Clinical Decision Making and Intuitive Judgment in the Complex Trauma Center Environments

Policarpo C. deMattos, Eui Park, Daniel Miller, and Younho Seong
Department of Industrial and Systems Engineering
North Carolina A&T State University
Greensboro, NC 27411 USA

Abstract

Recent advances in computer technology and a growing number of available simulation tools provide immeasurable contributions to clinical decision making processes. However, the increasing complexity of trauma center systems makes decision-making and problem-solving process complex. Traditionally, a medical team is compelled to intuitively capitalize solely on its members' rich experiences for diagnosis during the stressful moments of a trauma event. This paper presents through a literature review how the conceptual frameworks in science have shifted from the science of reductionism with its emphasis on the breakdown of processes into small parts to the science of complexity. Complexity science, as the alternative technique, allows for the study of all parts in relation to one another, to the whole entity, and to the environment in which it exists. It provides a innovative approach in understanding the highly complex trauma center systems. It attempts to address trauma centers' complexity and how these changes in science might suggest further developments of applications to trauma centers' processes by which clinical decisions are accomplished, and the importance of intuition and judgment on trauma clinical decision making. The conceptual framework of complexity theory might also advance the discussions about how diagnostic decisions should be made under the stressful environment of trauma centers.

Keywords
Complex adaptive systems, complexity, clinical decision making, judgment, protocols, intuition

1. Introduction

The science of complex adaptive systems provides important concepts and tools for responding to the challenges of healthcare in the 21st century. Today's epidemics have fuzzier boundaries: they are the result of the interplay of genetic predisposition, environmental context, and lifestyle choices (Plsek and Greenhalgh 2001). With this view of today's environment, decision makers are placed in situations that are increasingly complex, which are the "results from the inter-relationship, inter-action, and inter-connectivity of elements within a system and between a system and its environment" (Chan 2001). Therefore, decision making tasks vary according to the dynamic complexity of the system (Diehl and Sterman 1995). Healthcare organizations are an ideal setting for the application of complexity science due to the diversity of organizational forms and interactions among organizations that are evolving. It seems that strong institutional demand exists for a simple, intuitive metric for assessing health status across a broad range of applications that can be applied with little explanation or technical expertise.

Despite recent advances in computer technology and the growing number of available simulation tools that provide immeasurable contributions to decision making processes, the increasing complexity of the trauma center systems makes decision-making and problem-solving processes complex, requiring vital solutions during critical periods. Decision makers (agents) "scan their environment and develop schema representing interpretive and action rules" (Dooley 1997) to engage members in distinguishing what is essential before decisive action takes place. These schemas, which have been described in the literature as "patterns used by the mind to grasp an aspect of reality," may therefore provide trauma physicians with multiple and creative paths for action (Gell-Mann 1997). For these physicians, the trauma center medical team's strategies and practices help them form the schemata, affecting the success or failure of the team as measured by the outcome of life or death of the injured patient. The current state of a trauma patient is no predictor of what that patient will be in any given time because, as introduced by Serena Chan while unfolding complexity, "tiny disturbances can produce exponentially divergent behavior" (Chan 2001). Chan was referring to disturbances in a complex system, which is related to Gell-Mann's assertion that "on Earth, all complex adaptive systems seem to have some connection with life" (Gell-Mann 1997). Murray Gell-Mann was the Nobel Prize laureate in physics, who is currently focusing on complex adaptive systems. But the reverse in a complex system is also true that in a complex, non-linear system a large disruption may cause only a small change or even no change at all, as it has been the case of some healthcare organizations overspending in certain areas and not achieving the objectives of the expenditures (Holt 2004).

"Complex Adaptive Systems (CAS) theory allows one to analyze the organizational systems from a more holistic point of view" (Dooley 1997). As recently as 2002, researchers had not yet decided on a satisfactory mathematical definition of complexity (Lansing 2003). Therefore, CAS theory and its applications had been somewhat slow in getting widely disseminated. Indeed, a reason for slow diffusion is complexity theory is relatively new and is still struggling for legitimacy and institutionalization (Begun, Dooley et al. 2003). To better understand the implications and applications of CAS in environments such as those of the trauma centers, "we must examine the intellectual history from which it springs" (Holden 2005). The reader should refer to Holden's article for detailed description into an historical context to fully appreciate the state of science in the early 21st century and how major scientific developments have shaped and informed the historical framework of complexity science (Holden 2005). "Two domains that could particularly benefit from a complexity science perspective are (1) innovation in healthcare delivery and (2) structure and performance of integrated delivery systems" (Begun, Dooley et al. 2003). Begun and his researchers claim that "Complexity affects the ability of the healthcare systems to generate diversity and innovation, particularly innovation that is transformational." This assertion is significantly supported through the definition provided by other researchers that "a complex adaptive system is a collection of individual agents with freedom to act in ways that are not always totally predictable, and whose actions are interconnected so that one agent's actions changes the contest for other agents(Plsek and Greenhalgh 2001). Whilst this is a basic concept aimed toward those with limited or no mathematical skills, it is a definition that helps in the understanding of a complex adaptive system.

2. Trauma Center Complexity

"What is [trauma] care if not the rapid assessment and treatment of patients with undifferentiated and undiagnosed conditions?" This was the question posed by Heather McClelland (2008) in her article as the editor of the International Emergency Nursing Journal (McClelland 2008). Trauma medical teams are the experts in clinical assessment, resuscitation, establishment of differential diagnosis, and trauma treatment. In short, if all these things describing the actual trauma environment aren't complex enough, it may be added that these medical teams "are the team players of the health service, working with a multitude of clinical teams and professions to ensure effective and efficient patient care" (McClelland 2008). The delivery of care is often overly complex across all disciplines, at all levels, and throughout the world; and it "is becoming more complex" (Plsek and Greenhalgh 2001; Carroll 2002). This is particularly true of the complex critical care in the trauma center environment which, as part of a healthcare system, is not any different. In a report entitled "Crossing the Quality Chasm: A new Health System for the 21st Century" prepared by the Institute of Medicine (IOM), the researchers concluded that every community will require a fundamental, sweeping redesign of the entire health system in order to bring state-of-the-art care to all Americans (Corrigan 2005). The report argues that simply making incremental improvements in current systems of care will not be sufficiently adequate. This paper doesn't argue the report's findings. However, it believes that a better understanding of the complexity involved at all levels of care ought to bring the much sought out improvements. As researchers have pointed out, Newton's "clockwork universe" in which problems are broken down into smaller pieces and analyzed may no longer be a viable solution for healthcare because "this machine metaphor let us down badly" (Hoffman 2000; Plsek and Greenhalgh 2001). These researchers concluded that "the new science of complex adaptive systems may provide new metaphors that can help us to deal with [healthcare] issues better" (Plsek and Greenhalgh 2001).

Measures of the complexity of trauma clinical problems need to be developed. "Complex would describe a problem which combines difficulties of all aspects of assessment and management" (Hennen 1984). Ogilvie e*t al.* (2010) reported that "it is obviously an uncontrolled environment for at least the first few minutes when any patient with potentially lethal injuries arrives in a Level I trauma resuscitation unit" (Ogilvie, Pereira et al. 2010). A common thread here is that "illness (and health) results from complex, dynamic, and unique interactions between different components of the overall system" (Wilson and Holt 2001). A basic feature of a trauma center is that agents influence one another through interactions (i.e., face to face) and the basic building blocks of a trauma center are the agents (i.e., a physician, nurses, technicians, technologies). It is important that we understand a trauma center as a system composed of interacting agents and processes that builds architectures to overcome possible existing systemic limitations. The medical team "is responsible for a complex situation and has to quickly establish a rapport, gather information, assess the physical condition, and design a treatment plan" that is effective, by basically forging the dynamics of the process from within the system (Wiman, Wikblad et al. 2007). It enables the trauma team to recognize the complex, context-dependent, and the changing needs of the injured patient.

Unlike any other medical domain, in the complex environment of trauma center, patients present major diagnostic and therapeutic problems (Houshian, Larsen et al. 2002). Any delay or setback, in providing timely and efficient needed treatment may cause patient's death, increased

complications that directly lengthens hospital stay, and increases cost. In the United States, trauma physicians are trained by the American College of Surgeons in the methods for immediate management of the injured patient. Within the concept of the "golden hour" that emphasizes the urgency for successful management of the injured patient, trauma physicians and their teams are trained in the process of accurately assessing the injured patient's needs. Besides the identification and treatment of life-threatening or potentially life-threatening injuries, this decision-making process becomes more complex when it is factored in variables such as the vulnerable condition of the patient. Physicians must be alert to patient's visible physical conditions as well as to the non-visible conditions in which the injured patient arrived, such as the patient being frightened or traumatized not only by the injuries but also by the environment of the trauma center. In this complex environment, only an active participant may be able to appreciate the difficulties imposed on the decision making process that has a positive impact on mortality and morbidity associated with trauma. In trauma centers, there isn't a consistent pattern of change; instead, we find a great deal of job complexity. Central to many definitions of job complexity is that complex jobs are mentally challenging and require the worker (i.e., physicians) to use a number of complex skills (Chung-Yan 2010). The trauma medical team is faced with complex tasks that "are also characterized by ambiguity, difficulty, and a lack of structure (Chung-Yan 2010).

3. Nature of Clinical Decision Making

The application of science and global resources to improve health and well-being is ubiquitous in every corner of the world. Working across developed and emerging markets to advance wellness prevention, researchers strive to set standards for quality, for the creation of new procedures, new technologies, and new drugs, which are placed in the market at an increasingly rapid rate. Information is also disseminated across the globe at an unprecedented rate. In an editorial comment to the Journal of Trauma, Richard Burney, MD, from the University of Michigan Medical Center, wrote that in order for one to provide the best care for patients, all this information must be brought to bear on the medical team's daily work. Furthermore, he wrote, "it is difficult to change day-to-day clinical behavior: too often decision making on rounds derives from custom, from anecdote, or from 'my last case' thinking." The striking variations in clinical decision making practice that exist across the country are "irrefutable and embarrassing evidence" of this decision making practice (Burney June 1998). Individual knowledge and experience alone are inadequate in making decisions in trauma centers as they involve complex set of choices.

In another editorial comment Richard Mullins, MD and Professor of Surgery at the Oregon Health Sciences University, remarked that "if the decision maker accepts the premise that every effort is justified if the alternative is death, it is simple to proceed in every case. If the decision maker incorporates values, including quality of life, patient preference, and the variably maligned 'economic concerns,' complexity creates for the decision maker conflicting values in a situation that irritatingly demands an explicit choice." (Mullins 1999). Medical personnel at all levels of decision making in trauma centers use multiple criteria to analyze their complex problems, always incorporating available resources and science in achieving objectives in clinical decision making. Trauma physicians face constant challenge of responding to a need in research, innovation, and collaboration in a world of changing values and attitudes, always

focusing on human information interaction with the underlying objective of getting the injured patient to the right level of continuum of care with the right resources for recovery.

Theories of decision making have often neglected emotions, however, emotions can aid decisions making (Gigerenzer 2001). In reality, skilled and experienced trauma physicians are firmly embedded in emotions running wild, with little time for actions, and limited initial knowledge of the patient's conditions. Emotions keep trauma physicians in the adaptive task of caring for and healing multiply injured patients as they come through the trauma center. From his "nonrational theories" in decision making, Gigerenzer (2001) concluded that the cognitive process that involve emotions "guarantees commitment more effectively than would a nonemotional mind that tried to optimize quality" and that emotions such as "fear and anger can speed decision making" (Gigerenzer 2001). Another cognate concept of emotion in clinical decision making is that of regret, which results when the decision maker compares the outcome of his or her decision with the outcome that would have occurred had a different decision been made. Emotions exploit the structure of information in real environments. These types of theories provide trauma medical teams with a more realistic picture of decision making when knowledge is scarce, deadlines are rapidly approaching, and the future is hard to predict.

"Clinical decision making is certainly no new idea─it's been around since the dawn of medicine"(Patton 2010). Though researchers and clinicians employ somewhat different terminology to label steps in the process of clinical decision making, they all give the impression to see it as strongly similar to a systematic approach to deciding on the best course of action like this: (1) list all possible actions, (2) list all possible outcomes, (3) predict the probability of each outcome from each action, (4) select the best action based on outcome likelihood and outcome utility (Patton 2010). For a definition of the terms "actions" and "outcome" in the context of clinical decision making, we refer the reader to the original article by Dr. D. Patton, MD (Patton 1978; Patton 2010). Patton's decision making model is actually a reformulation of Leonard R. Savage's theory of subjective expected utility (SEU theory) (Savage 1954). As Savage wrote in at the very beginning of his book, " I am about to built up a highly idealized theory of the behavior of a 'rational' person with respect to decisions" (Savage 1954). It was H. Simon that analyzed this "highly idealized theory" and summarized it, saying that SEU theory postulates that choices are made (1) among a given, fixed set of alternatives; (2) with (subjectively) known probability distributions of outcomes for each; (3) in such a way to maximize the expected value of a given utility function (Simon 1990). Based on this "classical theory," it is assumed not only that there exist alternatives, possible consequences, and preferences, but that the decision maker, at least the rational decision maker, knows them (Adams 1962). Just three years after SEU theory had been promoted as model for uncertainty and risk, Simon criticized those assumptions and proposed to replace them by introducing the concept of 'bounded rationality" (Simon 1957) to designate rational choice that takes into account the knowledge and computational capacity cognitive limitations of the decision maker. These researchers of a few decades ago were hesitant and not keen toward factoring in the variables of emotion, intuition, or human judgment, and even political decisions as scientifically valid assumptions of clinical decision making processes.

As it is shown on the following sections, the initial impression caused by a patient on the medical team allows for the formulation of a number of plausible diagnosis (hypothesis), which in turn helps in the collection of data that will be used to accept, reject, refine the initial diagnosis

(hypothesis), or search for another one. This process that seems to be a "search and scan" continues until the trauma team arrives at a conclusion, typically marked by an appropriate diagnostic course of action for the patient's condition in a way that maximizes the expected value (utility) of the "actions" to follow (McGuire 1985).

Over the years, there have been a plethora of published researches on clinical decision making. Nevertheless, these researches have essentially entailed the same discourse on how physicians should approach clinical decision making. "All these approaches have entailed, at least to some degree, both descriptions of how physicians do behave and prescriptions for how they should behave" (McGuire 1985). Further, physicians are taught a huge body of facts and methods for gathering and interpreting data in addition to concentrating attention on describing steps used on a physician-patient encounter (McGuire 1985; Kassirer 2006). The theoretical basis for clinical decision making has been studied for decades, "since the dawn of medicine" from a number of different perspectives, including that of psychology, clinical psychology, clinical practice, and clinical education (Round 2001; Patton 2010). Because of the dynamic character of clinical decision making, in more recent years there has been a strong emphasis towards the application of the theories of complexity, intuition, and judgment for the understanding of this critical medical discipline.

4. Intuition and Judgment in Clinical Decision Making

In 1975, J. Kassirer, MD, wrote a timeliness piece of literature entitled "The Principles of Clinical Decision Making: An Introduction to Decision Analysis"(Kassirer 1976). He introduced the topic as follows: "The ability to make rational decisions that lead to optimum therapeutic outcomes is one of the cardinal characteristics of an outstanding physician. Nonetheless, most of the energy expended in the education of medical students and house officers is directed into teaching a huge body of facts and methods for gathering and interpreting data; little or no attention is given to the principles that underlie decision making." (Kassirer 2006). One decade later, findings in another research on the same subject have highlighted that many studies have yielded evidence that physician's clinical decision making are based on rudimentary assessment of probabilities, suggesting that the "subjective estimates of probabilities are considerably less than accurate" (McGuire 1985). Clinical decision making involves both individual patients and clinical trials for the purpose of evaluating and deciding among alternatives, which allow physicians to formulate hypothesis based on clinical findings, patient informational cues. "Clinical judgment in these circumstances involves an irreducible element of factual uncertainty and relies to a greater or lesser extent on intuition and the interpretation of the wider history of the illness" (Tim Wilson 2001 (16)).

The literature of clinical decision making brings a plethora of cases and information that assert the unpredictability of complex trauma events that a medical team faces in its daily rounds (Holland 1992; Mullins 1999; Fraser and Greenhalgh 2001; Plsek and Greenhalgh 2001; Plsek and Wilson 2001; Wilson and Holt 2001; Burney June 1998). Therefore, in many ways there is an obvious understanding that "effective clinical decision making requires holistic approach that accepts unpredictability and builds subtle emergent forces within the overall system" (Wilson 2001). Intuitive judgment may be one of the answers to this unpredictability of the system by allowing for the recognition of patterns in the event.

5. Recognizing Patterns of Intuitive Judgment

The following case exemplifies the power of intuition in trauma episodes and a surgeon's abilities to recognize patterns within a complex event. This case helps conceptualize ways to apply the ideas of intuitive decision making in the clinical setting, showing methods to reduce complexity of the process by taking an incremental approach to the problem at hand. It is "The Case of the Red Leg" (Gawande 2002). The case is one of those situations in which the absence of algorithms and protocols about what do drive physicians to make gut feeling, intuitive human-judgment-decision-making. This is the story of one very complex decision making event under extraordinarily uncertainty.

A 23-year old woman presented in the emergency department of the hospital with a red and swollen leg. The resident physician at the scene in the emergency department thinks that it is probably only a bad case of cellulitis, a simple skin infection, and started the patient on intravenous antibiotic. Because of the severity of the rash, he calls on another physician, a surgeon, for a second opinion. The surgeon looked at the young woman. She looked fit, athletic, and almost teenage. There did not seem anything seriously ill about her, as she watched television. The young woman again told the surgeon the same story that she had already told the resident trauma physician, which was the same story she had a few days before also told to her private attending physician. It was a grand wedding she attended where she kicked off her shoes and went dancing bare footed all night. A tiny blister, afterwards an infection, and now she is in the trauma center in a lot of pain. Initially, the surgeon was about to concur with the resident trauma physician's initial diagnosis. However, without any explanation, pops up in the surgeon's mind the possibility of one of the most horrendous disease ever to befall on a human being, a horrendously lethal type of infection known as necrotizing fasciitis. The tabloid media had called it a disease of "flesh-eating bacteria" and the term is not an exaggeration. Very little is known about the disease, except that, it is highly aggressive and rapid invasive. This disease has been associated with significant morbidity and mortality, killing up to 70 percent of the people who get it, exceedingly fast, with significant mortality if operation is delayed 12 to 24 hours (Sudarsky 1987; Wong 2003). There is no antibiotic or any treatment that can stop it.

Only about 500 to 1000 cases of necrotizing fasciitis occur in the entire United States each year, mainly in the elderly and chronically ill (Gawande 2002; Wong 2003). How do you tell a young woman, full of life, just beginning her existence that she possibly has this horrendous disease? Furthermore, her fever had all but gone, and the only signs of the infection were the red rash and the pain on her leg. The surgeon only had the gut feeling that intuitively told him to search deeper and, as he recognized the pattern, he "gained a sense of the situation" (Klein 2004). He excused himself from the room, spoke with other physicians on the phone, and within the hour and with the young woman consenting on a recommendation of a biopsy of the affected tissue and possibly amputation of the affected leg, they were in the operating room. The biopsy revealed that indeed her condition was flesh eating bacteria. The surgeon had assembled an impressive multidisciplinary team composed of surgeons, pathologists, radiologists, dermatologists, and the technological facilities only available in another hospital, all working in synchrony to save her life. The surgeon opted for a debridement of the infected tissue coupled with a washing out of the entire area. For recovery, her doctors recommended hyperbaric oxygen

which required transport to a nearby hospital for a two hour therapy, two times daily. After four similar operations to remove infected tissue, the leg seemed to be growing new tissue.

Physicians don't see this disease often because it isn't common; actually, some physicians don't see it at all throughout their careers. There is no test whatsoever to tell the two diagnosis, cellulitis or necrotizing fasciitis. The scenario is completely unpredictable from patient to patient. The only way is to go into the operating room, cut the patient open, and look inside (Sudarsky 1987; Gawande 2002; Wong 2003). If it is the necrotizing fasciitis disease, the medical team sees the destruction caused by the bacteria. If it is not too late, cut the leg (or whatever the part affected) and hope to stop the bacteria from spreading to the rest of the body.

Researchers of intuition and human judgment, such as Gary Klein, might say that the surgeon "had stumbled onto the phenomena of intuition" (Klein 2004). "To illustrate how intuition is so important," Klein used the story he titled "A Baby in Crisis." The nurse in the intensive care unit caring for the infant baby "had missed the classic symptoms of sepsis, which seemed so obvious" (Klein 2004). In this case study, the nurse caring for the infant had missed the dangerous signs but the supervisor nurse, despite not having hands on care for the infant, noticed the signs of problems at a routine inspection and her "intuition" told her of the more serious danger facing the infant. Immediately, the nurse supervisor sought help and information, which was met with the approval of the attending physician who agreed with the supervisor nurse's diagnosis, decision, and treatment, therefore saving the infant's life.

The surgeon in the necrotizing fasciitis case did not have any of the "classic symptoms" for guiding the decision making process because there are no symptoms for physicians to decide positively on the diagnosis of the disease. The pieces were put together on the mind to the surgeon that developed into a story that revealed the larger pattern. The recognition of the visual patterns (i.e., the red leg) and the auditory (i.e., the young woman's account), and the learning of such pattern recognition are evidence for the great adaptive abilities of the human brain (Gluskov 1966). The significance of this pattern recognition was the surgeon's ability to combine certain sets of observations and information to create an image of the disease that allowed to the assembling of the multidisciplinary team and to translate his "experience into action" (Klein 2004). The recognition patterns helped the surgeon to capitalize on the stored representations, by way of constructing mental algorithms for learning the pattern, that offered a direct access to the judgment and decision making process. The surgeon's judgment did not have the system's accurate description of the properties characterizing the trauma to arrive at a decision, only the intuitive thought and gut feeling about the whole thing that allowed for making a judgment of what was going on underneath the skin of the young woman's leg. This seriously contrasts with statistical approaches where probabilities and likelihood ratios may provide some guidance in the diagnosis. But, as John Fox puts it, statistical numbers represent "a relationship between symptoms and diseases, but in abstract form." They say nothing about the symptoms or the disease; if it is just a symptom or a disease; or whether a symptom is caused by a disease or just statistically associated with it. "Each number records the *scale* of a relationship but not its *sense*" (Fox 1984).

"Intuition is holistic and can reveal a remarkable degree of accuracy if the learning context has provided representative and valid feedback" (Plessner, Betsch et al. 2008). In addition to the

limited information acquired from the trauma event environment, the surgeon had had an experience with another patient with the same disease sometime ago. The disease in this other patient had started with a scratch on the patient's chest and escalated to the rest of the body, despite all the efforts of the medical team to eradicate the bacteria in an attempt to save the patient. Gut feelings are based on surprisingly little information. Experiments demonstrate the amazing fact that less time and less information can improve decision making (Gigenzer) "The output of intuition is a feeling, for instance, the feeling of liking the entity or a feeling of risk" (Betsch 2009) because feelings are powerful means of communication. Trauma systems, amalgams of medical personnel from different specialties, rely on the combination of this sort for human judgments, which can be buttressed by solid information forthcoming from the medical team as represented by Figure 1 bellow which depicts the complex spatial arrangement of knowledge-in-action. If the initial intuition is proven correct, the surgeon expectancies should match the events with the solid knowledge-base of the assembled multidisciplinary team.

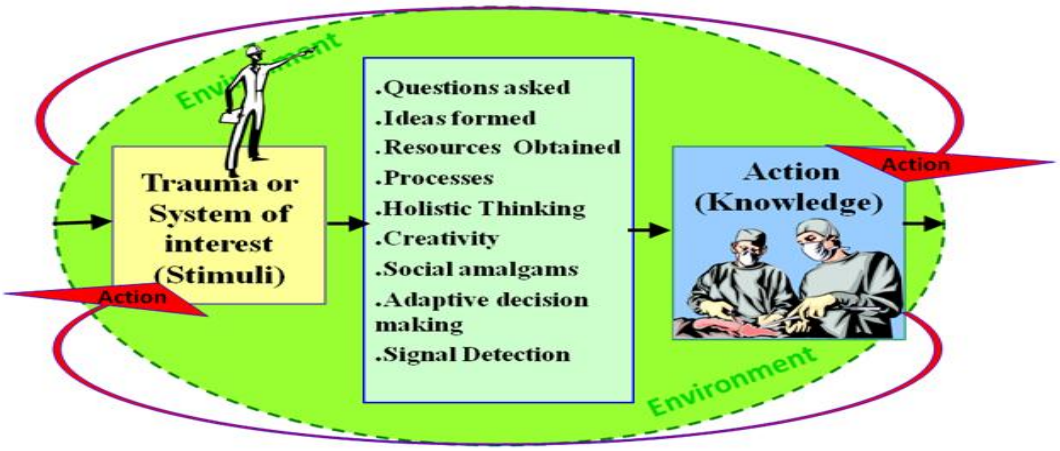

Figure 2.1 "Knowledge-in-action"

Conversely, if intuition fails the surgeon, the surgeon can quickly use the team's vast stored knowledge to notice the existent problem, take corrective action, and provide representative and valid feedback on the event. The intuition feeling is a risk that is worth taking.

A year later, the surgeon visited the young lady's family to check on her progress, noticing that the patient recovered full use of her leg. Expert medical personnel, such as the surgeon, are capable of attending and extracting the most relevant cues in the trauma environment and can avoid attending to distracting or irrelevant cues that the learning context provided as feedback. In "The Case of the Red Leg," the surgeon's perceptual skills included many of the intuitive decision making processes of pattern recognition, the use of extraction of cues, visual search strategies, and signal detection. This important difference in viewing the patient had rendered the disease recognizable simply because it eventually transpired the lethal aspect of the infection.

For many complex clinical decisions such as the one just discussed, all the data in the world can't surpass the lifetime's worth of experience that informs one's gut feeling, instinct, or intuition (Matzler, Bailom et al. 2007). Researchers have struggled to understand human intuitive judgment by building mathematical models of how each item of information influenced the clinical decision maker's overall judgments. The consistent and amazing finding of these

researchers was that ridiculously simple models did as well as in study after study as sophisticated, experienced clinicians; and the explanation for, and implications of, these results are still hotly debated (Connolly 2000). “Intuition is an essential, powerful, and practical tool,” that has been defined as “the way we translate our experience into action” (Klein 2004).

6. Conclusion

The clinical decision making process for “The Case of Red Leg” trauma event had the implications of patients’ preferences. If the young woman patient had not agreed with the conditions proposed by the surgeon, the necrotizing fasciitis disease would have claimed another victim. It is hoped that the relative simplicity of the case gave considerable depth not only to the process that decision makers use to chose among given alternatives, but also to the problem solving processes the same individuals use to find possible diagnostic course of action. “The behavior of the complex, real world, is a continuous, dynamic flow that can only be explained in causal terms after a decomposition into discrete events” (Rasmussen, Pejtersen et al. 1994). The problem faced by trauma medical teams then is to distinguish between causal correlations to the event from mere statistical results, which make little sense in certain complex contexts. Therefore, the concept of causal interaction of events, humans, objects, and technologies depends on a characterization of human observations and their experiences (intuitive judgments).

Intuitive judgment enables insight into the functioning of decision making processes in an environment of high complexity and uncertainty, such as those of trauma centers. Historically, physicians have had a fierce commitment to the rational decision making process. The rationalism model, however, requires from the decision maker “full scanning of all relevant data” and it “is often impossible to heed” (Etzioni 2001). A logical conclusion for future research might be the development of a model of decision making that includes intuitive judgment for performance on environments of high complexity, unpredictability, and uncertainty. Trauma center provides an ideal arena for the study of decision making. It involves a fairly small set of options, uncertainty about outcomes, and multiple attributes on which to compare options (Chapman 2000). The value of any decision depends largely on the accuracy and validity of the information on which it is based. Rather than technological innovation, the key issue for decision-making processes in the next decade may simply be the scientific diffusion of intuitive judgments to be used to buttress complex decision making processes.

References

Adams, E. (1962). "Book Review: Models of Man, Social and Rational by Herbert A. Simon 1957 " The Journal of Philosophy **59**(7): 177-182.

Begun, J., K. Dooley, et al. (2003). Health Care Organizations as Complex Adaptive Systems. Chapter In S. M. Mick and M. Wyttenbach (ed.), 2003 Advances in Health Care Organisation Theory San Francisco, Jossey-Bass, pp 253-288.

Betsch, T. (2009). The Nature of Intuition and Its Neglect in Research on Judgment and Decision Making. In Intutition in Judgment and Decision Making H. Plessner and C. Betsch. New York, NY, Psychology Press

Burney, R. (June 1998). "Editorial Comment." Journal of Trauma-Injury Infection & Critical Care **44**(6): 956-957.

Carroll, J. (2002). "Crossing the Quality Chasm: A New Health System for the 21st Century." Quality Management in Healthcare **10**(4): 60.

Chan, S. (2001). Complex adaptive systems, Cambridge: MIT.

Chapman, G. B. a. S., F A (2000). Decision Making in Health Care: Theory, Psychology, and Applications. Cambridge, UK, Cambridge Press.

Chung-Yan, G. A. (2010). "The Nonlinear Effects of Job Complexity and Autonomy on Job Satisfaction, Turnover, and Psychological Well-Being." Journal of Occupational Health Psychology **15**(3): 237-251.

Connolly, T., Arkes, H., Hammond, K. (2000). Judgment and Decision Making - An Interdisciplinary Reader, Cambridge University Press Cambridge, UK.

Corrigan, J. (2005). "Crossing the quality chasm." Building a Better Delivery System

Diehl, E. and J. Sterman (1995). "Effects of feedback complexity on dynamic decision making." Organizational Behavior and Human Decision Processes **62**(2): 198-215.

Dooley, K. (1997). "A complex adaptive systems model of organization change." Nonlinear Dynamics, Psychology, and Life Sciences **1**(1): 69-97.

Etzioni, A. (2001). Humble Decision Making. In Harvard Business Review on Decision Making. Boston, MA, Harvard School Publishing**:** 45-58.

Fox, J. (1984). "Formal and knowledge-based methods in decision technology." Acta Psychologica **56**(1-3): 303-331.

Fraser, S. and T. Greenhalgh (2001). "Complexity science: coping with complexity: educating for capability." British Medical Journal **323**(7316): 799.

Gawande, A. (2002). Complications: A surgeon's notes on an imperfect science. New York, Henry Holt Co.

Gell-Mann, M. (1997). "The simple and the complex." Complexity, Global Politics, and National Security: 3–28.

Gigerenzer, G. (2001). "Decision making: Nonrational theories." International encyclopedia of the social and behavioral sciences **5**: 3304–9.

Gluskov, V. M. (1966). Introduction to Cybernetics. New York, NY Academic Press.

Hennen, B. (1984). "Measuring the complexity of clinical problems." Academic Medicine **59**(6): 487.

Hoffman, E. (2000). "Women's Health and Complexity Science." Academic Medicine **75**(11): 1102-1106.

Holden, L. M. (2005). "Complex adaptive systems: concept analysis." Journal of Advanced Nursing **52**(6): 651-657.

Holland, J. H. (1992). "Complex Adaptive Systems." Daedalus **121**(1): 17-30.

Holt, T. (2004). Complexity for clinicians, Radcliffe Pub.

Houshian, S., M. Larsen, et al. (2002). "Missed injuries in a level I trauma center." The journal of Trauma **52**(4): 715.

Kassirer, J. (2006). "The principles of clinical decision making: an introduction to decision analysis." The Yale Journal of Biology and Medicine **49**(2): 149.

Kassirer, J. P. (1976). "The Principles of Clinical Decision Making: An Introduction to Decision Analysis." The Yale Journal of Biology and Medicine **49**(2): 149-164.

Klein, G. (2004). The power of intuition: How to use your gut feelings to make better decisions at work. New York, NY, Doubleday Random House.

Lansing, J. S. (2003). "Complex Adaptive Systems." Annual Review of Anthropology **32**: 183-204.

Matzler, K., F. Bailom, et al. (2007). "Intuitive decision making." MIT Sloan Management Review **49**(1): 13.

McClelland, H. (2008). "Trauma-who really cares?" International emergency nursing **16**(2): 71.

McGuire, C. H. (1985). "Medical problem-solving: a critique of the literature." Academic Medicine **60**(8): 587-95.

Mullins, R. (1999). "Editorial Comment." Journal of Trauma-Injury, Infection, & Critical Care **46**(1): 127-128.

Ogilvie, M., B. Pereira, et al. (2010). "First Report on Safety and Efficacy of Hetastarch Solution for Initial Fluid Resuscitation at a Level 1 Trauma Center." Journal of the American College of Surgeons **210**(5): 870-880.

Patton, D. (1978). Introduction to clinical decision making, Elsevier.

Patton, D. D. (2010). "Introduction to Clinical Decision Making." Journal of Nuclear Medicine **40**(5): 319-326.

Plessner, H., C. Betsch, et al. (2008). Intuition in Judgment and Decision Making. new York, NY, Taylor & Francis Publishing Group.

Plsek, P. E. and T. Greenhalgh (2001). "Complexity Science: The Challenge Of Complexity In Health Care." BMJ: British Medical Journal **323**(7313): 625-628.

Plsek, P. E. and T. Wilson (2001). "Complexity Science: Complexity, Leadership, And Management In Healthcare Organisations." BMJ: British Medical Journal **323**(7315): 746-749.

Rasmussen, J., A. Pejtersen, et al. (1994). Cognitive systems engineering.

Round, A. (2001). "Introduction to clinical reasoning." Journal of Evaluation in Clinical Practice **7**(2): 109-117.

Savage, L. R. (1954). The Foundations of Statistics. New York, NY, Willey & Sons. pp 7.

Simon, H. A. (1957). Models of Man, Social and Rational: Mathematical Essays on Rational Human Behavior in a Social Setting. New York, NY, Willey & Sons.

Simon, H. A. (1990). Bounded Rationality. In The New Palgrave: Utility and Probability. J. Eatwell. New York, NY, Norton & Company. pp 15.

Sudarsky, L. A. (1987). "Improved Results from a Standardized Approach in Treating Patients with Necrotizing Fasciitis." The Annals of Surgery **206**(5): 661-665.

Wilson, T. and T. Holt (2001). "Complexity Science: Complexity And Clinical Care." BMJ: British Medical Journal **323**(7314): 685-688.

Wiman, E., K. Wikblad, et al. (2007). "Trauma patients' encounters with the team in the emergency department: A qualitative study." International Journal of Nursing Studies **44**(5): 714-722.

Wong, C., Chang, H., Shanker, P., Khin, L., Tan, J., Low, C., (2003). "Necrotizing Fasciitis: Clinical Presentation, Microbiology, and Determinants of Mortality." The Journal of Bone and Joint Surgery (American) **85**(8): 1454-1460.