From Task Interruptions to Electronic Health Records: Understanding Emergency Physician Stress and Workflow

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• Member of the 21\textsuperscript{st} Century Cures Act Health Information Technology Advisory Committee. Views expressed here are my own.
National Center for Human Factors in Healthcare

• We focus on studying human capabilities and designing technology, systems, and processes to meet these capabilities for safety, efficiency, & quality

35 team members
- Human Factors (4 PhD, 2 MS)
- Health Equities (1 PhD)
- Computer Science (4 MS)
- Aerospace Engineering (1 MS)
- Clinicians (4 MD, 2 RN, 1 PT)
Physician Burnout

Changes in burnout by specialty 2013–2017

Consequences:
- Increased likelihood of error
- Clinician harm and attrition

Source: Medical Lifestyle Report 2017
Recognized Contributors to Burnout

1. Understand the “cognitive impact” of these contributors

2. See the evolution of methods to study clinician work processes

3. Understand the implications of EHR usability
Anatomy of an Interruption

Primary Task

Suspend Primary Task
Work on Interrupting Task
Resume Primary Task

Interruption Lag

Resumption Lag

Altmann & Trafton, 2002
Memory for Goals Theory

• Retrieving the correct goal is based on activation levels
• Strengthening constraint- history of the goal matters
• Priming constraint- mental/environmental cues can boost activation of a goal
• Interference level- goals decay slowly over time

(Altmann & Trafton, 2002)
Activation = \ln\left(\frac{n}{\sqrt{T}}\right)
Management strategies:

1. Delay the interruption during critical tasks
2. Reject the interruption
3. Use the interruption lag to rehearse
Errors by Interruption Length

(Ratwani & Trafton, 2010)
Interruptions in the ED

• 18 attending EM physicians
  – 2 hour observations
  – 3 urban hospitals

Reality...

Interruption Sources and Tasks Interrupted

- 12.5 interruptions per hour
- In-person was the primary source
- Computer tasks commonly interrupted

**Source of Interruption (N=18)**

- Direct Patient
- Other
- Phone
- In-Person Staff

**Task Being Interrupted (N=18)**

- Other
- Phone
- Direct Patient
- In-Person Staff
- Multi-Tasking
- Paper
- Computer
Management Strategies Rarely Used

![Image of a box plot showing the number of interruptions per hour for different management strategies: Reject, Delay, Multi-Tasking, and Start. The box plot indicates a higher number of interruptions per hour for Multi-Tasking compared to the other strategies.](www.MedicalHumanFactors.net)
Leveraging Sensor Technology

- Physiological response
- Attention allocation
- Social interactions
- Observational data collection for context
Task Tracker with HR sensor

ECG sensor worn under the physician scrub and attached to chest strap

Physician HR During Clinical Shifts

- Pilot data from 4 EM physicians
- 60-70 resting
- 160 max

- Larger study just completed
Electronic Health Record (EHR) Usability
EHR Usability and Safety

• Over 90% of providers have adopted an EHR
• Usability is lacking
  – Extent to which the technology can be used efficiently, effectively, and satisfactorily
• Consequences of poor usability:
  – Clinician frustration & burnout
  – Direct patient harm
Usability: Interface Design and Usefulness

User Interface Design
- Context Independent
  - Font Sizes
  - Icons
  - Colors & Contrast
  - Layout

Cognitive Task Support
- Context Dependent
  - “Workflow Design”
  - Visualization
  - Memory Aids
  - Error Anticipation
EHR Usability and Safety Studies

1. Cognitive impact of transition to an EHR

2. Understanding variability from implementation

3. Usability and safety hazards
Impact of the EHR on Workflow

• How does use of a new EHR with CPOE impact physician performance in the ED?
  – Three study periods: pre, go-live, post
  – 2 hour observation periods
  – 14 EM physicians during each phase

• Observers record minute by minute allocation to different tasks
  – Computer, verbal communication, patient time, paper

Task Allocation Time

Current State of EHRs

• EHR usability study conducted at 4 sites
  – 2 Epic
  – 2 Cerner

• 12-15 EM physicians at each site
  – Worked on the test system of their own EHR
  – Complete six clinical scenarios

• Recorded mouse movements, keystrokes, screen capture, eye tracking
<table>
<thead>
<tr>
<th>EHR Functions</th>
<th>Usability &amp; Safety Metrics</th>
<th>Vendor A-Site 1</th>
<th>Vendor A-Site 2</th>
<th>Vendor B-Site 3</th>
<th>Vendor B-Site 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-ray (left elbow, wrist, forearm)</td>
<td>Time (sec)</td>
<td>64.1</td>
<td>24.3</td>
<td>33.3</td>
<td>55.5</td>
</tr>
<tr>
<td></td>
<td>Clicks</td>
<td>31.1</td>
<td>7.7</td>
<td>8.1</td>
<td>15.5</td>
</tr>
<tr>
<td></td>
<td>Error Rate</td>
<td>25%</td>
<td>16.7%</td>
<td><strong>35.7%</strong></td>
<td>20%</td>
</tr>
<tr>
<td>Prednisone Taper (60mg, reduce by 10mg every 2 days for 12 days)</td>
<td>Time (sec)</td>
<td>148.6</td>
<td>152.7</td>
<td>175.1</td>
<td>178.7</td>
</tr>
<tr>
<td></td>
<td>Clicks</td>
<td>34.9</td>
<td>20</td>
<td>42.3</td>
<td>28.2</td>
</tr>
<tr>
<td></td>
<td>Error Rate</td>
<td>16.7%</td>
<td><strong>41.7%</strong></td>
<td>50%</td>
<td>40%</td>
</tr>
</tbody>
</table>

Identifying Usability and Safety Hazards

• Analyzed patient safety event report data
  – 1.7m reports
  – Explicit mention of top five EHR vendor and categorized as a harm event

[DATE] 1842 by [NAME]--- 9 mg dose Gentamicin AND a 9.9 mg dose Gentamicin were in patient bedside med drawer, **EACH ONE was scheduled to be given at 1000** (on the EHR worklist, in EHR Current Scheduled Medications, and each one had an entry on the MAR as being due at 1000). I notified pharmacy and she discontinued one of these doses. **Concern that [Vendor Name] EHR allowed both doses to be ordered**, and if these were timed farther apart there is a possibility that **both doses may have been given**. I printed the information from EHR and placed it in the NICU PCS mailbox.
<table>
<thead>
<tr>
<th>Usability Issue</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data entry</td>
<td>EHR data entry is difficult or not possible given the clinicians’ work process preventing the clinician from appropriately entering desired information</td>
<td>Pharmacist searched for the q24hr entry in the EHR by typing “q24h” Enter and Enter again, which pulls up “Q24HP” and “Q24HR,” but because she hit Enter a second time, it is assumed that the selection is q24hr; the EHR populates all frequencies in alphabetical and numerical order</td>
</tr>
<tr>
<td>Alerting</td>
<td>EHR alerts or other feedback are inadequate because they are absent, incorrect, or ambiguous</td>
<td>Allergy alert did not fire to prescriber even though gelatin allergy was listed in the EHR</td>
</tr>
<tr>
<td>Interoperability</td>
<td>EHR interoperability is inadequate within components of the same EHR or from the EHR to other systems, hindering the communication of information</td>
<td>Patient was admitted as a trauma; the lab value did not flow into the EHR when the patient identification was confirmed</td>
</tr>
<tr>
<td>Visual display</td>
<td>EHR display of information is confusing, cluttered, or inaccurate resulting in clinician difficulty interpreting information</td>
<td>The orders in the EHR still showed the medication from the previous 2 administrations at the correct dose (unchanged), but dated for the previous day, which is subtle to notice in a long list of medications</td>
</tr>
<tr>
<td>Availability of information</td>
<td>EHR availability of clinically relevant information is hindered because information is entered or stored in the wrong location or is otherwise inaccessible</td>
<td>I placed postoperation orders in EHR; they were initiated and I signed them; the perianesthesia nurse called and said they had “failed”; on the orders menu, all orders had failed; I was unable to place new orders, the nurse was unable to initiate old orders</td>
</tr>
<tr>
<td>System automation and defaults</td>
<td>The EHR automates or defaults to information that is unexpected, unpredictable, or not transparent to the clinician</td>
<td>Yesterday, I was entering a patient’s warfarin dose to start October 1 at 8:00 PM; when I entered the time, I did not realize the EHR had defaulted to October 2 at 8:00 PM before pushing the order through</td>
</tr>
<tr>
<td>Workflow support</td>
<td>The EHR workflow is not supported due to a mismatch between the EHR and the mental state of the end user</td>
<td>A test ordered by the office through the EHR was “thyroid group”; the specimen was drawn and ordered by the laboratory; one part of the thyroid test was not performed because it was a confusing translation between the physician order and the EHR</td>
</tr>
</tbody>
</table>
Usability and Harm Events

1.735m Patient Safety Event Reports

1,956 (.11%) explicitly mentioned EHR vendor and reported patient harm

557 (.03%) contained language suggesting usability as an issue

# Harm Levels Associated with Usability Events

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<th>Harm Level</th>
<th>Percent (count)</th>
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<tbody>
<tr>
<td>Reached patient and potentially required monitoring to preclude harm</td>
<td>84% (468)</td>
</tr>
<tr>
<td>Potentially caused temporary harm</td>
<td>14% (80)</td>
</tr>
<tr>
<td>Potentially cause permanent harm</td>
<td>1% (7)</td>
</tr>
<tr>
<td>Could have necessitated intervention to sustain life or could have resulted in death</td>
<td>&lt;1% (2)</td>
</tr>
</tbody>
</table>
Usability Challenges

38% During Order Placement
37% Medication Administration

Data Entry Alerting Interoperability Visual Display Availability of Information System Aut. & Defaults Workflow Support

38% During Order Placement
37% Medication Administration
What do we do?

• EHRSeeWhatWeMean campaign

• Examples of usability and safety issues from Cerner and Epic

• Letter to congress urging action
  – Sign it (takes less than 1 minute)

    EHRSeeWhatWeMean.org
Thank You

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