our task is to cope with illness and to enable every human being to lead a life as long and free of frailty as science will allow. The steps are often uncertain. The knowledge to be mastered is both vast and incomplete. Yet, we are expected to act with swiftness and consistency, even when the task requires marshaling hundreds of people – from the laboratory technicians to the nurses on each change of shift to the engineers who keep the oxygen supply system working – for the care of a single person. We are expected to do our work humanely and with gentleness and concern. It’s not only the stakes but also the complexity of performance in medicine that make it so interesting and, at the same time, unsettling. Atul Gawande “Better: A Surgeon’s Notes on Performance”
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What is Human Factors? Past, present, systems

Human Error. Types of error, contributing factors, reducing error

Cognitive Factors. Information processing, attention, memory, action

Physical Factors. Workplace design, environmental conditions

Credit: polyscifi (Dominic DeLuque) Flicker Creative Commons.
The most recent year with complete records, **116 wrong-site surgeries**, up from 93 in 2007, were recorded by the Joint Commission, a national hospital accrediting agency.

Preliminary reports logged **137 wrong-site surgeries** from March 2009 through June 2010.
What is Human Factors?

**Definition**

The study of how humans accomplish work-related tasks in the context of human-machine system operation, and how behavioral and non-behavioral variables affect that accomplishment.

**Fundamental Goal**

Reduce error, increase productivity, and enhance safety and comfort when the human interacts with a system.
What is Human Factors?

Individual
Motivations
Situated Competence

Improved Patient Safety

Environment
Organization
Technology
Human Performance
What is Human Factors?

HF CONSIDERATIONS
- USERS
- USE ENVIRONMENT
- DEVICE / INTERFACE

DEVICE USE

OUTCOME
- SAFE & EFFECTIVE
- UNSAFE/INEFFECTIVE
Benefits of Human Factors?

**Caregivers**
Empowered, more productive, more comfortable, more satisfied, protected from design-induced errors

**Manufacturer**
Simpler training, greater sales, lower liability exposure, lower customer support requirements

**Patients**
More comfortable, receive better care

**Care Facilities, Insurers**
Better worker performance, greater worker satisfaction, fewer mistakes leading to negative outcomes, lower liability exposure, lower cost of care
Motivations

Practical Needs
Technological Advancements
Linguistic Developments
User Centered Design Process

Design Controls

Post-Market Surveillance

User Research

Conceptual Design

Detailed Design and Specification

Criteria and Requirement Development

Evaluation

Deployment

Iterative Cycle

Design Input

Design Output

Regulatory Approval

Verification and Validation

Credit: ANSI/AAMI HE74:2001
User Centered Design Process

Credit: SonoSite, Inc.
Human Information Processing

[Diagram showing the processes of human information processing, including stimuli, perception, decision and response selection, response execution, and feedback.]
What is the big deal with human factors?

- Estimated that there are **98,000 deaths per year** in the US hospital system due to medical error\(^1\).

- Annually, medical error costs the US healthcare system **$29 billion**\(^1\).

- Medical error is the **5\(^{th}\) leading causes of death** in the United States (above motor vehicle accidents, diabetes, kidney disease, breast cancer, and influenza).

  Sources: (1) *To Err is Human*, (2) *WrongDiagnosis.com*

- FDA estimates **30,000 deaths per year are related to medical device error**.

- Application of Human Factors to the design of medical devices reduces use error and improves the use-safety.
- HF/Usability work is not provided in submission
- No HF/Usability work prior to validation testing
- “Explaining away” use-related issues (blame training, user ... anything but the device)
- Lack of follow up on residual risk in device and performance issues
- Not identifying and focusing on tasks with highest degree of risk
- **No or inadequate characterization of use errors**
- No systematic collection of users subjective assessment of use safety
- Not testing with representative users
- **Not objectively assessing behavioral performance**
- Use of “usability” objectives that are derived arbitrarily, not related to risk
Human Error
Categories of Foreseeable User Action

- **Unintended**
  - **Slip**
    - Attentional Failure:
      - Intrusion
      - Omission
      - Reversal
      - Misordering
      - Mistiming
  - **Lapse**
    - Memory Failure:
      - Omitting planned item
      - Place-losing
      - Forgetting intentions
  - **Mistake**
    - Rule-based
    - Knowledge-based
    - Skill-based

- **Intended**
  - **Correct Use**
  - **Abnormal Use**
    - Inadequately trained
    - Exceptional violation
    - Reckless use
    - Sabotage

Credit: EN62366:2008
Categories of Foreseeable User Action

- Unintended
  - Correct Use
  - Abnormal Use
    - Inadequately trained
    - Exceptional violation
    - Reckless use
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- Intended
**Categories of Foreseeable User Action**

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</tbody>
</table>
## Three Levels of Performance Control

### Situations
- **Routine**
- **Trained for problems**
- **Novel problems**

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</tbody>
</table>

Contributing Factors

Management
Physical Environment
Equipment Design
Work Itself
Social/Psychological Environment
Worker/Coworker

Credit: Sanders and Shaw, 1988
Reducing the Likelihood of Error

- Simplify the process; reduce hand-offs
- Standardize
- Reduce reliance on memory
- Improve information access
- Use constraints and forcing functions
- Design for errors

- Adjust work schedules
- Adjust the environment
- Improve communication
- Decrease reliance on vigilance
- Provide adequate safety training

Credit: Patrice Spath, Error Reduction in Health Care
Cognitive Factors
Cognitive Factors

needle  window  color / name  display / dial  push button
Attention

**Selective**
Monitoring several sources of information to perform a single task.

**Focused**
Attending to one source of information while excluding others.

**Divided**
Two or more separate tasks must be performed simultaneously, and attention must be paid to both.

**Sustained**
Maintain attention and remain alert to stimuli over prolonged periods of time (vigilance).
Attention

Credit: Christopher Wickens, Multiple Resource and Mental Workload (2008).
Memory

Sensory
Temporary storage mechanism.

Working
Encode and transfer information from sensory to long-term memory; to hold information in working memory requires that the person directs attention to the process (short-term memory).

Long-term
Storehouse of facts about the world and about how to do things.
Memory

Working Memory

Long-term Memory

ENCODING (learning and training)  
STORAGE  
RETRIEVAL
Physical Factors

Physical Work and Manual Materials Handling
Motor Skills
Environment
  Illumination
  Climate
  Noise
What is Human Factors? Past, present, systems

Human Error. Types of error, contributing factors, reducing error

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Physical Factors. Workplace design, environmental conditions
Application

**Thinking**

Human performance is embedded in, and systematically connected to the situation (e.g., device, environment, organization, other people) in which it takes place.

**Systems**

Complex systems cannot be reduced to their individual components, and are better modeled after their relationships rather than component behavior.
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Credit: Road to the Horizon (cogdogblog, Alan Levine), Flicker Creative Commons