, concern for the quality of care the patient receives should be the physician’s first consideration."

  - AMA Code of Ethics, Quality: "As professionals dedicated to promoting the well-being of patients, physicians individually and collectively share the obligation to ensure that the care patients receive is safe, effective, patient centered, timely, efficient, and equitable."

  Source: AMA.org issued March 1981; Updated June 1994 and June 1998; Updated December 2003

- CPOE applications reduce errors, producing less harm to patients and allow more time for doctors to spend with patients

CPOE applications help uphold AMA codes of ethical conduct
Success Stories
Success Stories

- **Manages Complexity**
  - **Commonwealth of Massachusetts** used SE principles to successfully manage the complexity of CPOE implementation within 10 Massachusetts hospitals

    "CPOE implementation is a change management process."
    
    *Source: Massachusetts Hospital CPOE Initiative CPOE Readiness Roadmap Guide*

- **Lowers Risk**
  - **Children's Hospital in Seattle** lowered risk of CPOE implementation through careful attention to process redesign and leadership. It showed a mortality rate decrease from 4.22% to 3.46% in the first 13-months post-implementation

    "Our experience suggests that careful design, build, implementation, and support can mitigate the risk of implementing new technology even in an ICU setting."
    
    *Source: SeattleChildrens.org, 2001*
Success Stories

• Increased Patient Safety
  - Lucile Pack Children’s Hospital used CPOE to decrease mortality rates by 20% over an 18-month period since it’s system was implemented.

  “LPCH saw the CPOE implementation as a work flow redesign supported by health IT. The implementation was less about technology and more about redesigning processes and work flows to be smarter and more efficient.” Source: CPOEs Can Decrease Mortality Rates, Research Shows, 2010

• Lowers Cost
  - Denver Health Medical Center used CPOE to reduced mis-ordering of a $125 test by 82%.

  “The driving force behind Denver Health’s implementation of CPOE was to support our initiatives for improving patient safety and the quality of care, more effective care, and more efficient care.” Source: Improving Care, Reducing Costs: Successful CPOE Implementation at Denver Health, 2010

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Long Term Usability

- **St. Jude Children’s Research Hospital (SJCRH)** through a phased implementation plan has been successful in implementing a robust CPOE system with integrated EMR that is being successfully utilized since 1997

- "Extensive use of electronic order sets, formal process redesign and system analysis, careful and strategic use of clinical decision support, and a phased implementation approach were essential for safe implementation of CPOE for chemotherapy at SJCRH."

CPOE implementation is a vital change for healthcare, even though the switch may seem daunting.

By using SE strategies that have worked for CPOE development and implementation at other organizations, future organizations can also find success.

SE processes encourage communication and provide meaningful methods by which to assess the overall process of clinical care.
Questions?
The End