Human Factors Engineering

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Overview

- Case study presentation
- Human error
- Systems approach
- Human Factors Engineering (HFE)
- Examples inside and outside medicine
- What you can do now
Case Study

- 32 year old healthy male
- Presents to ED
  - chest pain, low BP, rapid heartbeat
- Cardioversion @50j → refractory
- Repeat cardioversion @ 100j → VF arrest
- 45 minute resuscitation → patient dies
- Code summary revealed that nurse failed to put device in SYNC mode for second shock
Case Study

- Response?
  - Fire the nurse?
  - Retrain the ED staff?
  - Forbid nurses from defibrillating?
  - New policy? Memo?

- Root cause analysis:
  - Human error?
  - Inadequate Training?
  - Familiarity with device?
What is Human Error?

- Definition (Reason, 1990)
  - “The failure of a planned action to be completed as intended” (error of execution)
  - “the use of a wrong plan to achieve an aim” (error of planning)
  - “Plan the flight and fly the plan”
- Human Error: Big consequences
  - Three mile island
  - Challenger
  - Chernobyl
Types of Human Error

- **Active Errors**: effects felt immediately
  - Front-line operators (pilot, ATC, RN, MD)
- **Latent Errors**: adverse consequences lie dormant within system
  - Designers, high-level decision makers, construction workers, managers, maintenance personnel

Human Error

Goal: “Eliminate Medical Error?”

NO!!!

- Human Error cannot be eliminated
- Futile goal; misdirects resources
- Causes culture of blame and secrecy
  - “name, blame, and train” mentality
- It is about HARM, not ERROR
Typical Human Error Rates

- 0.003  Error of commission, e.g. misread label
- 0.01   Error of omission without reminders
- 0.03   Simple arithmetic errors
- 0.10   Inspector fails to recognize error
- 0.25   very high stress/dangerous activities/rapid

*From Park K. Human Error, in Salveny G, ed. Handbook of human factors and ergonomics*

- To become a high reliability organization, cannot depend on the human component
  - Wire case…
Mitigating Human Error

- If error is inevitable... How to improve safety?
  - Reduce the occurrence of human error
  - Mitigate the effects of inevitable error

- System design
  - “Error trapping”
  - “Mistake mitigation”
Swiss Cheese Model (Reason)

Slices = system protections

Active Error

Adverse Event

Holes = Latent hazards

Modified from Reason, 1990
Lawnmower: System Protections

- Old protections
  - User manual
  - Training at sale
- New Design Features
  - Clump resistant
  - Blade not within reach
  - Forcing Function: Auto shutoff
Lawnmower Swiss Cheese

ACTIVE ERROR:
Decision to pull out clumps

ADVERSE EVENT:
Cut off fingers

owner’s manual

training

auto shutoff

Clump resistant

Modified from Reason, 1990
Culture ➔ Realities

“Most serious medical errors are committed by competent, caring people doing what other competent, caring people would do.”

- Donald M. Berwick, MD, MPP

- Not just about the people
- About the design
  - System, medical devices, procedures
Culture ➔ MYTHS

- It is BAD to make a mistake ("Who is at fault?")
- Human error is **preventable** through:
  - Training
  - Remediation
  - Guidelines
  - Protocols
  - Fear of discipline
- The systems approach protects “bad providers”
Contributing factors to adverse events in health care.

*Diagram credit: Kerm Henriksen, PhD (AHRQ)*

Sometimes hard to distinguish
System Design

- After errors are identified, systems can be designed to compensate for the error
  - “Keep the error from reaching the patient.”

“Every system is perfectly designed to achieve exactly the results it gets”

--Donald Berwick, MD (1999)
Defibrillator Case: Contributing Factors

- **Design issues**
  - Lack of user feedback
    - Device silently leaves sync mode
  - Lack of forcing function
    - Allows unsynchronized shock for SVT

- **Standardization issues**
  - Hospital has several different makes

- **Liability issues, culture of blame**
  - Prior cases known, others not
Defibrillator Usability Study

- Fourteen paramedic participants
- Four tasks: 2 routine, 2 emergent
- Two defibrillator models
- SimMan™ patient simulator
- 50% of participants inadvertently delivered an unsynchronized countershock for SVT
  - 71% of participants never aware

Response

- Fire the nurse?
  - Creates culture with incentive to hide errors
  - Results in less experienced workforce

- Retrain the ED staff?
  - Ineffective way to improve system reliability

- Study past events?
  - Requires culture change
  - True protected reporting

- Improve medical devices interface design?
Defibrillator design

- AED inadvertent actuation
  - Power button when shock intended
- Monitor/Defibrillators
  - SYNC issue
  - Ability to power down during pacing mode
- Why is this all possible???
  - Culture in medicine:
    - The provider should know how to operate device
    - “device functioned as intended”
Human Factors Engineering

- Human Factors Engineering tries to:
  - Optimize the relationship between technology and the human user
  - Design the system to match abilities
  - Designing for human use
  - Prominent in aviation, nuclear, automotive, military, system safety engineering
Human Factors: Definition

“Human factors applies knowledge about human strengths and limitations in the design of interactive systems of people, equipment, and environments to ensure their effectiveness, safety, and ease of use.”

- How humans err is not the focus
- Focus on the interaction or interface between people and the system (tools, devices, environment).
- Fit the tools and environment to the person; not the person to the tools and environment (training)
- Put knowledge in the system rather than knowledge in the head (forcing functions)

--Adapted from Kerm Henriksen PhD, AHRQ
System design

- The QWERTY keyboard
System Design

- Population Stereotypes
  OFF or ON?

- On/off switch
- Faucets
- Screws
- Volume control
System Design

• Minimize opportunity for errors
Latent Error in the ED

- Communication
- Situational awareness is critical
- Study of 5 EDs:
  - Nurses and Doctors never signed out together

(Wears and Perry)

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Examples of Simple HFE Problems

Transcription error??
Interpretation error??
Visual Display
Pyxis Machine- all caps?

From: Stan Caplan, Usability Associates
Can Pyxis Facilitate Error?

20 mcg Fentanyl IV Push Please!
Case

- 74 year old woman to ED for syncope
- Monitored in ED
- Workup negative
- Admitted, but hospital full
- Inpatient orders written (boarding)
- On bedside monitor & telemetry
- 3:30am- blood drawn
- 5:30am...
The monitor case

- Hospital response
  - Lock out HR alarm override
  - “quality checks”
  - Mandatory RN inservice
  - Move monitor bank down
  - Monitor techs IN ED

- Design:
  - No ability to “learn” patient-specific rhythms
  - No feedback for arrhythmia alarm disable
Manufacturer Response

“Monitor was determined to be operating as configured according to manufacturer’s specification”

Traditional approach of device industry:

“We design, test, and build high-quality medical products. It is the responsibility of users to avoid making dangerous errors when using them.”
Wrong Dose, Wrong Med
### Table 1. Risk Factors and Relative Contraindications

<table>
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<tr>
<th>Risk Factors</th>
<th>Contraindications for Inpatient Anticoagulant Prophylaxis</th>
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<tbody>
<tr>
<td>Major</td>
<td>Active, uncontrolled bleeding, cerebrovascular hemorrhage (not bas)</td>
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<td>Dissecting or chronic aortic dissection</td>
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<td>Preeclampsia, eclampsia, abruptio placenta, or placental abruption</td>
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<td>Immobilizing injury or paraplegia</td>
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<td>Hypertension (systolic &gt; 160 mm Hg)</td>
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<td>SEVERE hypothermia</td>
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<td></td>
<td>Retinopathy, retinal hemorrhage</td>
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<td>Stroke, nontraumatic</td>
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<td>Minor</td>
<td>Convulsions or malignant</td>
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<td>Pregnancy or &gt; 1 month postpartum</td>
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<td>Curves, congenital</td>
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<td>Had surgery, trauma, interventional therapy, interventions</td>
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<td>Infection, known (surgery, infectious)</td>
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<td>History of HF, MI, stroke, hypertension, History of MI</td>
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<td>Chronic wounds of the skin or wounds</td>
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### Table 2. DVT-PE Risk & Prophylaxis

<table>
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<tr>
<th>Medical Patient Risk Factors</th>
<th>Risk Class and Prophylaxis</th>
<th>Medical Patient Risk Factors</th>
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</thead>
<tbody>
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<tr>
<td>High</td>
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### Table 3. Procedure-specific Prophylaxis

- **Intravenous Low Molecular Weight Heparin (LMWH)**
- **Intravenous Bivalirudin**
- **Low-Dose Intravenous Heparin**
- **Intravenous Fondaparinux**
- **Intravenous Arixtra**
- **Intravenous Enoxaparin**

*Note: Anticoagulation regimens may vary based on individual patient characteristics.*
Age > 60 DVT-PE Prophylaxis Selection Screen

Non-Surgical
- No operative procedure planned during admission

Surgical Procedure (other than those listed below)
- <45 minute operative duration
- >45 minute operative duration

Procedure Specific
- Intracranial surgery
- Acute spinal cord injury
- Cesarean section
- Multiple trauma
- Hip fracture
- Total hip replacement
- Total knee replacement

-OR-
- Prophylaxis not indicated
DVT-PE Prophylaxis Pathway

DVTTEST, LTFORTY M 24Y
Mr#: 0000000000817 Pt#: 3167 Isol: U
Allergies: NKA

- 1 or more major risk factors
- 1 or more minor risk factors
  Major:
  - prior DVT or PE
  - malignancy
  - hypercoaguable state
  - prolonged immobility (>72hr)
  - paralysis
  - immobilizing cast
  - central venous access
  - myocardial infarction
  - heart failure, decompensated
  - sepsis or severe infection
  - stroke (non-hemorrhagic)
- No risk factors
- Prophylaxis not indicated
  Minor:
  - obesity (BMI >30)
  - heart failure, compensated
  - trauma
  - pregnancy or < 1 mos postpartum (except in active labor)
  - Varicose veins
  - Inflammatory bowel disease
  - oral contraceptive
  - HRT, raloxifene or tamoxifen

F1 Pt List F4 Display Risk Factors
F2 Option Menu
F3 Previous Screen
DVT-PE HIGH RISK OPERATIVE Prophylaxis Order Screen

Preferred Single Therapy: (Recommended)
- Heparin 5000 units SQ q 8 hrs/ begin preop

Sequential Therapy
- Intermittent Pneumatic Compression Stockings followed by heparin 5000 units SQ q 8 hrs

Alternative Therapies
- Intermittent Pneumatic Compression Stockings followed by LWMH
- Heparin 5000 units SQ q 8 hrs/ begin postop
- Enoxaparin 40 mg SC QD
- Dalteparin 5000 units SC QD
- Intermittent Pneumatic Compression Stockings

- Display Contraindications
Result of CPOE System

- Human Factors technique called “usability testing” used to develop a system using end-user input (residents and attendings)
- Result: easy to use (non-encumbering) series of 2-3 screens for every new admit brought the provider to exactly the right prophylaxis level
- Dramatic increase in compliance rates
  
  50% → 66% → 93%

Error Identification

- Anticipate errors, design system protections
  - Study near misses & adverse events
    - “Today’s near misses are tomorrow’s adverse events”
    - Event reporting systems
  - Strong egos breeds secretive culture
    - “People who make mistakes are bad”
    - Punitive nature (peers, employers, regions, states)
    - Hierarchical structure predominates
Error Attitudes

name-blame-train

- vs -

preclude-detect-mitigate

error as cause

- vs -

error as consequence
The single greatest impediment to error prevention in the medical industry is “that we punish people for making mistakes.”

--Dr. Lucian Leape; Professor, Harvard School of Public Health
Iceberg or Pyramid View of Accident Causation

- 1 serious or major injury
- 10 minor injuries
- 30 property damage injuries
- 600 incidents with no visible damage or injury

1,753,498 accidents from 297 companies, 21 different industries

Slide acknowledgment: Robert Panzer, MD

Bird, 1969
Event Reporting in Medicine

- IOM recommends reporting systems
- Failure of most in medicine
  - No incentive
  - Cumbersome
  - Classified by end-user
- Model System: VA PSRS (NASA)
- Most states still punitive
  - “state reportable”
Event Reporting in Medicine

- The last question on the NYPORTS form
- Does this breed a punitive culture?
- There needs to be a balance between standards and an understanding of the systems approach ("just culture")

Was the quality of care met?
- Standard of care was met (If yes, no further action)
- Standard of care was met but there is room for improvement
- Standard of care was not met; attributable to systems
- Standard of care was not met; attributable to individual practitioner (If yes, complete the following:)
  Practitioner’s Name: ________________ License #: _____
  Practitioner’s Name: ________________ License #: _____
Culture → REALITIES

- Human component → least reliable component of any system
- Proclamations for greater vigilance do not work on the long term
- You cannot reduce adverse event rates until you understand the concept of “normal error”
- Otherwise:
  - Providers hide mistakes
  - Leaders close case after assigning blame and planning remediation
  - Miss many opportunities to identify system failures
  - (Incompetence will still be identified!)
What You Can Do

- When Should You Use HFE Tools?
  - During a tough Root Cause Analysis
  - Before procurement or during implementation of a new device
  - New technology assessment

- This is an introduction, so you will learn more on your own
What You Can Do

- Ask manufacturers to report their Human Factors efforts
- How were HFE techniques applied and what are the results?
- What are the most concerning use-related threats/hazards/risk?
- How have they designed for this?
What You Can Do

Focus on contributing factors that can be changed

- Use non-punitive QA systems (educational)
- Use non-punitive reporting systems
- RCAs and incident reviews should examine system factors
- Study near misses
- Ask staff about “accidents waiting to happen”
What You Can Do

- Facilitate culture change
- Open lines of communication (talk about error)
- Employ system safety analysis techniques
- Enact protective system changes (slices)
- Abandon the “name, blame, train and shame” mentality— it is counterproductive
HFE Resources

- Human Factors & Ergonomics Society [www.hfes.org](http://www.hfes.org)
  - resources and consultant directory
- FDA Human Factors Program [www.fda.gov/cdrh/humanfactors](http://www.fda.gov/cdrh/humanfactors)
- VA Ntl Ctr for Patient Safety [www.patientsafety.gov](http://www.patientsafety.gov)
- Univ. Chicago [www.ctlab.org](http://www.ctlab.org)
- Short Courses in Medical Human Factors
  - U. Wisconsin: [www.fpm.wisc.edu/seips](http://www.fpm.wisc.edu/seips)
  - Mayo Clinic: [www.mayo.edu/cme/quality.html](http://www.mayo.edu/cme/quality.html)
- Examples from ADL: [www.baddesigns.com](http://www.baddesigns.com)
HFE Resources

- **Set Phasers on Stun**, Steve Casey (1998)
- Human Error, James Reason (1990)
- Normal Accidents, Charles Perrow (1984)

**easy reading**


More HFE Citations


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Research Programs:
www.EmergencyPharmacist.org
www.EMSsafePatient.com

Winner of the "Not My Job" Award - ADOT
Litchfield Park, AZ 85