The Roadmap to a More Useful and Usable Electronic Health Record

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The Promise of the EHR
Methods

• Usability-Measurement of Efficiency, Effectiveness and Satisfaction with the Health Information Technology such as the EHR

• The Functional Definition of Usability
  • Measure and optimize data flow
  • Measure and optimize work flow
  • Measure and optimize cognition

• Agile Development and Heuristics of work flow and data flow
  • UNMC and UNO College of Information Science and Technology
  • Mark Adkins PhD and ThinkTank Collaboration System
  • The American College of Cardiology Informatics Taskforce
Methods

• We used a Simulated Patient (actor)
  • Uniformity across sites
  • Eliminated HIPAA and Security Concerns from individual sites

• Convergent Parallel Mixed Methods
  • Qualitative analysis using nVivo
  • Quantitative analysis using the System Usability Scale
  • Heuristic evaluation by clinical informatics and computer science experts
Results-Initial Evaluation: Understanding the Wants and Needs of Clinicians

• 55 Physicians, Fellows, and Advanced Practice Providers from the 8 test sites: UNMC, Duke University, Indiana University, VAMC-Omaha (Creighton), Swedish Medical Center (Seattle, WA), Parkview Health (Fort Wayne, IN), Ascension Health (Indianapolis, IN, and Faith Regional Health (Norfolk, NE)

• Qualitative Analysis
  • Results echoed our previous work—the EHR is very cumbersome to use, too many clicks, ultimately they felt the EHR interfered with patient care.
  • Current EHR design and implementation induces a significant extrinsic cognitive load.
  • Specifically:
    • Too much effort used in searching the EHR for information
    • Bloated, non-useful notes
    • Too much time spent documenting and ordering
    • Too much documentation of “impertinent negatives”
Results-Initial Evaluation:
Understanding the Barriers, Needs and Wants of Clinicians

• Quantitative Analysis of Installed EHRs
  • System Usability Scale: 46.7 (scores <65 indicate poor design)
  • Satisfaction Score: 3.10 (Likert scale 1-5, with 1-very unsatisfied, 5-very satisfied and 3-neutral)

• We did not evaluate the differences between systems (but there was no obvious difference in comments or scores between sites)
User Centered Design:
EHR Framework and Prototype Development:

We set a goal of saving 1-2 minutes per clinical encounter (assuming 1.2 billion visits in the US that would be a saving 25 to 50 Million hours annually).

The Tcheng Challenge

“No, no, no! One to two minutes is not enough. We have to save 5-8 minutes per encounter.”
EHR Framework and Prototype Development: Review, Interview, Document

• Review
  • Pertinent History and Pertinent Diagnostics
  • Begin building your cognitive model of the patient and their problem(s)

• Interview
  • Information synthesis
    • History
    • Diagnostics (the Physical Exam is a diagnostic evaluation)
  • Patient Education
  • Patient Engagement

• Document
  • Your thoughts
  • Your orders
## EHR Framework and Prototype Development:

<table>
<thead>
<tr>
<th>Direct Patient Care</th>
<th>Administrative Data Collection</th>
<th>Medical Decision-Making</th>
<th>Clinical Documentation and Communication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td>Chart Review</td>
<td>Problem list reconciliation</td>
<td>Self and partners</td>
</tr>
<tr>
<td>Quality Metrics and Registries</td>
<td>History Taking</td>
<td>Medication reconciliation</td>
<td>Clinical team</td>
</tr>
<tr>
<td>Research</td>
<td>Information Synthesis</td>
<td>Decision Support Tools</td>
<td>Primary Care Provider</td>
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<tr>
<td>Billing</td>
<td>Patient Education</td>
<td>Orders</td>
<td>Patient</td>
</tr>
<tr>
<td></td>
<td>Patient Engagement</td>
<td>External References</td>
<td>Payer</td>
</tr>
</tbody>
</table>
EHR Framework and Prototype Development:

Lawrence Weed

Father of Problem-based Charting

• Problems constructed from Symptoms, Diagnoses, and Therapeutic Procedures

• Problem Connectors
  • Links diagnostics and therapeutics to a specific problem

• Problems are Data
  • Can be encoded by ICD-10 or SNOMED CT
EHR Framework and Prototype Development:
EHR Framework and Prototype Development:

- **Initial Encounter**
  - Data Collection
  - Data Synthesis
  - Data Storage
  - Data Retrieval

- **Return Encounter**
  - Data Review
  - Data Collection
  - Data Synthesis
  - Data Storage
  - Data Retrieval

**Data Persistence**

- Confirm data integrity
- Data gaps filled
- Plan i+1

**Cognitive Support**
EHR Framework and Prototype Development:

• Data can be thought of in two formats:
  • Structured- data that is understandable on its own as a singular concept e.g. an ejection fraction or sodium value
  • Unstructured-data that is a complex. Humans understand complex data but is difficult for computers e.g. Has the patient had a myocardial infarction in the past 12 months?

• Patient Data exists in three states: recorded, clarified, and verified. The physician may be involved in the first two steps, but must be accountable for verification.

• Interoperability is the flow of data without human transformation.
EHR Framework and Prototype Development

• Reducing Intrinsic Cognitive Load
  • Supporting problem-based connectors (i.e. medications, labs, and quality metrics linked to problem)
  • Pushing problem-based data forward
  • Passive decision-support
  • Bring data forward for verification

• Reducing Extrinsic Cognitive Load
  • Static Design
  • Consistent functionality (when I push a button it does this)
  • Adopt established web functionality principles
  • Provide ample real estate for display
Results:
EHR Framework and Prototype Development:

• Concept 1: Episodes of care are an artifact of paper-based charting and billing. Patient care is a continuum with episodes of care representing a snapshot of a point in time.

• Concept 2: The physical exam is no longer central to the clinical encounter. A better formulation is history and diagnostics, with the physical examination a component of diagnostics. Further, the history is obtained from two sources: the EHR and the patient.

• Concept 3: For the clinician, the encounter breaks into three components: Review, interview, and document. The review and interview processes are iterative, not sequential. Clinicians synthesize the data to form a mental model of the patient and their problems.

• Concept 4: Clinicians want easily searchable data, not voluminous documents. The problem list, if appropriately curated, serves as the anchor for efficient and effective use of the EHR.
EHR Framework and Prototype Development-Design Assumptions

Driver 1:

• Cardiovascular medicine is practiced the same across the country and independent of installed EHR. While different individuals adopted different workflow and processes during the clinical encounter, there was little variance in tasks and desired functionality across sites. This was confirmed by Delphi modeling with the ACC Taskforce.
EHR Framework and Prototype Development-Design Drivers

Driver 2:

Clinical care is continuous. An encounter simply represents a snapshot of the patient by a clinician at a specific point in time. All of the patient’s medical history should be represented within the EHR. To organize clinical content, we created the metaphor of the patient’s medical record as a library; different clinicians want different “books” from the patient library. The clinician can take a book off the shelf, view it, use it, or reshelve it. This metaphor reduces note bloat while supporting information synthesis and documentation for billing.
EHR Framework and Prototype Development-Design Drivers

Driver 3:
EHR data can exist in three states: collected, clarified, and verified. In addition to the data framework illustrated in Figures 1 and 2, another step to optimizing clinician workflow is the inclusion of the patient in data collection. However, because of varying levels of medical knowledge by the patient, there is a need for data clarification (the appropriate translation of patient terminology into medical terminology). In this framework, any member of the healthcare team can clarify data. The final step is data verification, a step that is the responsibility of the clinician provider.
Driver 4:

Clinicians want pertinent data pushed to them. Using Dr. Weed’s concept of the problem list and problem connectors (33), it is possible to push pertinent data (including quality metrics and images) to the clinician. With the help of the ACC Taskforce and use of Delphi-modeling we were able to determine what information clinicians wanted pushed to them for specific cardiovascular disorders. This included embedded reminders and context-specific decision support.
EHR Framework and Prototype Development

Driver 5:
Minimize extrinsic cognitive load imposed by the EHR and support clinical expertise. The heuristics of good design to reduce cognitive load are well-established. The consistent use of well-established actions across all web pages is important to reduce the cognitive load imposed by the EHR. Further, while humans have a limited ability to hold multiple independent data elements in short term memory, studies of experts recognize their ability to process chunks of data and place them in established schema to provide greater granularity of data and identify narrative gaps. Further, we found that standardized actions portrayed across a large physical display with no hidden data optimized data representation and recall. Of note, although cited as a major factor in clinician burnout, we specifically incorporated all known administrative tasks within the fabric of our prototype design.
Final Evaluation and Framework Validation

• Training was one on one on the prototype and typically took 15-20 minutes. It consisted of demonstrating design principles and a single complex use case.

• Testing involved a simulated patient (actor) who was recently admitted through the Emergency Department and discharged from “your hospital” and now coming to set up care with you.

• The research subjects were not involved in the design of the prototype

• The research subject (the clinician) drove the computer with support provided when asked.
### Medications

<table>
<thead>
<tr>
<th>Name</th>
<th>Dosage</th>
<th>Route</th>
<th>Instructions</th>
<th>Start Date</th>
<th>Expires On</th>
<th>Pharmacy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anaphylactic reaction due to shellfish (crustaceans)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Associated Medications</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Atrial Fibrillation</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amiodarone</td>
<td>200 mg</td>
<td>Oral</td>
<td>po q day</td>
<td>1/23/2020</td>
<td></td>
<td>Walgreens</td>
</tr>
<tr>
<td><strong>Coronary Artery Disease (CAD)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspirin</td>
<td>81 mg</td>
<td>Tablet</td>
<td>po q day</td>
<td>1/23/2020</td>
<td></td>
<td>Walgreens</td>
</tr>
<tr>
<td>Clopidogrel + PLAVIX</td>
<td>75 mg</td>
<td>Tablet</td>
<td>po q day</td>
<td>1/23/2020</td>
<td></td>
<td>Walgreens</td>
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<tr>
<td>Metoprolol + METOPROL, SUCCINATE</td>
<td>25 mg</td>
<td>Oral</td>
<td>po q day</td>
<td>1/23/2020</td>
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<td>Walgreens</td>
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<tr>
<td>Nitroglycerin</td>
<td>2.5 mg</td>
<td>Oral</td>
<td>si prn q 5 x 3</td>
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<tr>
<td>Rosuvastatin + CRESTOR</td>
<td>40 mg</td>
<td>Oral</td>
<td>po daily</td>
<td>7/23/2020</td>
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<td>Walgreens</td>
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<tr>
<td><strong>Hypertension</strong></td>
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<tr>
<td>Chlorothalidone</td>
<td>25 mg</td>
<td>Oral</td>
<td>po q day</td>
<td>1/23/2020</td>
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<td>Walgreens</td>
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<tr>
<td>Telmisartan</td>
<td>40 mg</td>
<td>Oral</td>
<td>po q day</td>
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<tr>
<td><strong>Long term (current) use of anticoagulants</strong></td>
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<tr>
<td>Apixaban + LIQUIFS</td>
<td>5 mg</td>
<td>Tablet</td>
<td>po bid</td>
<td>1/23/2020</td>
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<td>Walgreens</td>
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<tr>
<td><strong>Presence of aortocoronary bypass graft</strong></td>
<td></td>
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<tr>
<td>No Associated Medications</td>
<td></td>
<td></td>
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<tr>
<td><strong>ST elevation (STEMI) myocardial infarction involving other coronary artery of inferior wall</strong></td>
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<tr>
<td>No Associated Medications</td>
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</tbody>
</table>

*Verify All [✓]*

*Send to Bookshelf [✓] Next: PHR*
MRI confirms inferior wall scar and EF of 51%
Final Evaluation and Framework Validation

Results (n=35 final)

• Qualitative Analysis
  • The layout is easy to understand
  • Linking medications to problems helped identify gaps
  • Pushing data forward really saved time
  • Loved the images
  • We need a better way to document the transition from inpatient to ambulatory
  • It is easy to demonstrate your quality measures
  • This is much faster and logical
Final Evaluation and Framework Validation

Results (n=55, initial, n=35 final)

• Quantitative Analysis

<table>
<thead>
<tr>
<th></th>
<th>Installed EHR SUS (Initial)</th>
<th>Installed EHR SUS (final)</th>
<th>Prototype EHR SUS (final)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUS Score</td>
<td>46.7 +/- 16.6</td>
<td>48.1 +/- 16.7</td>
<td>77.8 +/- 12.4</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>Satisfaction Score</td>
<td>3.10 +/- 0.93</td>
<td>3.16 +/- 0.85</td>
<td>4.40 +/- 0.58</td>
<td>p&lt;0.001</td>
</tr>
</tbody>
</table>
Figure 2: System usability scale (SUS) scores for the installed and prototype EHR. The scores from our initial testing of the installed EHR (n=39) was 47.1. SUS scores for the installed EHR did not significantly improve over the ensuing 3 years with a follow-up SUS scores of 48.1 (n=25). The prototype EHR demonstrated a substantial improvement in SUS score compared with the installed EHR used by the clinician (77.8, p<0.001)
Conclusions:

• Cardiovascular Medicine is practiced the same across the Country and is independent of installed EHR. Therefore, Best Practices can be established. We believe this will proof generalizable to other specialties.

• Time savings must come from compressing the processes of review, documentation, and communication

• Structured data, Concise unstructured data (the narrative) and access to images are important to help the clinician synthesize data

• Effectiveness can be maintained with enhanced efficiency

• A prototype build around user-centered design was demonstrated to be superior to current installed EHR

• It is hoped that this project can help inform EHR vendors of desired functionality
The Research Team

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