Towards More Resilient Performance of Emergency Departments

INDUSTRIAL & SYSTEMS ENGINEERING
TEXAS A&M UNIVERSITY

Son, C., Bernat, M., Sasangohar, F.
cson@tamu.edu, mihabernat@tamu.edu, sasangohar@tamu.edu
Applied Cognitive Ergonomics Lab, Department of Industrial and Systems Engineering, Texas A&M University

APPLIED COGNITIVE ERGONOMICS LAB

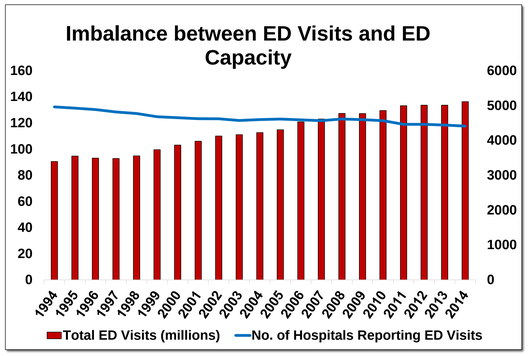
1. Background

Crisis in Emergency Departments (EDs)

The ED is a complex, dynamic system that copes with:

- Limited time and resources,
- Uncertain demands,
- Risks of causing high-consequence of medical errors, and
- Economic pressure due to competitive market and federal mandate. (e.g., Emergency Medical Treatment and Labor Act or EMTLA)

EDs are at a Brittle Point



- ✓ Growing influx of ER patients.
- ✓ ED shutdowns are increasing.
- ✓ 'Crowing/dumping' patients becomes common.
- ✓ Chronic shortage of physicians and nurses.

(Source: American Hospital Association Annual Survey data, 2014. U.S. Census Bureau: National and State Population Estimates, July 1, 2014

Resilience Engineering as a Remedy

Resilience engineering is defined as "a paradigm for safety management that focuses on how to help systems cope with complexity under pressure to achieve success[1] (Woods & Hollnagel, 2006)."

Safety-I Perspective[2]

- See what things go wrong
  - Errors, mistakes, accidents
  - Finding failure
- Emphasize the reduction of human intervention (e.g., "*To Err is Human*")

Safety-II Perspective[2]

- See what things go right
  - Adaptation, variability
  - Finding success
- Stress the need to support human adaptation

2. Resilient ED Responses

Four Types of Resilient ED Responses[3]

Responsive capacity of EDs is finite and limited in quantity and quality of staff, availability of technology, processes, equipment and facility.

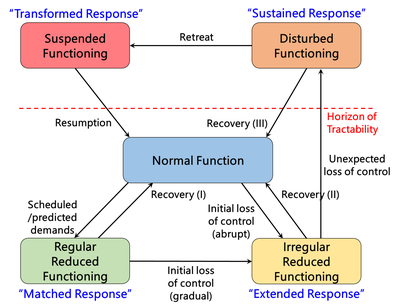
Type	Demand Level	Response Pattern	Example
Matched	Below max. capacity	'Eat up' existing resources	Routine emergency cases, e.g., single car crash
Extended	Slightly over max. capacity	Consume additional resources	Unusual but expectable cases, e.g., multiple car accidents
Sustained	Moderately over max. capacity	Stay 'extended' for a longer period or 'free fall'	Rare and unexpected instances, e.g., train derailment
Transformed	Largely over max. capacity	Change its behavior in a radical way	Mass casualty incident, e.g., suicide bombing

3. Representation of Resilience

Representation of Resilience of EDs

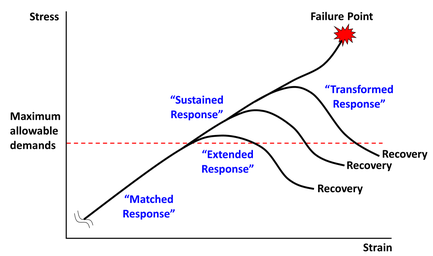
Resilience is a tacit, covert property of a system. Hence, visualization efforts help understand some of dimensions it possesses.

1. State-Space Model[4] (adapted from Hollnagel & Sandström (2006))



- ✓ The ED possesses a set of discrete states.
  - Normal state
  - Regular Reduced Functioning
  - Irregular Reduced Function
  - Disturbed Functioning
  - Suspended Functioning
- ✓ Cons:
  - Limited in explaining temporal changes.
  - State transition occurs between adjacent states.

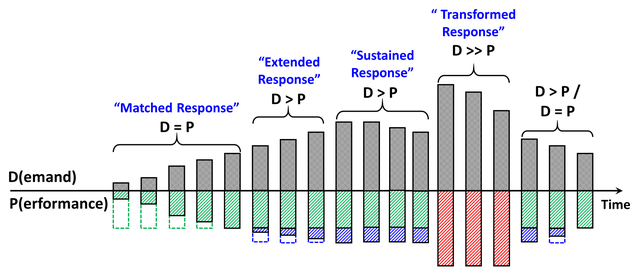
2. Stress-Strain Curve[5,6] (adapted from Sheridan (2008); Woods, Wreathall & Anders (2006))



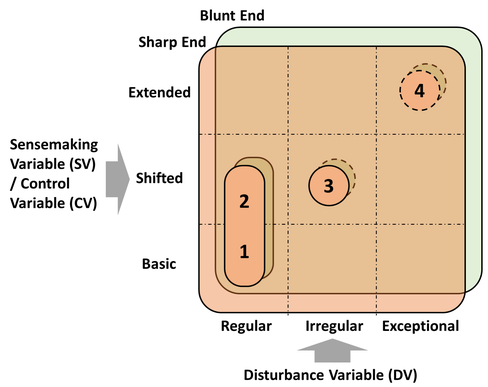
- ✓ Resilience is a physical property of a material.
- ✓ A system can be viewed resilient or brittle.
- ✓ A system reaches a failure when it uses up all the adaptive capacity.
- ✓ Cons:
  - Same as for State-Space Model.

3. Discrete Temporal Model[7] (adapted from Cook (2006))

✓ Illustrate how system's performance elongates or shrinks against varying demands.

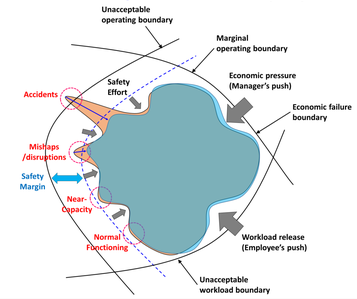


4. Variety Space Diagram[8] (adapted from Rankin et al. (2013))



- ✓ A system can function in various states and is controlled by two ends.
  - Sharp end (e.g. nurses)
  - Blunt end (e.g., hospital management).
- ✓ Interaction between two ends comes along as the system sustains.
- ✓ In extreme events, e.g., MCI neither sharp or blunt end has control actions available to them.

5. Stretched Dynamics Model[9] (adapted from Cook & Rasmussen (2005))



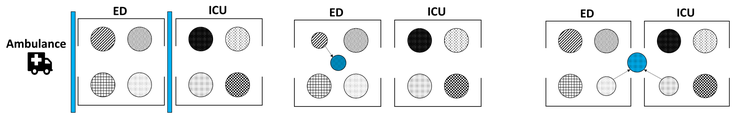
- ✓ A system's operating capacity expands with dynamic interplay among opposing forces.
  - Economic pressure
  - Workload release
  - Safety effort
- ✓ As these forces push the system near and over the operating boundary, accidents, mishaps and near-misses take place.
- ✓ This model can display multiplicity of disruption – response patterns.

4. Strategies for Resilience

4 S's: Staff, Supplies, Structure and Sequence

1. Staff[10,11]: human resources such as physicians, nurses and other practitioners.

1) Defensive 2) Autonomous 3) Cooperative



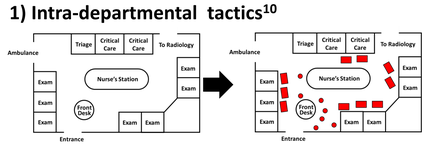
By blocking inflow of patients By assigning staff to a specific role By sharing a common staff pool

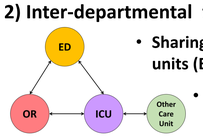
2. Supplies[12,13]: medical apparatus, equipment and pharmaceuticals

- Stockpile a cache of essential commodities
- Conserve restriction on a certain therapy
- Adapt for purposes for they are not intended
- Substitute between functionally compatible tools
- Reuse after proper cleaning and sterilization
- Reallocate to those in the largest needs

3. Structure: organizational structure and facility layout.

1) Intra-departmental tactics[10] 2) Inter-departmental tactics[11]





- Sharing among similar units (ED-OR-ICU)
- Borrowing from dissimilar units

4. Sequence[14]: work processes, steps involved in the responses.

- Skipping: Some life-threatening cases directly admitted to OR and jump paperwork.
- Expediting: Displacing non-critical patients to other units earlier than needed.
- Reordering: Put less urgent surgery, e.g., cosmetic, orthopedic, later than cardiac, abdominal ones.
- Sacrificing: Choosing more critical patients over those with lesser injury.

5. Path Forward

1. Observation studies: some of theoretical and hypothetical arguments need to validated in the real hospital settings.
2. Measuring resilience: patterns of resilient performance must be defined in operational terms for future improvement in e.g., process and interface design.
3. Develop and test resilience-based design principles for healthcare applications

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For more information about this work, contact Changwon Son: cson@tamu.edu / (202) 413-2491