Information Overload in the ICU – Safety Implications and Solutions

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Multidisciplinary Epidemiology and Translational Research
Clinical Informatics in Intensive Care

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Disclosure

• **Conflict Statement:**
Mayo Clinic and Brian Pickering have a financial conflict of interest related to research discussed in this presentation
  • Patents pending or issued on technologies discussed in presentation (AWARE, Sepsis and ALI sniffers, PCT/US2010/022750)
  • Licensed technology discussed in presentation (AWARE, Sepsis and ALI sniffers)
  • Board of Directors, Ambient Clinical Analytics
• **Funded by**
  • Center for Medicare and Medicaid Innovation (CMMI) Health Care Innovation Award “Patient Centered Cloud-based Electronic System: Ambient Warning and Response Evaluation (ProCCESs AWARE)” (1C1CMS330964-01-00)
  • Mayo Foundation, President’s Discovery Translation Program Award
Objectives

At the conclusion of the presentation the audience should understand the following key concepts:

- Sources of information overload in the acute care setting
- Impact of information overload on human performance and patient centered outcomes
- Principles of human centered interface design
- Concept orientated data views as an information management strategy in the ICU
What is information?

Anything which reduces uncertainty
Sources of Clinical Data in Acute Care Settings
The Care of the Patient Generates lots of Data

Laboratory Data

Physiologic Monitor

Physiologic Supports

Patient Examination

Radiology

Other investigations

Nursing Staff
Pharmacist
Respiratory Therapy
Consult services

Family
Data volume before and after ICU admission

Total data points per patient-hour

Microbiology, labs, medications, chest X-ray, Nurses flowsheet, Clinical notes (history and impression/plan) – VITAL SIGN DATA NOT INCLUDED
“Data-points” in acute setting

**Routine noninvasive monitoring**
- EKG
- Arterial blood pressure
- Heart rate
- Respiratory rate
- Temperature

**Fluid balance**
- Fluid IN
- Fluid OUT
- Urine output

**Laboratory blood**
- Hemoglobin
- Serum electrolytes
- Blood chemistry

**Invasive hemodynamic monitoring**
- Central venous pressure
- Arterial blood gases and pH
- Pulmonary arterial pressure
- Oxygen transport variables

**Natural contexts**
- Demographic data
- Chronic diseases history
- Allergies
- Stress
- Pain

**Ventilator monitoring**
- FiO₂
- PIP
- PEEP/CPAP
- Mean airway pressure
- Tidal volume

**Brain function monitoring**
- Electroencephalography
- Intracranial pressure

**Tissue perfusion / oxygenation monitoring**
- Pulse oximetry
- Transcutaneous oxygen and carbon dioxide monitoring

**Average data points per day**

<table>
<thead>
<tr>
<th></th>
<th>Per Patient</th>
<th>Per 24 bedded ICU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labs</td>
<td>60</td>
<td>1440</td>
</tr>
<tr>
<td>Drug Orders</td>
<td>10</td>
<td>240</td>
</tr>
<tr>
<td>Microbiology</td>
<td>2</td>
<td>48</td>
</tr>
<tr>
<td>X ray</td>
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Not new...

Minimizing Information Overload: The Ranking of Electronic Messages
Journal of Information Science
15 (3) 1989, 179–189.
Robert M. Losee, Jr.
U. of North Carolina

Guardian: An Experimental System for Intelligent ICU Monitoring
Barbara Hayes-Roth, Serdar Uckun, Jan Eric Larsson, John Drakopoulos
Knowledge Systems Laboratory, Computer Science Dept., Stanford University
David Gaba, Juliana Barr, Jane Chien
Dept. of Anesthesiology, Stanford University
Palo Alto Dept. of Veterans Affairs Medical Center

We are developing an intelligent agent for patient monitoring named Guardian. It is applied to the post-operative monitoring and therapy management of surgical patients. The knowledge base contains information on about 70 diseases and complications, 120 parameters, 200 signs and symptoms, and 100 treatment actions.
LACK OF INFORMATION
How do we transform data into information?
How do we translate information into action?
Data to Action: Internal Medicine

Past medical history

Complains and present status

Plan of care. Orders
Data to Action: Critical Care

Past medical history → Complains and present status → Plan of care. Orders
You will be Interrupted

- 1 interruption every 2 minutes in the ICU
- An interruption of as little as 10 seconds can result in individuals forgetting to complete their original task
- New admits during rounds do poorly in medical ICU
- You have on average 2 minutes to gather your data, synthesis it, make a decision and act on it.

## Imperfect Processes of Care

<table>
<thead>
<tr>
<th>Number of Steps</th>
<th>Probability of Success for Each Step in the Process</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>0.95</td>
</tr>
<tr>
<td>1</td>
<td>0.95</td>
</tr>
<tr>
<td>25</td>
<td>0.28</td>
</tr>
<tr>
<td>50</td>
<td>0.08</td>
</tr>
<tr>
<td>100</td>
<td>0.006</td>
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178 processes of care per day
1.7 errors of process per patient per day
544 Human errors in a single ICU over 4 months
147 errors had resulted in harm or had the potential to result in harm
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The data you need to make decisions in the ICU should be readily available to you

Impact on Cognition?
More than we can handle?

• More then 200 variables during critical care rounds [1]
• Systematic response to more than 7 variables is impossible [2]
• Humans are limited to estimate degree of relatedness between only 2 variables [3]

2. Miller G (1956), The magic number seven…
Impact of information overload on performance

doi:10.1097/CCM.0b013e3181a96267
Impact of information overload on patient centered outcomes

- Failure to recognize (resulting in incorrect diagnosis)
- Failure to rescue (resulting in late interventions)
- Waste (resulting in increased costs)
- Communication breakdown and process failure
Information Management Strategies for the Intensivist
I. Less is More
Is a “Trial of Treatment” the right approach?

Ask these questions:

- How much uncertainty exists?
- Will more data reduce uncertainty?
- How harmful is the least-good treatment option?

A “Trial of Treatment” may provide you with the most usable information.
Anatomy of a Decision: Data driven approach

- Review History
- Fluid Balance
- Examination
- CVP
- Waveform Analysis
- CXR
- ECHO
- BNP
- Urinalysis

- Give Fluid
- Give diuretic
- Improve Perfusion
- Do nothing
Anatomy of a Decision: “Trial of therapy” approach

- Low Urine Output
- Give Fluid
- Give diuretic
- Improve Perfusion
- Do nothing

- Review History
- Fluid Balance
- Examination
- CVP
- Waveform Analysis
- CXR
- ECHO
- BNP
- Urinalysis
II. Human Centered Interface Design
Human centered design?
Progress?

1985

2010
Problem: Database centered EMR
Data Cloud

Extract High Value Data

Information Packages Constructed

Holistic Picture Emerges
Defining Information Needs

**SEPSIS Syndrome (n=47)**
- Bilirubin
- Base Deficit
- Support Level (Renal)
- Glucose
- HCO3
- Support Level (CVS)
- Blood Products
- PaO2
- PCO2
- Lactate
- K+
- Platelets
- INR
- Delirium
- Fluid Responsive
- pH
- WCC
- GCS
- Recent Infection
- Support Level
- ST Changes
- Fluid Balance
- Hb
- Oliguria
- Dysrhythmia
- CXR Changes
- Creatinine
- DNR/DNI
- FIO2
- RR
- MAP
- SpO2
- HR

**GI Bleed Syndrome (n=31)**
- Bilirubin
- Base Deficit
- Support Level (Renal)
- Glucose
- HCO3
- Support Level (CVS)
- Blood Products
- PaO2
- PCO2
- Lactate
- K+
- Platelets
- INR
- Delirium
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*Pickering B et al 2008*
Concept Orientated Views

Organ Identifier

- IHD
- CCF
- Hypertension
- Surgery-Stent
- Home Meds
  - Atenolol

Current Organ Physiological Status

- HR: 120 SR
- MAP: 55
- ST Δ: No
- NE 0.05 mcg/kg/min

Status of relevant investigation

- EKG: N/A
- ECHO: N/A
- Troponin: N/A
- HB: 10g/dL
- Blood Loss: 0 ml
- Hct: 0.27
- X Match: None
- IV Access: 2x20G

Clinical Contextual Data

- CVP: N/A
- Lactate: N/A
- SvO2: N/A
- Antibiotics: Given

Current Organ Support

- Provider Actions

Status of relevant Provider Actions
Coordinated Care View
Results: Improved Efficiency
(happy administration)
Results: Reduced cognitive load (*happy clinicians*)
Results: Reduced errors
(happy patients)
III. Building the Hospital of the Future
Figure 1. Challenges and opportunities for improving health care delivery in acute hospitals.

Pickering, Herasevich et al Crit Care 2012
The Present

HIT  =  

≥

The Future

+  ≥
Conclusion

• Acute care physicians have access to an abundance of data.
• Information overload is common in the Acute care setting
• Failures of cognition lead to error and patient harm
• Electronic medical records are database centered
• Well-designed information systems can promote shared understanding, improve decision-making and ultimately prevent patient harm.
• Managing information and displaying it at the point of care in a meaningful manner requires an understanding of human, environmental and contextual factors.
• As health care providers become more sophisticated in their understanding of these issues it will be important to have a framework in place for developing user interfaces that plug into existing infrastructure and deliver high value data to the right person at the right time.
Acknowledges

Ognjen Gajic, MD, MSc
Vitaly Herasevich, MD, PhD

Team Work
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http://mayoresearch.mayo.edu/mayo/research/clinical-informatics-in-intensive-care/