Reliability Versus Resilience: What Does Healthcare Need?

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System performance in healthcare pivots on the ability to match demand for care with the resources that are needed to provide it. High reliability is desirable in organizations that perform inherently hazardous, highly technical tasks. However, healthcare's high variability, diversity, partition between workers and managers, and production pressure make it difficult to employ essential aspects of high reliability organizations (HROs) such as redundancy and extensive training. A different approach is needed to understand the nature of healthcare systems and their ability to perform and survive under duress; in other words, to be *resilient*. The recent evolution of resilience engineering affords the opportunity to configure healthcare systems so that they are adaptable and can foresee challenges that threaten their mission. Information technology (IT) in particular can enable healthcare, as a service sector, to adapt successfully, as long as it is based on cognitive systems engineering approaches to achieve resilient performance.

Talk about healthcare reliability assumes that sector can achieve the same properties as other high hazard sectors such as the military. This presumption may be incorrect. Reliability is often accomplished by means such as standardization and simplification. Imposing these sorts of traits on healthcare systems has the potential to impede, rather than to improve, their performance. Instead, it may be more productive to cultivate aspects of healthcare that are *resilient*. We offer information technology (IT) as an example of creating tools to support healthcare resilience.

Background

Performance in any system relies on the ability to fulfill the mission that it was created to perform. System performance in the healthcare sector pivots on the ability to match the demand for care with the resources to provide it. Multiple systems have evolved through time in order to match demand and resources reliably and efficiently, from acute care (hospitals) to alternate care (clinics, nursing homes, physician offices) to residential care.

In acute care, specialized facilities that optimize a particular procedure (*e.g.*, cardiac surgery) perform on a different set of assumptions than general hospitals. Limiting the kinds of cases that are accepted reduces variability in a number of ways. Patients are referred, which increases prior knowledge about the patient from previous exams and tests. Cases are of a single type, which reduces uncertainty and the potential for surprise. Skills, equipment, supplies and facilities can be limited to perform the set of procedures that the facility will allow, which reduces the variety of operating and maintenance knowledge that is required. Cases tend to be elective, which reduces time pressure. In this setting, standardization and simplification make some sense. In other settings, such as general tertiary care, it does not.

In general tertiary care hospitals, the demand for care varies widely in a number of dimensions: degree of acuity, patient volume, when care is needed, and what kind of care is required. Patients arrive in need of care and the hospital's mission is to provide it. Patient conditions and diagnoses, as well as their treatment, are highly specific to each individual. The degree of acuity is greater than primary or secondary care facilities such as community hospitals, which can also induce time pressure. Reserves of resources such as sophisticated equipment and clinicians are limited by practical considerations such as qualifications and cost. The knowledge, skills, equipment, supplies, and facilities that are appropriate for each procedure are assembled *ad hoc* and cannot be easily reconfigured. Clinicians have developed various protocols such as advance planning (Nemeth, *et. al*. 2006a), sign-out sheets (Nemeth *et. al*. 2006b) and call schedules (Nemeth *et. al*, *accepted*) in order to cope with the need to match limited resources to these widely variable requirements.

A hospital is not an aircraft carrier

Few contributions to the notion of the high reliability organization (HRO) rival Rochlin, LaPorte and Roberts' (1998) analysis of U.S. Navy aircraft carrier flight operations. That seminal work identified four aspects of interest to reliability:

Self design and self replication—Tasks are broken down internally into decomposition rules that are often *ad hoc* and circumstantial. The organization is integrated horizontally, vertically, and across command structures. Structures shift in time to adapt to varying circumstances. Continual training and retraining develops, transmits and maintains the information needed for safe and efficient operation. Workups intensify training prior to operational deployment. Objects, events, situations and appropriate are codified. Assignments are rotated regularly.

The paradox of high turnover—Efforts to manage rapid crew turnover benefit the organization. Turnover requires officers to command respect among senior petty officers. Organizational and technical innovation are resisted until proven to benefit operations, then quickly diffused throughout the fleet. Standard operating procedures (SOP) and procedures are unusually robust.

Authority overlays—Officers negotiate to plan operations and act cooperatively to maximize output.

Redundancy—Technical and supply back-ups, decision cross-checks, shadow roles, and the ability to perform more than one task make it possible to replace lost capability.

Efforts have been made to export the HRO concept to other sectors, including healthcare (Leape, *et. al*. 1998; Bogner, 1994). Significant differences make the transfer of such models difficult, if not problematic. Healthcare systems do not share the same characteristics as other operational systems such as the naval aircraft carrier. The difference in character makes it difficult, if not futile, to expect healthcare to display results in the same way.

Development—Military systems are developed according to specifications and maintained according to strict procedural requirements. Healthcare is been likened to a collection of cottage industries that have a loose affiliation. (Reid, *et.al*., 2005:12-13).

Hierarchy—Military systems develop and use policy and procedures to improve interchangeability, which enables units and individuals to quickly affiliate and re-affiliate. Career growth relies on candidate evaluation by boards of promotion and screening boards that follow legally mandated guidance. Healthcare follows a commercial and professional model of selection.

Management—Military leaders rise to senior levels of command after training as (generally) engineers and years of exposure to the operational work setting. Healthcare managers are typically businessmen and women who have no clinical background.

Behavior—The military encourages coordination and, in some services, initiative, based on long standing service tradition. Healthcare allows for individual caprice if individual practitioners are politically powerful or generate enough billing.

Mission—The military can, and does, stand down to deal with significant safety concerns. Healthcare never stands down.

Gaba (2003) seeks to export the notion of HRO to healthcare by citing four key characteristics:

- Systems, structures and procedures conducive to safety and reliability are in place
- Intensive training of personnel and teams takes place during routine operations, drills and simulations
- Safety and reliability are examined prospectively for all the organization's activities, and organizational learning by retrospective analysis of accidents and incidents is aggressively pursued
- A culture of safety permeates the organization

Among these four, procedures, training and culture place clinician behavior at the center of attention. Given the complex interactions of procedures, equipment, facilities along with personnel, it is not clear whether this is feasible, tenable, or even desirable in healthcare. Very real practical considerations stand in the way of their implementation. Cost limits force systems to run at or near capacity, making the imposition of new systems, structures and procedures problematic. Current pressures to generate revenue allow little room for intensive training beyond what already occurs. (Cook and Rasmussen, 2005) Creation of a facility-wide “culture of safety” pales in importance in comparison with the built-in hazards that require engineering, not simply behavioral, attention. The third trait, though, holds a kernel of promise: prospective. “Anticipation” of what may come has the potential to change healthcare safety and a particular kind of system may provide the resources to do it.

Information technology and resilience

Information technology (IT) has been advocated as a means to improve healthcare efficiency, safety and reliability. IT can be used to improve the provision of services by supporting communication, information access, retrieval, display, and cognitive aiding. Recent reports of failures due to unexpected results (CHAOS 1994; Xia, *et.al*. 2004) from automation surprises indicate that IT demonstrates brittle (Sarter, Woods and Billings, 1997) properties that result from poor understanding of the work settings that they are intended to support. Indeed, IT systems are often installed in an attempt to fix problems that are actually embedded in the social organization (Wears, 2005). IT alone cannot solve such issues. Instead, a broader approach is called for to understand the nature of systems and their ability to perform and survive under duress: in other words, to be *resilient*.

Resilience is the ability of systems to survive and return to normal operation despite challenges. Resilience engineering (Hollnagel, Woods and Leveson, 2006), which stems primarily from the field of complexity study (Csete and Doyle, 2002), seeks to create and maintain systems that can cope and adapt to complex, changing environments. It is used to “assess changes in the adaptive capacity of an organization as it confronts disruptions, change, and pressures” (Woods, 2006). Notions of resilience have evolved in multiple disciplines. Traditional risk assessment (Rasmussen, 1983) has approached resilience as a minor variation in performance due to over- or under-adaptation. Complexity studies approach resilience as an engineering and ecological issue. Organizational research views it as the need for collective mindfulness (Wildavsky, 1988; Weick, Sutcliffe and Obstfeld, 1999). More recent discussion (Vogus and Sutcliffe, *accepted*) distinguish between an anticipatory approach that is intended to design error out of a system beforehand and a resilience approach that recognizes any organizational system is inherently flawed, operating close to its performance limits, and requires management of deviations as soon as possible after they are detected. The resilient organization enlarges informational inputs, loosens control, and reconfigures resources to meet the challenge of discrete jolts and organizational strain.

Resilience, and resilient information technology (IT), are possible, and desirable for healthcare. Healthcare that is resilient readily adapts to changing demands. IT systems offer significant potential to change rapidly and convey needed information in the face of changes and challenges. Research into resilience is a promising avenue to influence the course of development for healthcare IT. Workers and managers need information on changing vulnerabilities and new means in order to meet challenges and IT systems have the potential to serve that role. Their success, though, depends on adaptability in the face of change, which are properties that IT systems do not currently demonstrate.

The following brief example from Nemeth and Cook (2004) demonstrates how IT can be used to increase healthcare resilience. A senior anesthesiologist develops and relies on a master schedule to manage anesthesia assignments for 50 to 80 procedures a day. Master schedule hard copies have sufficed for years, but did not show a crucial element of this work domain: time. Recent conversion to a computer-based display poses an opportunity to leverage IT capabilities. Figure 1 shows an assignment display concept based on time that makes

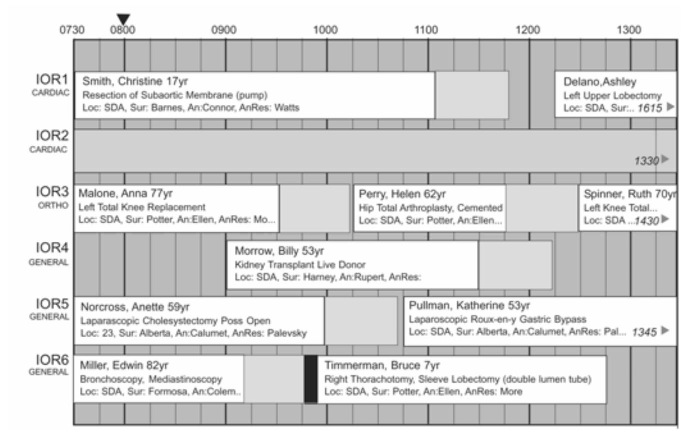

Figure 1: Schematic Master Schedule

it possible for a coordinator and other clinicians to not only see current assignments, but also to review earlier results and anticipate what is to come. Each case is displayed according to both location (the operating room to which it is assigned) and time of day. The display changes “on the fly” as cases are cancelled, added, or run longer or shorter than anticipated. Conflicts that evolve (shown by the black bar in “IOR6” at 9:45AM) can be reconciled before they cause problems. Opportunities to optimize (such as closing up gaps between cases (shown in “IOR4”) can be initiated, saving expensive resources. The display’s ability to quickly reflect changes to the work setting makes it possible for clinicians to make trade-off decisions that hard copies could not support as well.

Discussion

It is not enough to say that better tools will improve resilience. To enhance resilience, solutions must rest on a well-grounded understanding of the subtle local factors that mould the work setting. The challenge is to develop methods that will identify those factors and assess their contribution to resilience. Such inquiries will expose the bottlenecks and trade-offs (“sacrifices”) that workers need to make in order to cope with the real world. At the moment, there is no systematic method to do this. If there was, those who use it might be surprised to discover how numerous and intractable those influences are.

On a broader level, our research needs to find out what limits the ability to be resilient. Is it possible that reliability is suited to systems that are well-bounded and have few degrees of freedom such as a refinery, or power generation and distribution? Is resilience more germane to systems like healthcare, which is poorly bounded and has countless degrees of freedom? Is there a trade-off between reliability and resilience? For example, do efforts to improve the reliability of one or two system features result in an overall decrease in resilience?

Conclusions

Research into resilience needs to address questions that have genuine import for healthcare and IT systems that are intended to support it. Does IT integration foster resilience? Is IT a source of brittle system configurations? How can IT be deployed without disturbing existing resilient parts of the healthcare system? What are the longer-term consequences for healthcare that is conducted in the context of IT systems?

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