"Free Fall" – A Case Study of Resilience, Its Degradation, and Recovery in an Emergency Department

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Abstract. Emergency Departments (EDs) are open systems that routinely cope with highly variable and uncertain inputs. This paper will use two critical incidents to explore worker adaptations to complexity and unpredictability, and the organizational interpretation of threats to performance. We use the concept of resilience state space and state transitions to analyse the ED's response to chronic constraints and unexpected shocks.

1 INTRODUCTION

Emergency departments (EDs) are dynamic, open, high-risk systems that function under considerable uncertainty. Like many systems in health care, they have been engineered or designed to only a limited (and some might say naïve) extent. Instead, they have largely evolved sets of artefacts, processes, skills, and attitudes that serve their goals through a process of *bricolage*. These processes support EDs' resilient adaptation to multiple types of variation (*eg*, in numbers of patients, or in the kinds of diagnostic or therapeutic problems encountered), and also to the constraints of economics and human work limits that tend to push them towards working at maximum capacity (Leveson, 2004) and towards the boundary of the safe operating envelope (Cook & Rasmussen, 2005). For the most part, these adaptations are skillfully and unconsciously, almost invisibly performed, as expressed in the Law of Fluency (Woods & Hollnagel, 2006).

However, the resilient capacity of EDs is finite. When it is exceeded, the resulting events offer insight into the ways in which people in the system are sensitive to the possibility of failure; know where to look for evidence of failure and for the resources to cope with it; choose strategies to regain control of the system; and decide which goals to sacrifice in order to meet more important goals and maintain system integrity.

The objective of this paper is to use case studies of two similar events in which the resilient capacity of the ED was exceeded, leaving the system in an uncontrolled state (here called 'free fall'), as a means to explore how resilience is created, lost, and restored in this complex environment.

2 CASE NARRATIVES

Both events occurred in the ED of an inner-city, 653 bed, US teaching hospital that is part of an 8 hospital network. The ED has roughly 90,000 visits per year, and is a Level 1 trauma center. It is subdivided into five major treatment areas totaling 79 beds; two of these areas are dedicated to severe trauma patients and to pediatric cases. Like many US EDs, it experiences severe over-crowding due primarily to a lack of inpatient beds, leading to the 'boarding' of large numbers of admitted patients in the ED (IOM Committee on the Future of Emergency Care in the US, 2006). In response, the ED had reserved one of its non-dedicated treatment areas (comprising 28 beds) for these 'boarders.' One of the remaining two units, with 21 beds, was equipped and staffed for seriously ill patients, and was the site of the episodes described here; the other unit is used only for minor cases. Finally, because the overcrowding problem had previously led to extensive problems with diversion of ambulances en route to EDs in the region, the local public safety authorities had banned the practice of ambulance diversion.

Information on these incidents was gathered by semi-structured interviews of involved staff using the critical incident method, review of documents and personal notes associated with the events, and the ED's volume and through-put records.

2.1 Case 1 – 14 December 2005

At the start of the evening shift (at 1500) on 14 December, the ED was boarding 43 patients. 28 of these filled the unit reserved for boarders, leaving the remaining 15 to be held in a combination of the other two areas and the hallways. Seven were held in the hallway, and all four critical care bays were filled with admitted patients on ventilators. As the shift change rounds in the acute care unit began, the ED received notice that an ambulance was en route with a critically ill patient. Over the course of the next four hours, the ED received by ambulance an additional five critically ill patients (for example, cardiac arrests) requiring ventilator support and other intensive measures, and multiple additional seriously ill but not critical patients (*eg*, chest pain suggestive of heart attack) by ambulance or private conveyance. All treatment spaces were filled; all temporary spaces to hold stretchers were filled; the unit ran out of stretchers and began 'storing' incoming patients in chairs near the nursing station. Congestion was severe, making it physically difficult to move around in the treatment area. This was particularly a problem when new critical patients arrived, since they needed to go to specific treatment spaces because of equipment requirements, and the patients occupying those spaces thus needed to be moved to other locations on very short notice.

The staff later described this situation as a feeling of "free fall", in which they did not know the numbers, types, or problems of the patients in their area of responsibility. The crisis continued until approximately 2200, by which time the staff present felt they had finally gained control of the situation (in the sense of having a clear picture of which patients were present, where they were located, and at least a vague idea of the nature of their problem) and that the system had stabilized.

No identifiable adverse events were associated with this episode, as far as is known.

2.2 Case 2 – 16 November 2005

During the analysis of Case 1, we became aware of a similar incident four weeks prior to it. Events here are structurally almost identical to those outlined in Case 1. The ED was crowded with admitted patients, and the situation had steadily worsened throughout the day. By 1500, there were "… patients everywhere – in chairs, in the aisles. There were no stretchers. We had MICU [critical care] patients from bed 1 to bed 7, and 7 Rescue stretcher patients lined up to be triaged." During this day, the staff recognized that lack of physical space had become the dominant constraint on performance, and attempted a novel adaptation by placing newly triaged, unevaluated cases on stretchers in the hallway. These hallway locations had heretofore only been used for admitted patients for whom no bed was available. Detailed information is available on the trajectory traced by one patient, who suffered an adverse event, as detailed below.

This 58 year old woman presented complaining of severe abdominal pain for several days. She was triaged directly to the hallway since there were no treatment spaces available. The physician performing her initial evaluation was impressed with the seriousness of her condition and felt the problem might require emergent abdominal surgery. She switched this patient with another of her own patients in a routine treatment area, in order to have enough privacy to do a proper physical examination (including a pelvic exam), and then moved them back to their original locations. The routine investigations for an acute abdomen case were ordered, including a plain film (x-ray) of the abdomen. Twice, the patient was moved to x-ray but had to return without radiography because all the technicians were busy with cases in the trauma unit. Finally, near the shift change at 2300, a decision was made to order a computed tomography (CT) scan of the abdomen in anticipation of eventually getting a negative result from the plain film. This decision was influenced by several factors: 1) desire to have a "clear plan" for the oncoming shift; 2) knowledge that the surgical team was similarly overwhelmed in the trauma unit and would be unable to break away to evaluate the patient for some time; 3) the general opinion that the plain film rarely adds important information in these cases; 4) knowledge that the surgeons would probably request the CT prior to their evaluation to save time; and 5) knowledge that an abdominal CT often takes several hours to complete. Eventually, the plain film was obtained, but due to the congestion and confusion in the area, and the discussion about the CT scan at shift turnover, it was not read prior to the administration of oral contrast material in preparation for the CT. Unfortunately, the plain film showed free air, indicating the perforation of a hollow organ (such as the stomach or intestine). In a perforation, oral radiographic contrast material is contraindicated because it can spill out through the perforation and cause a chemical peritonitis, aggravating an already severe condition and complicating the required surgery. The radiologist eventually read the plain film before the CT was performed but after the patient had been given oral contrast, and alerted the ED to the problem. The surgeons were then called, and the patient was taken to the operating room where a perforated ulcer with extensive peritonitis was repaired successfully. Post-operatively the patient suffered a severe stroke; the relationship of this to the preceding events is unclear.

Ironically, a meeting to investigate the cause of this patient's injury was held on 14 December (the date of Case 1), prompting one of the participants to remark, "… the same thing is happening out there again today."

3 ANALYSIS

These cases represent episodes where the resources and coping strategies that normally provide resilience against variation and the unexpected became exhausted, and workers had to adopt new strategies and make sacrifice decisions, abandoning lower level goals in order to preserve higher ones and regain control of the situation (Cook & Nemeth, 2006).

State space model. The resilience state space model (Hollnagel & Sundström, 2006) provides a compact way to summarize the state of the ED as it progressed into and out of this crisis (see Figure 1). Both shifts began in the state of 'regular reduced functioning' – this was not 'normal functioning', at least in the normative sense, although this was certainly the most common state of the ED at this season. The 'normalization of deviance' (Vaughan, 1996) had insidiously consumed the ED's buffering capacity, such that the capability to absorb sudden disruptions had been degraded. This represents a state of chronic decompensation in the system; it remained operable, but at a reduced level of functioning and a reduced margin of safety. Because of the loss of buffering ability, the ED was more tightly coupled to the inpatient beds than was normally expected.

As a result, when the number of critical and serious patients needing assessment and intervention grew rapidly, (and seemingly without limit), the ED shifted to 'irregular reduced functioning'. This was marked by an attempt to continue with diagnostic and therapeutic measures in all patients, using irregular spaces and informally supported sacrifices of some routine procedures. In Case 2, the novel adaptation of triaging newly arrived patients to the hallway when stretcher spaces were exhausted, is an example of this strategy of trying to use novel spaces to maintain some reduced level of functioning. Essentially this was a strategy to develop new compensatory buffers to help manage the disturbance.

One interesting aspect of these adaptations was the strategy of placing patients in chairs. It was never spoken explicitly, but widely recognized, that the ability to maintain postural tone (*ie*, to sit in a chair) was an indicator of a certain level of stability; thus management of patients in chairs could be sacrificed in order to attend to patients of higher criticality. In effect, this strategy identifies patients who might be physiologically more resilient, and "borrows" some of their resilience to provide additional buffering capacity to support higher level goals and operations.

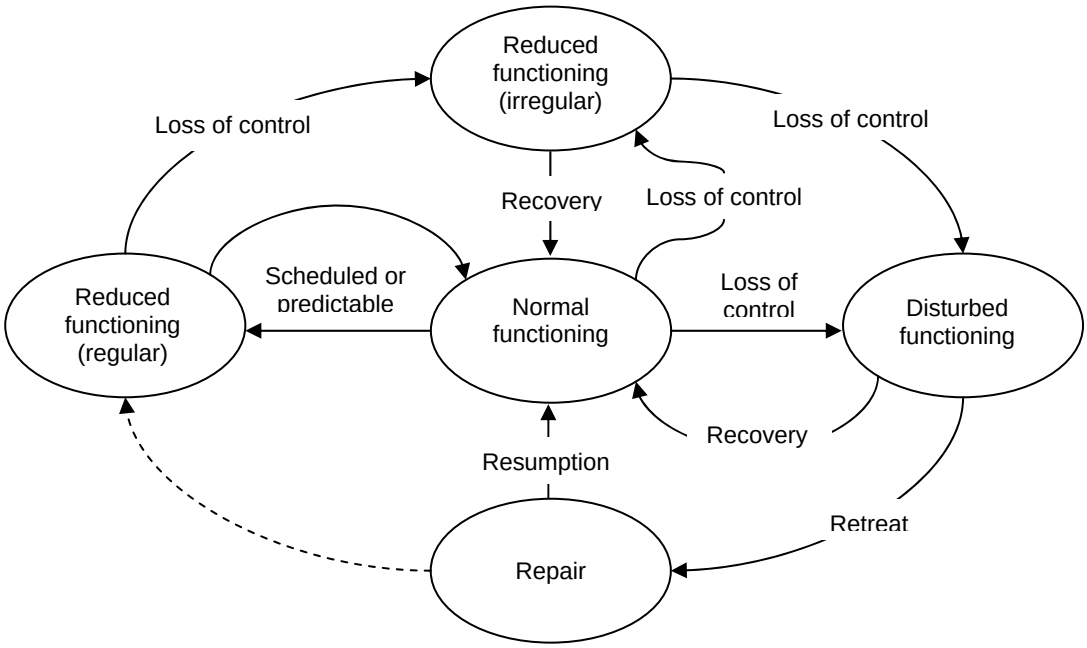

Fig. 1. State-space diagram for service organizations. (After Hollnagel & Sunström 2006, p 341, used with permission)

A second strategy involved sacrificing some lower level goals in order to be able to satisfy higher one. An illustration of this behaviour can be found in the timing of electrocardiograms (ECGs) for chest pain patients. A national standard has been proposed that any chest pain patient should receive an ECG within 15 minutes of arrival to the ED. In this ED, due to chronic decompensation, the mean time to ECG is typically around 35 minutes; in Case 1, the mean increased to 52 minutes (range 0 to 154 minutes).

A third adaptive strategy seen at this level, in both cases, was an anticipatory attempt to use 'feed-forward' techniques to facilitate routine operations in the future. This strategy assumes that the current disturbance will be transient, so the goal should be facilitating those functions that will be important on resumption of more nearly normal operations. In both cases, physicians used a strategy of anticipatory test ordering to try to 'save time in the future'. Here, instead of selecting tests in series, specifically tailored to a patient's condition (which would require a detailed assessment for which there was no time), physicians would order a broad battery of tests in parallel, assuming that by the time the results came back (typically in several hours), they would have completed that detailed assessment and would thus know which results were not relevant. This offers obvious advantages over waiting to place the order, since the results would then be even further delayed. This can be viewed also as a strategy for shifting some of the overload to other parts of the organization, is a mechanism by which the disturbance spreads; it also tightness the coupling between the lab and the ED. In Case 2, this strategy led to placing the order for the CT scan without first reviewing the plain film and other, simpler tests.

In both cases, the situation eventually worsened to 'disturbed functioning', where additional and highly irregular resources were employed. For example, a small office for

the attending physician adjacent to the treatment area was used to perform ECGs on patients who were waiting in the aisles or in chairs, since it had a door that could be closed for privacy. Similarly, a small closet normally used for storage of respiratory and advanced airway equipment was used as a blood drawing area.

Finally, the ED was forced to retreat entirely from any semblance of routine operations for any but the most time-critical of patients. Essentially, this was a strategic decision to concentrate on 'disturbance management', and was manifested by a shift in operations from medical content to simple tracking – identifying patients, the (irregular) spaces to which they were assigned, and a vague categorization of problem type. In both cases, this was aided by creating a second status board within the ED's main status board. This second board was used for patients without assigned treatment areas who were waiting in chairs around the nursing stations, and listed only patient's name, location (this required some informal inventions, *eg*, 'Pyxis chair 2') and check boxes indicating that a physician had spoken to them, and that blood had been drawn. This is essentially the 'repair' state, and can be viewed as a strategy to stop continuing operations in an attempt to regain control. In terms of goal states, it involves the sacrificing of most lower and intermediate level goals in order to preserve resources to restart the system once the disturbance had passed. (It is undoubtedly not accidental that this strategy is expressed in the rhetoric of defeat and resignation).

Once the repair had been successfully accomplished (in that workers now knew which patients they had responsibility for, where those patients were physically located, and what their basic problem type was), and the system stabilized (aided by the decrease in the numbers of incoming critical patients), then normal operations could be gradually resumed. This was done cautiously; it took some time to build up confidence that the current assessments were accurate and complete – the "continuing expectation of future surprise" (Rochlin, 1999) led to a conservative and gradual re-starting of routine operations.

The rapidity of the degradation in performance suggests that the ED possesses highly nonlinear characteristics. The flow of patients through the department on these days seems analogous to phase shifts in the state of matter; discontinuous transitions from laminar, to turbulent flow, to complete stagnation, similar to the condensation of water from a vapor, to a liquid, to ice.

Other adaptations. Other adaptations also played a role in the recovery, albeit to a more limited extent. In Case 1, the crisis became apparent during normal working hours, so additional attending physicians were available to come to the ED to assist. These additional staff were helpful, but were hobbled by the general congestion (in fact, they added a bit to it). Similarly, the hospital's nursing supervisor on duty in Case 1 was widely thought to be one of the more effective, and her presence during the episode assisted in temporarily shifting some ventilator patients to non-standard areas (such as the trauma receiving unit) to regain valuable treatment space, and in caring for incoming critical cases.

Organisational response. In contrast to the worker adaptations performed dynamically in context, the higher level organizational responses to these events were delayed and muted. In Case 2, the specific adverse event was reviewed by an internal quality group, but the span of control of this group was limited, so no general review of the mismatch between resources and demand occurred; instead, the issue was referred upward to hospital administration, where it languished.

In Case 1, in part because no patient was apparently harmed no 'after action review' was held to analyze the hazards or vulnerabilities underlying the episode, despite requests from involved staff.

DISCUSSION

These cases illustrate a complex pattern of performance degradations: acute decompensation, superimposed on chronic decompensation (Miller & Xiao, 2006). The ability of the staff to compensate during the period of chronic decompensation masked the drift toward the boundary of failure. This proximity to failure was finally revealed when buffers that were not easily further expanded were exceeded. Specifically, the lack of available physical space became the irreducible constraint in both cases that led the system ultimately to transition to the repair state.

Clinicians who self-select to work in EDs have a high tolerance for uncertainty, and take great pride in their ability to respond resiliently to uncertain and unpredictable demands. The informal motto: "Anyone, anything, anytime", which was used as the title for a recent history of emergency medicine (Zink, 2006), neatly expresses this common ethos. In terms of patient load, the demands in both these cases were not extraordinary; the total daily visits on these days were close to the ED's average volume, and the acute care unit had successfully managed mass casualty incidents – large numbers of critically ill patients arriving simultaneously or in rapid succession – on numerous occasions in the past. Therefore, the sensation of "free fall" experienced on these two days was highly distressing to the health professionals involved. Rather than being able to "take things in one's stride", as they normally expect to do, they were confronted with an acute sense of overwhelming failure and lack of control (Cook & Nemeth, 2006). Although they did not have the language of the resilience state space in which to express it, the distress that many senior, experienced workers felt over these incidents likely stems from this being their first, ever, transition into the repair state. Since by definition, an ED should never be in the repair state, such a transition challenges the very core of their collective professional identity. In addition, the impression that these episodes were related to hospital management issues, rather than external events (such as a hurricane or other disaster), added a sense of abandonment, which increased the affective impact on the workers.

Resilience in this setting is dynamic and adaptive, but finite in capacity. Three characteristic shifts in strategy accompany changes in the 'resilience state' of the system. These strategies are: attempts to increase buffering capacity; sacrificing lower level goals to preserve higher; and using feed forward methods to facilitate future functional-

ity in anticipation of returning to normal operations. These adaptive strategies are generally, but not always successful, and sometimes bear risks of their own. However, their net effect seems to be to move the system from unstable to stable conditions and to allow the resumption of normal operations.

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