Limits on Adaptation: Modeling Resilience and Brittleness in Hospital Emergency Departments

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Abstract. The emergency department is a complex, highly adaptive system that operates in the face of uncertainty and limited resources. Field observations of an emergency department were conducted to investigate properties of resilience and adaptive challenge. A specific case was explored in order to make generalizations about the classes of adaptive challenge. In addition, researchers used this case to illustrate how the emergency department adapts as load increases in terms of the five properties of resilience in action that is grounded in actual observations.

1 INTRODUCTION

Some systems are designed to adapt to changing demands such as a hospital's emergency department. The emergency department is as a complex, dynamic setting where successful and effective work must occur in the face of high consequences of failure, practitioners are operating under time and resource pressures, and competing goal conflicts.

Analyzing how examples of such systems are adapted to potentially changing demands and studying how they adapt as load increases can reveal a great deal about how to design resilient organizations. Ironically, hospital emergency departments are also critical pressure points in the U.S health care system. In spite of be adaptive by design, recent assessments see emergency departments as a highly brittle component of the overall healthcare system (see Committee on the Future of Emergency Care in the US, 2006). Emergency departments are under resource pressures and face new demands which can lead to coordination breakdowns at boundary conditions (e.g. overcrowding, lack of coordination and boarding patients for other units).

This paper analyzes an active emergency department in terms of resilience concepts, in particular, to test the Westrum taxonomy of resilience situations and further refine the properties of resilience (Westrum, 2006; Woods, 2006). The data are based on observation of an emergency department as it handles different loads and retrospective analyses of actual cases of situations that drove this system very near its limit in adaptive capacity requiring a shift from one level in the taxonomy to another.

The strategies for adaptation are organized around four classes of adaptive challenge. A routine day is one in which the system is operating under usual conditions and described by practitioners as "run of the mill" where the system anticipates shifts beyond the routine and adapt apparently seamlessly. In a second class of situations, a key person recognizes system degradation as load and demands are increasing, thus initiates adaptive tactics (e.g., recruiting and reorganizing multiple resources) to manage the challenges and maintain performance. In other situations the demands increase to the point that the needed adaptations occur at the level of the whole department. In the latter two classes, the demands on the organization challenge its ability to sustain operations and risk escalating to a breaking point, which has been described by practitioners as a "free fall" (e.g., Wears, Perry, & McFauls, 2007). Practitioners have to recognize and anticipate the trend and to reorganize activities and resources at the same time as they are struggling to handle patient load, The last class of situations are planned for but rarely experienced events that call for a complete planned reorganization in the wake of a catastrophic event, e.g. a mass casualty event (Perry, Wears, & Anderson, 2007).

2 METHOD

Observations for this paper were done in a single emergency department during a four-day period and included brief follow-up interviews with the attending physician after the observed shift. A specific case that illustrates how medical personnel cope with complexity and illustrates a transition from a "run of the mill" day to a second class of adaptive challenge is analyzed using a process tracing technique.

3 CASE STUDY

3.1 The Setting

The emergency department in the observed hospital consists of four areas: medical, trauma, pediatric, and flex-care (least critical patients). The observer spent the most time in the medical and trauma units, which is were the specific incident occurred and will be discussed in detail. The trauma unit is actually connected to the medical unit via a doorway leading into the area of the most critical patient beds in the medical (see Figure 1).

The medical unit consists of four critical beds (e.g. patients that need to be on a ventilator), 15 other beds loosely descending in order of criticality, and a "fishbowl" where a sitter is present for the psychiatric patients. The staffing consists of a shared emergency department attending that also manages the trauma unit, four residents (a chief of the day, two other residents, and one that manages both the critical medical beds and trauma), five nurses, nurse of the day, charge nurse (responsible for all emergency department units), and two technicians.

The trauma unit consists of five beds and is meant to be a resuscitation area where patients are stabilized before being moved to other areas in the hospital. The staffing consists of two nurses, one medical technician, the shared resident, an on-call surgical attending, and the shared attending.

3.2 Case Study

Before the escalating event occurred in the emergency department, the night seemed to progressing in what could be described a "run of the mill" shift. The attending spends time shifting patients and deciding where to send the less critical patients in order to free up space in the units. Throughout the evening a steady flow of patients, in both units under observation. The medical unit has only one critical bed occupied, while the trauma unit actually received a number of patients earlier as well as from the night before, hence it only had one open bed. The patients were all stable and personnel were waiting to transfer these patients to other areas of the hospital. Of these patients two were on ventilators, while the other two were conscious. This is the setting for the following case which is described in a linear fashion with commentary from researchers about the properties of resilience.

Table 1. Case description and comments

Case	**Commentary**
The trauma unit of the emergency department receives a call about 3 incoming patients. In order to accommodate these patients, one current patient is admitted to the hospital, and another is moved to the hall.	The unit can only handle one more patient without reconfiguring. Therefore, they are too close to the **margin** if all 3 anticipated patients arrive given the current **capacity**. They reconfigure by moving a patient to the hospital and moving one patient to an area where ventilators cannot be used.
Patient 1 (first expected of 3 patients) comes into the trauma center and is very combative due to head trauma, so before he can be sedated, he is physically restrained by about 8 people.	By using the relatively large resource of eight people now to sedate the patient, he will require less active monitoring later.
Two more patients arrive. The first is the second expected patient of three. The second is her child, who was not expected. The first is put in the open bed, while the child is taken to the pediatric emergency department. The pediatric fellow who transferred the child had recently arrived to assist with the new patients in response to a standard page given to all physicians when critical patients are due to arrive, but had not been aware that a pediatric patient was expected.	In order to make observable all new critical patients to the emergency department all attendings and fellows are paged for any critical patients. When an unexpected child arrives rather than helping in the trauma unit the pediatric fellow changes plans taking the child to the emergency pediatric unit herself.
The unit is alerted that the third expected critical patient should arrive in less than 5 minutes. The	**Buffering capacity** is increased by creating more beds before they are

attending asks the observer to get the chief resident from the medical emergency department to help. The least critical of the patients is wheeled into the hallway (next to the 2 patients already in the hall). The first patient is intubated and second patient is assessed.	needed. In addition, it is a better buffer in that it allows the use of ventilators, which is not possible in the hallway.
Patient 4 arrives from an unrelated accident. The charge nurse asks the paramedic to page the nurse manager to get additional nursing staff. This patient is intubated at the same time as patient 1. The surgical attending arrives to decide which patient should be operated on first.	The charge nurse realizes that the trauma unit's resources (nursing staff) is running out. She unsuccessfully attempts to access resources from a larger resource pool (nursing for the entire hospital) as a **cross-scale interaction** attempt to find additional resources in order to increase the distance between the current state of the system and the safety boundary. The surgical attending is opportunistically deciding which patients would benefit most from surgery, which also frees up trauma resources.
The attending asks the radiology resident that is in the trauma unit to carefully examine all of the x-rays and report any abnormal findings to the trauma attending in order to minimize missing anomalies.	Attending realizes that in this state it is likely that an important alert might be missed, so she recruits other resources as a checking mechanism.
Patient 5 (husband of mother and child from car accident) arrives. All of the beds are taken and no more patients can be put into the hallway without blocking access. The attending asks the trauma charge nurse which patient is most stable and could be moved to a medical ED bed.	The trauma unit is reaching a **boundary** in that it has no more resources available within the unit itself, so in order to avoid collapse, the system shifts to utilization of resources in the medical unit.
Patient 6 arrives with a knife wound. He is quickly examined and the charge nurse has the paramedics wait with the patient on the stretcher in the corner of the room until they have time to process him.	Personnel from outside the emergency department are recruited to monitor the patient in a holding pattern.
Patient 1 is taken to CT scan, and patient 5 is moved from the stretcher to a bed.	One resource reduction strategy employed at several points is reducing patient movement by doing tasks in the emergency department,

	but CT scans are not able to be moved due to the heavy equipment.
The unit receives word that another critical patient (7) is en route. The trauma charge nurse tells the medical charge nurse to expect a patient. Another pediatric patient who had previously been moved to the hallway to make room for the other patients is moved to the pediatric unit to make more room in the hallway.	Bed and staff resources are flexibly recruited from other units, including the medical and pediatric unit. This recruitment signals an understanding that the situation is **precarious** in the sense that they are near the edge of what they can tolerate with current resources.
The new critical patient 7 (hip fracture from car accident) arrives before a bed is made available, so ends up taking the space of the patient getting a CT scan. Patient 5 is prepared for a chest tube. In all, 24 caregivers are in a small, noisy space, primarily caring for patients 5, 6, and 7.	Although there are many patients, most resources are dedicated to a small number of prioritized patients.
The medical charge nurse starts triage and intake of patient 8 (intoxicated patient who had driven into a telephone pole) in the hallway. Another nurse from the medical ED assists the trauma nurses with patient care.	Facilitation occurs **flexibly** by sharing resources across the trauma and medical units.
Two more patients (knife wound and bleeding from artery due to an accidental wound) walk into the trauma unit. A medical ED bed is designated for on-site treatment by two resident physicians from the operating room. Three patients with minor wounds are stitched sequentially. Patient treatment continues without further incident for all other patients.	**Buffering capacity** in the operating room is increased given anticipated needs of critical patients by a non-routine strategy to provide surgical care.

4 DISCUSSION

The data about how an emergency department adapts as load increases provide the means to investigate the five properties of resilience in action in a realistic organization (Woods, 2006):

- the size or kinds of disruptions the system can absorb or adapt to without a fundamental breakdown in performance or in the system's structure (buffering capacity);
- the system's ability to restructure itself in response to external changes or pressures (flexibility versus stiffness);
- where the system is currently operating relative to one or another kind of performance boundary (margin);

- how a system behaves near a boundary – whether the system gracefully degrades as stress/pressure increase or collapses quickly when pressure exceeds adaptive capacity (tolerance); and
- cross-scale interactions, both upward—as when the ED makes demands on the larger hospital system to adapt to high load and downward—as when the hospital/care system adapts in ways that restrict the adaptive capacity of the ED.

Each of this ideas will be further elaborated on in the context of the emergency department case describe above.

The buffering capacity of the emergency department is dynamically generated and increased throughout this incident when the medical personnel recognize that their resources are depleted and the margin in reaching a breaking point. During this incident the attending recognizes that trauma unit in isolation can no longer provide adequate patient care, so she reconfigures the system by pulling resources from the medical unit. This reconfiguration is lead by a key figure, the attending, which cascades to others.

The notion of the buffer size changes as the scenario unfolds, such that initially the trauma unit accommodates the new influx of patients by "creating" beds in the hallway, but this strategy turns out to not be adequate to handle the patient load, so further adaptation must occur. The capacity of the trauma unit was smaller than the actual patient need, such that external resources had to be utilized in order to prevent collapse (see Fig 1 for illustration of where buffering capacity is increased). The trauma unit utilized these back-up resources that are in the margin zone to create resilience rather than undergoing a re-organization (Miller & Xiao, 2006).

Specifically the hallway became a patient holding area, the pediatric unit took extra patients, and similarly the medical unit took extra patients as well as had one bed turn into a "mini" operating room. Monitoring of the resources was more static and made observable to the distant units of the emergency department via the paging system. Hence, the trauma unit was able to off-load the pediatric patients that were taking up needed resources in the trauma unit. Additionally, how and when these additional resources are deployed depend on a variety of factors. This include where the system is in terms of its perceived distance from the margin and availability and timeliness of resources.

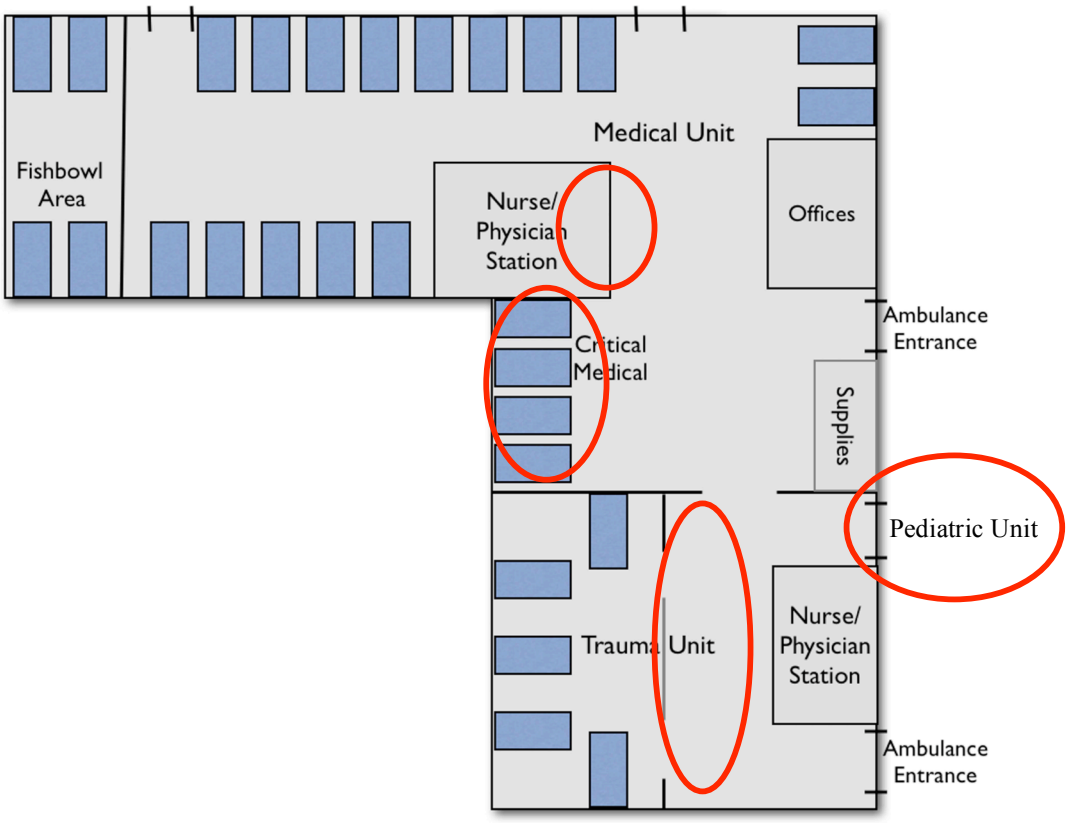

Fig 1: Layout of the medical and trauma units of the emergency department overlaid with areas utilized for patient care that were outside the normal system functions

In order to address the challenges of this case, available resources performed functions outside the scope of normal practice. The flexibility required to do this is a property of resilience, without this flexibility the system would fail. The precariousness of the trauma unit is realized when the necessary resources are no longer available. As is illustrated in Figure 2, initially the resources of the trauma unit are able to cope with the situation, but as the situation escalates performance and resources degrade. The emergency department compensates by utilizing resources from the other units (medical and pediatric). In order to do that the attending made a sacrifice decision to abandon the goal of using resources only from the trauma unit, thus keeping other units free for other potential emergencies to using other units in order to maintain control of the situation (Cook & Nemeth, 2006).

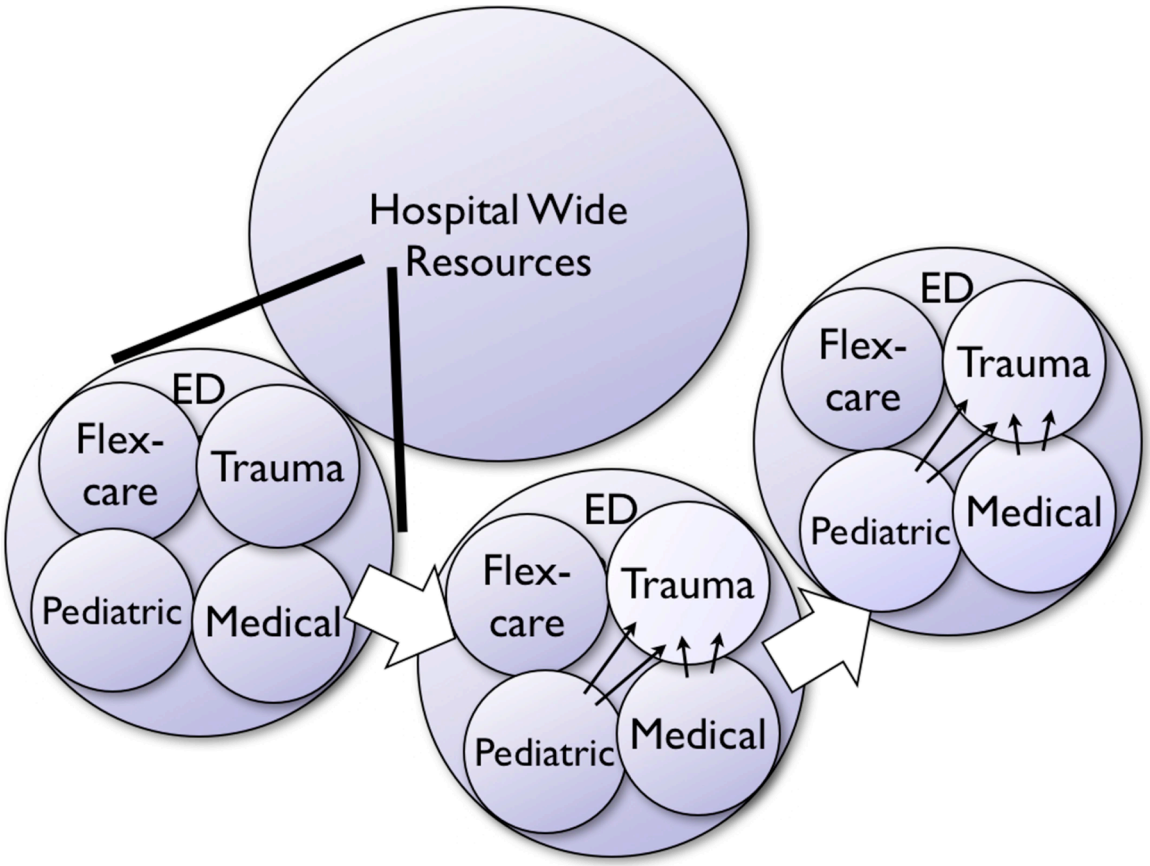

Fig 2: Representation of resource allocation within the hospital and where resources were garnered

Finally, not only does the trauma unit coordinate within the emergency department, but also with resources outside it. The paramedics take over patient care for a less critical patient while the other personnel attend to the more critical patients.

5 CONCLUSIONS

The emergency department exhibits properties of resilience in the way patient care is coordinated. In the current paper a single case was examined in terms of the five properties of resilience, which create a framework for classes of adaptive challenge. In maintaining a balance of these properties potential for collapse can be perceived and adapted for in advance, thus changing the class of adaptive challenge.

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