Patient Safety Handbook

Second Edition

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Patient Safety is an Organizational Systems Issue: Lessons From a Variety of Industries

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The 1999 Institute of Medicine publication of *To Err Is Human: Building a Safer Health System* directed national attention to the issue of patient safety. Although its content is laudable in nailing the culprit behind the accident scene as being the organization or the system of organizations that together provide health care, its title is misleading. For years accident investigations and industrial psychological and human factors research on worker safety identified the worker/operator as the person behind the industrial accident. This perspective results in name-and-blame, then train-or-fire, cultures in industries concerned with safety.

For example, until quite recently investigations of U.S. Navy aviation accidents didn't look beyond the skin of the airplane for perpetrators. Once mechanical failure was ruled out, the investigation went on to look for operator failure, while failing to recognize that even when operators do fail, there is usually an organizational or systemic reason for failure. One might, for example, observe that the pilot was poorly trained. Is that the pilot's fault? Amount and kind of training are usually dictated by organizational policy. One might ask about the role of the commanding officer in the failure. Did he or she have a need to push his or her squadron beyond its capacity? Was the commanding officer under orders to deliver firepower to inaccessible places? How much pressure was brought to bear on him or her by his or her superior officers? One might also ask about the culture of the organization or system. Had the organization built a John Wayne–type individualistic macho culture when teamwork was required?

Over the last few decades, there has been a major shift in our social conception of the function of medical care.[1] Medicine has shifted from a disease-oriented to a health-oriented enterprise. That is, outcomes that are indicative of healthcare quality and safety have begun to include not only mortality and morbidity, but also the quality of life associated with illness and treatment. Physical functioning (e.g., pain, energy levels, sleep quality), cognitive functioning (e.g., memory, concentration), and emotional well-being (e.g., affective responses, suffering, anxiety, vitality) have all become part of the assessment of health-related quality of life.

This patient-centered ethic underscores the provider's obligation to inform the patient of potential adverse outcomes and solicit and take seriously the patient's self-report regarding unacceptable risks. In addition, such an ethic requires providers to be responsive to the patient's subjective experiences of the downside of care. Patient-centered care reminds us that healthcare excellence and safety not only concerns itself with technical excellence but also with the patient's experience of care. Patient-centered care encourages patients to communicate valuable information to their caretakers as well as mandates caretakers to take proactive approaches to elicit nuanced but valuable information that can improve patient safety. Patient-centered care parallels the shift from regarding patient safety as a human factors issue to a systems and organizational issue because, although it might take a single doctor to treat a disease, it takes a team of doctors, nurses, and other healthcare providers and administrators as well as an organization of safety culture and reliable operations to treat a person.

FOUNDATIONS OF RESEARCH THAT CAN INFORM SAFETY ISSUES

If the traditional industrial and human factors research on safety is largely unhelpful to us in teasing out the etiologies of medical error, is there any work that is more helpful? Engineers and statisticians, human factors researchers, psychologists, and sociologists have made forays into research issues concerned with reliability enhancement or risk reduction. The engineering perspective has, not surprisingly, centered on physical aspects of systems. Human factors researchers and psychologists are largely interested in individuals and groups, and sociologists take a more macro view of the social context in which people work. Here we will draw on both the psychological and sociological approaches.

Sociologists preceded psychologists in developing interests in risk mitigation through a side door, the study of catastrophe. At first these researchers were only interested in disaster aftermath, how the social fabric of a community regenerates itself after destruction.[2,3] In addition, what were originally viewed as individual-level constructs, such as panic, soon came to be seen more as socially driven.[4] In 1978 Barry Turner noted that until that time the only interest in disasters was in responses to them. He provided the first social psychological approach to accidents, looking at the socially driven components of causes.

Human factors and social psychological threads of activity regarding reduction of error merged in the aviation industry. The introduction of reliable jet transports in the airline industry and in the military in the 1950s brought with it a dramatic reduction in aircraft accidents. It became apparent that the remaining accident contributors had more to do with people than with technology. As in many other industries (for example, medicine and the commercial marine industry) it was often noted that 70% to 80% of the problems involved operator error.

Much of the social psychological research on crew resource management came from Robert Helmreich's laboratory at the University of Texas. One of his contributions is the Cockpit Management Attitudes Questionnaire (CMAQ), a 25-item Likert scale assessment of attitudes regarding crew coordination, flight deck management, and personal capabilities under conditions of fatigue and stress.[5] Helmreich adapted this questionnaire for operating room use in the medical industry. Dr. David Gaba at Stanford and the Veteran's Administration, Palo Alto, borrowed heavily from it in the development of his Survey of Patient Safety Cultures in Healthcare Organizations.[6] This is an example of applying research results obtained in one industry to the needs of another.

In 1984, Charles Perrow's seminal book *Normal Accidents: Living with High-Risk Technologies* was published (it was recently republished). Based on his experience as one of the few social scientists asked to contribute to the Three Mile Island investigation, Perrow analyzed a large number of industrial accidents. He concluded that some technologies, like commercial nuclear power plants and modern militaries, are so dangerous they should be shut down altogether because their technologies are both tightly coupled (one event follows immediately after another without mediation) and complexly coupled (events are so complexly linked that their causal relations cannot be deciphered).

HIGH-RELIABILITY ORGANIZATIONS RESEARCH

Simultaneously with the publication of Perrow's book, a group of researchers came together at the University of California, Berkeley. They were interested in the ways organizations achieve risk reduction and highly reliable operations in spite of the great odds against it as hypothesized by Charles Perrow. They focused their interests on what they called high-reliability organizations (HROs). Their contention was that while some technologies are indeed worrisome enough that in an ideal world they shouldn't exist, calling for their overthrow is unrealistic. Thus, we need to do the best we can to insure nearly error-free operation of these technologies. They also demonstrated that relatively low-technology organizations, such as banks, can cause similar degrees of devastation.[7]

Although the original researchers have dispersed, their concerns with risk mitigation were picked up by organizational scholars at other universities. These researchers have studied a diverse group of organizations, including those that should have avoided catastrophe and didn't and those that did. They work in parallel with people coming from the other traditions previously discussed. Thus, today there is considerable interest in risk mitigation that can be and is translated into patient safety issues in the medical industry. Although some of the HRO research is directly cited in *To Err Is Human*, a number of additional findings from it are alluded to without direct citation because of the nature of the testimony behind these kinds of reports.

Findings from HRO Research

Here we summarize some major findings from HRO research. We then discuss reliability-enhancing features that were missing in a failed organization and illustrate how a finely tuned HRO operated to avoid catastrophe. We then discuss an application of HRO findings in a healthcare setting and conclude with suggestions about the kind of research on reliability enhancement and patient safety that should be done in medical settings. HRO findings are divided into two sets: those having to do with major organizational processes, and those more appropriate to a category we call command and control. Some of these processes are more tractable than others. Managers may want to address the easy issues first.

Seven of the HRO research findings are organizational processes. First, HROs are flexibly *structured* so they can move rapidly from bureaucratic tight coupling to more flexible, malleable forms as conditions change. Thus, when an aircraft carrier is in port with little to do, its command can afford to be top-down bureaucratic. But when it is in air operations at sea, its command has to be far more flexible to meet the changing conditions or "fog of war."[8,9] Second, HROs must emphasize *reliability* over efficiency. In fact, reliability rivals productivity as the bottom line.[10] The *cultures* of HROs are heavily imbued with reliability and safety "musts."

Rewards are appropriately used in HROs.[7] They reward the behavior that is desired and avoid rewarding behavior A while hoping for behavior B.[11] HROs are characterized by the perception that *risk exists* and that strategies also exist to deal appropriately with it. Both appropriate attention and strategies must be in place.[7] In HROs, individuals must engage in valid and reliable *sense making*.[12] That is, they must come to the correct conclusions about the meaning of things that are happening around them.[13] Finally, the different senses or meanings people draw from their situation must be meaningfully worked together and integrated across the organization through the *heedfulness* of individual players. Managers try to maximize this integration when they talk about "making sure we're all on the same page." One doesn't have to see the totality of the situation (unless one is at the top of the organization), but should recognize how one's role fits into the roles of the rest of the people in the organization.[14,15] People do not, for example, attend just to the physiology of the situation, but rather to the integration of physiology with the teamwork to deal with it, the state of the patient's family, and so forth.

Although the next five findings are also concerned with organizational processes, we highlight them here as command-and-control issues. HROs are characterized by *migrating decision making*.[9,16] That is, decisions migrate to the part of the organization in which the expertise exists to make them. The highest-ranking person is not always the appropriate person to make a decision. Migrating decision making would be impossible in rigid organizational structures. In addition, in HROs the top management always has *the big picture*, or an overall sense of what is going on. HROs are characterized by *redundancy*. There needs to be sufficient slack so if one party doesn't catch a mistake, another will. In addition, there must be *formal rules and procedures* that are spelled out to and followed by all organizational participants. Finally, HROs are characterized by enormous amounts of *training*.

Departure from Safety

During the 1970s and early 1980s the two major shipping groups in the Baltic Sea began to lower prices, cut costs, and transform their ferries into floating hotels with casinos, night clubs, and shopping malls. Transforming ferries into palaces of entertainment doesn't remind passengers and crewmembers of the potential risks involved in sea travel. The crews were structured to focus on achieving high efficiency and economies of scale through standardization, specialization, and routinized decentralization.

Early one spring evening in 1994, the passenger ferry *Estonia* left its home port and steamed toward its next port, Stockholm, into the teeth of a Baltic Sea storm. Noises from the front of the ship were ignored. The captain headed the ship directly into the waves (3 to 4 meters high) and into an increasingly strong wind. The ship left port at 1915 hours and sailed normally until about 0100 hours. On the bridge the master noted that she was rolling and that they were 1 hour behind schedule despite having all engines running. Shortly before 0100, during his scheduled rounds on the car deck, the seaman on watch heard a metallic bang. The master attempted to find the sound, but none of the orders given or actions taken by him or the crew was out of the ordinary.

Further observations of the noise were made at about 0105 by passengers and off-duty crewmembers. When a seaman reported water on the deck, it was news to the bridge. At 0115 the third engineer saw an enormous inflow on his monitor. He didn't report this to the bridge because he assumed the bridge had the same picture. And he didn't slow the ship down because he was waiting for orders from the bridge. In fact, the engines automatically shut down, and he tried to restart them. The officers on the bridge probably didn't look at the monitor.

The visor (top half of the double doors) separated from the bow at about 0115. As a result, the ramp was pulled fully open, allowing water to rush in. The distress message traffic from *Estonia* began at 0122 hours; the last one was at 01:29:27. The ship disappeared from the radar screens of other ships in the area at about 0150 hours.

The *Estonia* was one of a class of ferries with very large bows, and experience with similar designs was limited. The crew work schedule was 2 weeks on and 2 weeks off. This crew was in the 13th day of a 14-day cycle. It was relatively inexperienced. That night, except for the short time the captain was on the bridge and during the time the storm was increasing, the ship's responsibility was in the hands of the first through the fourth mates. The shift from 0100 to 0600 was in the hands of the second and fourth mates, with respectively 2.5 and 1.5 years of experience. These men were not trained to deal with heavy weather. The life boat orders were not given until 5 minutes after the list developed, and the time available for evacuation was between 10 and 20 minutes.

In this case the organizational structural problem is clear. Although standardization, specialization, and routinization are good strategies for operating organizations faced with benign and unchanging circumstances, they are very poor strategies if the organizations must face new, unexpected contingencies. This is well illustrated by the fact that the engineer failed to report the water on the deck to the bridge and failed to turn the engines off. Under routinization, it was appropriate for him to think the captain would tell him what to do. The industry's decision to change their ships into travel playgrounds was a system characteristic within which ships had to operate with no increased attention to structural safety enhancements.

The emphasis on efficiency over reliability is also clear. The new structure, with its focus on such things as shopping malls, directed attention away from reliability as a primary goal. It also changed the culture from one of seagoing wariness to one of having fun. That the reward system was out of kilter is clear. The master was concerned about schedules and therefore pushed his ship into rough seas. There was no reward system for other crewmembers to report activities that could put the ship in harm's way. It is unclear from evidence available to us whether the ship saw itself as experiencing risky situations. What is clear is that if the crew did so, they did nothing about it.

Sense making was not done in an appropriate way. Vigilance was entirely lacking on the bridge. It is probable that a bridge monitor showed exactly what was happening, but the crew failed to see it. The master had exactly the wrong picture of what was transpiring. Even when evidence of danger was clearly on the bridge's monitors, he and his crew failed to perceive it. The situation with the engineer shows even more clearly the absence of appropriate sense making. He *had pictures* of water. Despite that information, he tried to override an automatic engine shutdown. In every case, representation of the situation was incorrect. The decisions made on the bridge appear to have been rational responses to a situation that didn't exist. Without appropriate sense making, it was impossible to engage in heedful interaction.

Migrating decision making failed to occur, as in the case of the engineer failing to make a decision he was supposedly qualified to make, and waiting for the captain to give him orders. Clearly, the captain failed to have the big picture. Redundancy didn't exist, or someone would have said "why are we doing this?" Although we have no evidence of this, it appears that formal rules of safety didn't exist, weren't practiced, or weren't considered important. The case includes several references to lack of experience or training.

A Safe Landing

Following is an incident that could have turned into a disaster. In fact, it started as a disaster. One night in the summer of 1999, an F/A 18 Hornet (fighter/attack aircraft) was first in the launch cycle aboard the U.S.S. *Constellation*, awaiting launch from catapult 1. Upon launch the aircraft ingested rubber catapult covers that someone failed to remove from the catapult. The pilot (call sign "Oyster") could only manage his plane in full afterburner and at low altitude. He needed to land by trapping with the hook of the aircraft one of the wires at the rear end of the ship, preferably number 3. A number of people are involved in the story, including the landing signal officer, called Paddles. (Paddles he was in World War II movies, and Paddles he is today.) During flight operations the carrier is always followed by an escort (picket) ship and flies its helicopter as safety precautions. Here's the incident, as told by the pilot:

> There I was. Manned up in the hot seat for the 2030 launch about 500 miles north of Hawaii (insert visions of "The Shore Bird" and many mai tais here). I was positioned to be first off of cat one (insert foreboding music here) in the launch cycle. As the cat fires, I stage the blowers and am along for the ride. Just prior to the end of the stroke there's a huge flash and a simultaneous boom! and my world is in turmoil. My little pink body is doing 145 knots or so and is 100 feet above the Black Pacific. And there it stays—except for the knot package, which decreases to 140 knots. The throttles aren't going any farther forward despite my Schwarzzenegerian efforts to make them do so.
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> From out of the ether I hear a voice say one word: "Jettison." Roger that! A nanosecond later my two drop tanks are Black Pacific bound. The airplane leapt up a bit but not enough. I'm now about a mile in front of the boat at 160 feet and fluctuating from 135 to 140 knots. The next comment that comes out of the ether is another one worder: "Eject!" I'm still flying so I respond, "Not yet, I've still got it." Finally, at 4 miles from the ship I take a peek at my engine instruments and notice my left engine doesn't match the right (funny how quick glimpses at instruments get burned into your brain). About now I get another "Eject!" call. "Nope, still flying." At 5½ miles I asked the tower to please get the helo headed my way as I truly thought I was going to be shelling out. At some point I thought it would probably be a good idea to start dumping some gas. At 7 miles I eventually started a (very slight) climb. A little breathing room.
>
> Air Traffic Control chimes in with a downwind heading and I'm like: "Ooh. Good idea and throw down my hook." Eventually I get headed downwind at 900 feet and ask for a squadron representative on the radio. While waiting I shut down the left engine. In short order I hear his voice. I tell him the following: "OK, my gear's up, my left motor's off and I'm only able to stay level with minimum blower." At ten miles or so I'm down to 5000 pounds of gas and start a turn back toward the ship. Don't intend to land but don't want to get too far away. Of course as soon as I start in an angle of bank I start dropping like a stone so I end up doing a five mile circle around the ship. Air Traffic Control is reading me the single engine rate of climb numbers based on temperature, etc. It doesn't take us long to figure out that things aren't adding up. One of the things I learned in the training group was that the Hornet is a perfectly good single engine aircraft. It flies great on one motor. So why do I need blower to stay level!?
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> By this time I'm talking to air traffic control, the Deputy Air Group Commander (who's on the flight deck) and the Air Group Commander (who's on the bridge with the Captain). We decide that the thing to do is climb to three thousand feet to see if I'm going to have any excess power and will be able to shoot an approach. I get headed downwind, go full burner on my remaining motor and eventually make it to 2000 feet before leveling out. Start a turn back toward

the ship and when I get pointed in the right direction I throw the gear down and pull the throttle out of AB. Remember that flash/boom! that started this little tale? Repeat it here.

I jam it back into after burner and after three or four huge compressor stalls and accompanying deceleration the right motor comes back. I'm thinking my blood pressure was probably up there about now and for the first time I notice that my mouth feels like a San Joaquin summer. (That would be hot and dusty.)

This next part is great. You know those stories about guys who deadstick crippled airplanes away from orphanages and puppy stores and stuff and get all this great media attention? Well, at this point I'm looking at the picket ship at my left at about two miles and I say on departure freq to no one in particular, "You need to have the picket ship hang a left right now. I think I'm gonna be outta here in a second." I said it very calmly but with meaning. Paddles said the picket immediately started pitching out of the fight. Ha! I scored major points with the heavies afterwards for this. Anyway, it's funny how your mind works in these situations.

OK, so I get it back level and pass a couple miles up the starboard side of the ship. I'm still in min blower and my (fuel) state is now about 2500 pounds. Hmmm. I hadn't really thought about running out of gas. I pull it out of blower again and sure enough . . . flash, BOOM! I'm thinking that I'm gonna end up punching out.

Eventually discover that even the tiniest throttle movements cause the flash/boom thing to happen so I'm trying to be as smooth as I can. I'm downwind a couple miles when the Air Group Commander comes up and says "Oyster, we're going to rig the barricade." Remember, he's up on the bridge watching me fly around and he's thinking I'm gonna run outta fuel too. By now I've told everyone who's listening that there is a better than average chance that I'm going to be ejecting—the helo bubbas, god bless 'em, have been following me around this entire time. I continue downwind and again, sounding calmer than I probably was, call Paddles. "Paddles, you up?" "Go ahead," he replied. "I probably know most of it but you wanna shoot me the barricade brief?" (He was awesome on the radio, just the kind of voice you'd want to hear in this situation.) He gives me the brief and at nine miles I say, "If I turn now will it be up when I get there? I don't want to have to go around again." "It's going up now Oyster, go ahead and turn." "Turning in, say final bearing." "063" replies the voice in air traffic control (another number I remember—go figure).

I intercept glideslope at about a mile and three quarters and pull power. Flash/boom. Add power out of fear. Going high. Pull power. Flash/boom. Add power out of fear. Going higher. (Flashback to LSO school. . . . "All right class, today's lecture will be on the single engine barricade approach. Remember, the one place you really, really don't want to be is high. Are there any questions? Yes, you can go play golf now.")

Another landing signal officer is backing up Paddles and as I start to set up a higher than desired sink rate he hits the abort light. Very timely too. No worries. I cleared the deck by at least ten feet. As I slowly climb out I say, again to no one in particular, "I can do this." I'm in blower still and the Air Group Commander says, "Turn downwind." Again, good idea. After I get turned around he says, "Oyster, this is gonna be your last look so turn in again as soon as you're comfortable."

I lose about 200 feet in the turn and like a total dumbshit I look out as I get on centerline and that night thing about feeling high gets me and I descend further to 400 feet. Flash/boom every several seconds all the way down. Last look at my gas was 600-and-some pounds at mile and a half. "Where am I on the glideslope?" I ask Paddles and hear a calm "Roger Ball." Now the ball's shooting up from the depths. I start flying it and before I get a chance to spot the deck, I hear "Cut, cut, cut!" I'm really glad I was a Paddles for so long because my mind said to me "Do what he says Oyster" and I pulled it back to idle. (My hook hit 11 Oyster paces from the ramp.) The rest is pretty tame. I hit the deck, skipped the one, the two and snagged the three wire [and] rolled into the barricade about a foot right of the centerline. Once stopped my vocal chords involuntarily yelled "Victory!" on the radio. (The 14 guys who were listening in air traffic control said it was pretty cool. After the fact I wish I had done the Austin Powers' "Yeah Baby!" thing.) The lights came up and off to my right there must have been a gazillion people. Paddles said that with my shutdown you could hear a huge cheer across the flight deck.

I open the canopy and start putting my stuff in my helmet bag. I climb down and people are gathering around patting me on the back when one of the boat's crusty yellow-shirt Chiefs interrupts and says, "Gentlemen, great job but fourteen of your good buddies are still up there and we need to get them aboard." Here I sit with my little pink body in a ready room chair on the same ship I did my first cruise in 10 years and 7 months ago. And I thought it was exciting back then. By the way, I had 380 pounds of fuel when I shut down. Again, remember this number as in ten years it will surely be *fumes man, fumes I tell you!**

Although militaries are hierarchically structured, notice how in this case the structure was sufficiently elastic to allow many parts of the ship to help Oyster: the captain and air group commander on the bridge, the deputy air group commander and Paddles on the flight deck, the squadron representative in the tower, and the air traffic controller in the air traffic control center on the third deck. If efficiency had ruled over reliability, many things might have occurred differently. Perhaps the order to eject would not have gone out as soon as it did or the drop tanks would have not have been dropped as early as they were. The culture of reliability is illustrated by the several "must do's" Oyster engaged in that clearly came from his training.

The rewards for Oyster were clearly in the right place. In the first place, it was assumed by his superiors on the ship that he knew what he was doing, particularly when he refused to eject. Second, he was rewarded for getting the picket ship out of harm's way. Everyone perceived that risk existed, and appropriate strategies were in place to handle the risk. Valid and reliable sense making was surely characteristic of Oyster, and information from air traffic control and the squadron representative helped him to make appropriate sense of his situation. He needed the heedfulness of

*This account has been widely discussed in the Navy, and is in the public domain. There is no known published source.

the air group commander, the deputy commander, Paddles, the squadron representative, and air traffic control, each of whom saw his own role in the situation and helped keep it knit together.

Migrating decision making was also apparent. Oyster, not his superiors, made the decision about what to do. When he landed, a lower-level chief (aviators are officers) ordered him from the deck. Although we don't know this from the case, it is likely the captain of the ship had the big picture. We have some evidence that the air group commander did. We certainly know that redundancy was at work when Oyster and the air group commander simultaneously thought about the plane's fuel state. Formal rules and procedures guided Oyster's activities and were clearly evident when Paddles gave Oyster the barricade brief. Training was evident throughout (Oyster had over 10 years' experience flying off ships), and he mentions it with regard to the characteristics of the Hornet and the class on barricade approaches. Hopefully, every evolution a ship does is a training evolution.

A BROADER STORY

A number of researchers have confirmed that these and other organizational processes are necessary for reliability enhancement, which broadly includes safety. The information was obtained through analyses of accidents as well as systematic research in HROs. Work was done in the commercial nuclear power industry,[17] the commercial airlines,[18,19] primary school education,[20] wildland fire authorities,[12] community fire authorities,[9] the U.S. Navy,[8,21] offshore oil and gas platforms,[22] offshore pipeline operations,[23] commercial shipping,[24] and other aspects of the commercial marine industry.[25]

A number of organizations have applied some of the findings of the work in a variety of different ways. It was used to develop training programs in community policing.[26] The U.S. Coast Guard used it as a basis for their comprehensive Prevention Through People program, the only management program the Coast Guard developed to reduce mishaps and errors. The Society for Worldwide Interbank Financial Telecommunications (SWIFT) used various aspects of the work to develop what it calls its Failure Is Not an Option program. SWIFT moves 97 % of the money that is moved worldwide and very successfully progressed through both the European move to the euro and Y2K.

Findings from this research are behind a recently conceived program for the U.S. Navy. After the fatal crashes of three F-14 aircraft in 1996, the Navy developed a Human Factors Quality Management Board to review its safety-related activities in carrier aviation. At the request of the board, the Navy developed what is now called the aviation Command Safety Assessment. This is a device to help aircraft squadron commanding officers assess the safety readiness of their squadrons in comparison with all squadrons in the database, squadrons of the same type, squadrons at sea or on land, and so forth. The program is on the Web at safetyclimatesurveys.org. To date it has been used by about a third of the naval aviation squadrons and some aviation maintenance squadrons.[6] The Marine Corps ground forces are beginning a special project to adapt the instrument to their specific needs. The commercial aviation community is showing considerable interest in this approach.

Some aspects of the approach, including specific items, were borrowed by David Gaba at the Palo Alto Veteran's Administration Hospital for use in the Patient Safety Center of Inquiry's development of a safety assessment for the Veteran's Administration.[6]

AN APPLICATION IN THE HEALTH INDUSTRY

Loma Linda University Children's Hospital (LLUCH) is the tertiary children's hospital for a geographic area more than three times the size of the state of Vermont. The population is 2.5 million people, with 500,000 younger than 15 years. The catchment area includes urban, rural, and wilderness areas, with a large number of desert and mountain communities. The LLUCH pediatric intensive care unit (PICU) has 25 beds with an average daily census of 21 patients, 9 on ventilators. One hundred and five registered nurses are assigned to the PICU, with 14 on duty at any one time. There are 20 respiratory care practitioners, with 4 working at any one time. Four residents rotate through the PICU for 1 month at a time, one from emergency medicine and three from pediatrics. Pollack, Cuerdon, and Getson report mortality rates of 7.8 $\pm$ 0.8% for PICUs with more than 18 beds.[27] The PICU at LLUCH had a 5.2% mortality rate in 1996. About half of the admissions come through LLUCH's pediatric critical care transport system, now one of the larger transport services in the country.[28]

In an environment that has numerous social and psychological hazards, particularly for the nurses, the PICU philosophy is to support the bedside caregiver with an organizational culture of safety that encourages learning from mistakes in collaborative teams. Teamwork and team formation are fostered. Shaming, naming, and blaming, particularly after a bad outcome, are not accepted. There are many ways to approach care in the PICU; no one method is touted above the rest. The center of care is the team and support for the team leader and bedside caregiver. During rounds the patient is presented to the group for discussion of the diagnosis, general treatment plan, potential problems that may develop, and the family's response to the situation. All participants have an opportunity to present their perceptions, and ideas and questions are solicited. As a general rule, the team doesn't move on until all caregivers feel comfortable with the plan. Doctors, pharmacists, respiratory care practitioners, nurses, and a clinical dietitian make rounds presentations.

The Loma Linda University PICU can be described in the context of the good organizational processes and command-and-control mechanisms identified in HROs. The HRO concepts adopted by Drs. Daved van Stralen and Ronald Perkin include risk awareness, process auditing, quality review, appropriate rewards, and command and control.

Risk awareness increased over the first several years, with the goal of identifying a child who is in a state of covert compensated physiologic dysfunction. Van Stralen and Perkin began a program of in-service lectures specific to the various disciplines (nursing, respiratory care, resident physicians). They also developed two regularly scheduled conferences, one directed to emergency medical service providers and the other directed to nurses in emergency departments and intensive care units. Today it is rare for a patient to unexpectedly deteriorate in the PICU.

Process auditing in the PICU includes systematic checks and formal audits to inspect for problems in the "process." For LLUCH, the process is providing critical care medicine in an environment of physiologic uncertainty and instability. The unit constantly entertains the thought that it has missed something. It encourages questioning and the presentation of data that support or refute the working hypothesis. Quality review is performed to ensure that the PICU has the lowest rate of potentially preventable mortalities and morbidities. Quality improvement reviews are made by formal standing committees of the institution. Referent levels for quality improvement are adopted from nationally accepted norms and the medical, respiratory care, and nursing literature.

Appropriate rewards are made to encourage participation in patient care. Through participation of all disciplines, the PICU seeks to reduce accidents and the level of stress on caregivers while improving morale. The team is composed of members who respond quite well to symbolic rewards. As members demonstrate knowledge, insight, and discretion in care of patients, they tend to play a larger role in tactical and strategic management. Their opinions are more frequently sought and incorporated into care plans.

Command and control plays a major part of care and has given the unit its greatest successes. In the PICU this concept includes decision migration, authority gradient, situational awareness, redundancy, rules and procedures, and training.

The PICU fosters decision migration to the best-qualified caregiver (recognizing the limits to caregiver decision making). At the interface with a patient emergency, the most qualified person to make or guide decisions is the bedside caregiver. Frequently, team members can't predict what will work in a specific situation. However, quick decisions can bring stability to a rapidly changing situation during crisis situations. The authority difference that can occur between the physician or surgeon and other team members can lead to tragedy; this is especially likely if authority differences inhibit low-status members from offering valuable information that disagrees with the judgments of high-status members. In the past few years, nursing staff has made use of a form for professional interactions. These forms follow up the chain of command from the nurse to administration. It then moves downward to the physician involved through his or her chain of command. This insulates the nurse from reprisal.

Situational awareness comes both with experience in the PICU and experience as a supervisor. Experienced staff almost always teaches new staff. This is of major importance because residents come to the unit with limited experience in critical care. Van Stralen and Perkin rely on experienced nurses and respiratory therapists to teach the residents. Redundancy ensures thoroughness in evaluating the patient and in choosing a therapy. Many of the signs they monitor are measured by two methods; furthermore, during resuscitations, several team members will monitor the same vital sign.

Rules and procedures have allowed respiratory therapists and nurses to influence medical care to a greater degree and with a quicker response to change. As a teaching institution and one that develops new therapies, the PICU has the goal of always considering itself in training. Consequently, its members watch each other's performance and give assistance through mutual teaching and learning.

CONCLUSIONS

While van Stralen and Perkins have demonstrated at Loma Linda the effective application of HRO research findings to reduce errors in the PICU, much research remains to be done. Researchers must view health care from a systems perspective as well as from the perspective of a single unit. Errors are made in units and errors are made across units. Policies and procedures developed in one unit influence errors that develop in adjacent or distant units.

As complexity theory suggests, systems that consist of independent actors whose interactions are governed by a system of recursively applied rules naturally generate stable structure.[29] Here, we suggest that some good HRO practices or potentially good "rules," once applied to organizational systems, might generate increasingly safer and stable structures because the output of one application of rules becomes the input for the next round. That is, positive feedback loops that result from the interactions of a large number of components eventually simplify structures and give clarity to operations that enhance safety, crowding out irregular or nonstandard microscopic behavior and structures.

Research into how healthcare systems structure themselves would help us develop concepts of adaptability and flexibility useful in the medical industry. Medical practitioners need to know the conditions under which complex, tightly tied medical units and systems must incorporate flexibility. We also need to examine closely how roles should be interrelated in and across healthcare units. The imbalance of power held by physicians is probably dysfunctional to the delivery of safe health care. Once we know what appears to be appropriate role inter-relationship, we need to address the issue of how training institutions should deal with this knowledge. We need also to develop ideas about training mechanisms to disseminate such research findings and encourage their application. Last, we need to observe empirically how intervention of any kind affects the interdependence of the system, as well as how interventions of several kinds can combine and integrate to create larger systematic changes. These are tough nuts to crack!

Although David Gaba has begun to develop a culture assessment along HRO lines for the Veteran's Administration, more work needs to be done on this issue. The concept development work is far from complete and needs to be carried on in medical settings. Although constructs such as command and control seem useful, these constructs have not been sufficiently fleshed out. Nor does the instrument derived from these constructs have adequate psychometric properties. We need a good way to assess culture in medical settings that clearly follows from theoretical development. The cultures of various continuous medical units need to be examined together to see how one influences the other. Training needs can be identified from cultural phenomena.

As we saw from our examples, reward systems are extremely important to the adequate management of HROs. However, appropriate rewards are often specific to their situations. We need to develop a taxonomy of appropriate rewards for medical systems. We suspect that current policies in many medical units foster the use of the wrong rewards, if for no other reason than the requirements of managed care.

One of the most difficult research issues will be the investigation of sense making within and across units. Understanding the cognitive functioning of a single individual is difficult. But the characteristics of HRO operations require the integration of cognitions across many individuals. Mapping this integration to develop a picture of the heedfulness of a unit is challenging. Mapping the integration of units constituting a system is even more challenging.

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