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The Science of Safety

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Section A

Accident Causation
“In place were not just one, but a series of safeguards—some human, some procedural, some technical—that were supposed to ensure an accident of this nature could never happen. Yet, quite clearly, these safeguards failed.”
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— Gen. John Shalikashvili

Chairman, Joint Chiefs of Staff

Bhopal

- December 2–3, 1984
- Methyl isocyanate leak
- 8,000 killed
Recent downsizing and maintenance cutbacks had greatly increased operator workload and fatigue.

Displays did not display historical “trend” data.

Operators required to make maintenance and operation record entries in English.
Aviation

- 100 major incidents per year
- 25–30 “hull losses” per year
- Observations show 2 errors per flight = 100 million per year
100 major incidents per year
25–30 “hull losses” per year
Observations show 2 errors per flight = 100 million per year
Which one of these is the right metric?
How Do Accidents Happen?

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Individual Approach to Causation

- Errors arise primarily from aberrant mental processes, e.g., forgetfulness, inattention, poor motivation, carelessness, negligence, and recklessness
Systems Approach to Causation

- Basic premise: humans are fallible, errors are expected even in the best organizations
- Causes include traps in the workplace and organizational processes
- Countermeasures are based on the assumption that working conditions can be changed
### How Do Accidents Happen?

- All complex systems are intrinsically hazardous—
  - Road, rail, and air traffic
  - Space missions
  - Nuclear reactors
- Generally heavily defended against failure
- Contain latent errors
- Routinely run in degraded modes
- Catastrophe requires multiple failures
Ideal: Each Defensive Layer Impenetrable

- In reality, defenses are like slices of Swiss cheese
- Holes continually opening, shutting, shifting
- Presence of holes in any one “slice” does not normally cause a bad outcome
- Accidents happen when the holes in many layers momentarily line up to allow an accident
Section B

Human Performance
Paradox

- Health care workers generally
  - Highly trained
  - Conscientious
  - Well-meaning
  - Use sophisticated treatment
- Errors and harm are common
Human Performance

- Skills
- Rules
- Knowledge
Role of individuals in error causation
Not to point blame
But to help us design systems that take this into account
Human Performance

- Skills
- Rules
- Knowledge
Skill-Based Errors

- You know what you are doing, but your actions don’t go as planned (slips, lapses, fumbles)

Slips (Attention), Lapses (Memory), Fumbles (Execution)

You have a dentist’s appointment but drive to work anyway

“Have a good flight.” “You too.”

You forget your colleague’s name

Coffee misses mouth
Rule-Based Errors

- You think you know what you are doing, but fail to notice contraindications, apply a bad rule, or fail to apply a good rule (rule-based mistakes and/or violations)

Rule-Based Errors (If A, Then Do B)

- Crossing over the double-yellow line
- Ignoring the rule “Any female of child-bearing age is pregnant”
Knowledge-Based Errors

- You’re not really sure what you are doing (knowledge-based mistakes in novel situations)

Knowledge-Based Errors

- Driving on an unfamiliar road
- Is it nerve, artery, vein?
Cognitive Biases in Decision Making

- Heuristics/cognitive dispositions to respond
- Availability (recency)—things are more frequent if they come readily to mind
- Visibility bias

Cognitive Biases in Clinical Decision Making

- Overconfidence

Cognitive Biases in Clinical Decision Making

- Representativeness—if it looks like a duck . . .

Cognitive Biases in Clinical Decision Making

- Search satisficing—call off the search once something is found

Doctors and nurses are human, too
Human error inevitable