



Center for the Study of
Healthcare Management
Department of Healthcare Management

Applying Complexity Science to Health and Healthcare



PUBLICATION **3** SERIES

CARLSON SCHOOL OF MANAGEMENT
UNIVERSITY OF MINNESOTA

Applying Complexity Science to Health and Healthcare

Complexity is “a description of the complex phenomena demonstrated in systems characterized by nonlinear interactive components, emergent phenomena, continuous and discontinuous change, and unpredictable outcomes. Complexity is usually understood in contrast to simple, linear and equilibrium-based systems.”¹

IN MARCH 2003, PLEXUS INSTITUTE, MAYO SCHOOL OF CONTINUING MEDICAL EDUCATION AND THE CENTER FOR THE STUDY OF HEALTHCARE MANAGEMENT, UNIVERSITY OF MINNESOTA CONVENED THE CONFERENCE *COMPLEXITY SCIENCE IN PRACTICE: UNDERSTANDING AND ACTING TO IMPROVE HEALTH AND HEALTHCARE*. MANY PEOPLE BELIEVE THAT TRADITIONAL THINKING AND ACTIONS HAVE NOT LED TO DESIRED IMPROVEMENTS IN HEALTHCARE DELIVERY AND HEALTH OUTCOMES. THIS CONFERENCE OFFERED THE OPPORTUNITY FOR MORE THAN 150 HEALTHCARE SCHOLARS, SCIENTISTS, EDUCATORS, LEADERS, AND PRACTITIONERS TO LEARN ABOUT THE APPLICATION OF COMPLEXITY SCIENCE TO HEALTHCARE IMPROVEMENT. COMPLEXITY SCIENCE IS BASED IN THE NOTION THAT ORGANIZATIONS ARE COMPLEX ADAPTIVE SYSTEMS. IT OFFERS NEW WAYS TO THINK ABOUT THE TREATMENT OF PATIENTS IN THE CLINICAL SETTING, LEADERSHIP IN THE MANAGERIAL ENVIRONMENT AND, ON A LARGER SCALE, THE ENTIRE HEALTHCARE SYSTEM.

The first day of the conference included three plenary presenters who set the stage for participant discussion groups. John Holland, Ph.D., described current thinking about Complexity Science from his work in cognitive psychology and computer science. Timothy Buchman, Ph.D., M.D., drew on his experience as a critical care surgeon and genetic scientist to discuss biomedical complexity and how the human organism responds to illness and injury. Gareth Morgan, Ph.D., a researcher in business management, spoke about complexity applied to the turbulent organizational world.

On the second day of the conference, Reuben McDaniel, Ed.D., a professor of management

science and information systems, summarized the work of the conference, discussing the advantages of using complexity theory as a guide for research and for acting in diverse organizations.

The conference was wide-ranging, covering complexity theory as it relates to physiology, biology, clinical practice, leadership, healthcare policy, and research. A mix of breakout presentations and “conversation cafes”² gave participants a chance to learn from a diverse group of Complexity Science advocates and to explore topics in depth. We will not attempt to represent the entire conference, but choose three important themes relating to the application of Complexity Science to healthcare: 1) organisms and organizations as complex adaptive systems, 2) complexity and contemporary leadership, and 3) transforming professional roles based on Complexity Science.

Complexity and Complexity Science

Complexity Science considers aspects of systems that are overlooked by traditional scientific approaches. Conventional models are based on Newtonian scientific principles which view the universe and its subsystems as machines. In this approach, theory holds that by understanding simple universal rules that control the system



“Complexity theory should, in time, tell us where to look for building blocks and what combinations are most efficient.”

JOHN HOLLAND, PH.D.

parts, future behavior of the parts is predictable with linear cause and effect. Arguably, this framework for understanding how machines work guided the orientation of medicine around organ-based disciplines and physiological processes, and organizations around linear, hierarchal relationships and rules.

Whereas the dominant metaphor for Newtonian science is the machine, the metaphor for Complexity Science is the living system. Complexity Science is built on present-day research and thinking about biological models, where systems are viewed as nonlinear and able to adapt to a changing environment. It offers a framework for studying complex adaptive systems, focusing on the patterns and relationships among the parts in order to understand and act on the unpredictable aspects of working with people in dynamic organizations.³

Complex Adaptive Systems— Organisms and Organizations

John Holland, Ph.D., elaborated on the concept of complex adaptive systems and described Complexity Science as the science of the 21st century, distinct from Newtonian reductionism which has guided scientific thinking for over three centuries. Organisms and organizations are located in networks of complex adaptive groups of agents which interact, adapt and learn. For example, organisms are the adaptive agents within the ecosystem, antibodies are the adaptive

agents in the immune system, humans are the adaptive agents in the political system, and firms are the adaptive agents in the economic system. Each agent acts on its local knowledge and experience, and all agents interact together, adapting to the environment. Change and innovation are major characteristics of complex adaptive systems. Variety and change characterize complexity as opposed to simple, linear, and additive relations which are characteristic of Newtonian thinking.

Complexity Science theory tells us we must pay attention to the interconnections among the agents and not simply to an individual agent. Because complex adaptive systems have the freedom to respond to stimuli in unpredictable ways, scientists study complex systems by examining their individual components, or building blocks. For example, the building blocks of a house include wood, cement, electric lines, and plumbing materials. An agent can manipulate and combine a set of building blocks to create systems of varying complexity. While knowing the building blocks is critical, putting them together in innovative ways requires vision and collaboration.

Complexity Science can guide our understanding of the healthcare system, a multi-layered system largely driven by rapidly changing technology and information. In healthcare, organization and practitioner agents make up a continuously evolving system because of their innovative, diverse, and progressive adaptations. Knowing the building blocks of the organizational system, its core processes, is critical. Then, studying the interfaces of the building blocks allows system leaders to ask questions based on the flows or patterns among the processes, identify the feed-back loops, explore the interfaces, and ultimately identify an efficient system. With agents acting collectively, broken healthcare system interconnections can be identified and changed. Interactions among these agents encounter boundaries, and boundaries in the healthcare system may be the “bottom line” that constrains interactions.

Timothy Buchman, M.D., Ph.D.,⁴ explored disruptions to complex organisms and organizations using the biomedical model of multiple nesting systems of the human body. In human disease, an injury can lead to disability, and critical illness can lead to death. When this occurs, internal system agents act or are ready to act to maintain constancy or homeostasis. These





agents are connected and continuously evolving, recycling and adapting within each system. Body systems are multiple and interconnected, and critical illness erodes the connections. Healthy human systems are characterized by variability and elasticity, whereas regularity, or fixed response, indicates illness and pathology. Less complex signals from the system represent the loss of vitality preceding manifest disease. In the complex human system, injury and loss of

“Complexity Science encourages healthcare leaders to work with, rather than against, overwhelming complexity by focusing on relationship building, organizational values and culture, and widespread participation, rather than tight integration, formalization, and centralized decision-making. The leader serves the organization by making sense of a complex world, rather than providing neat answers that promise success.”

JIM BEGUN, PH.D.

variability at any connection can lead to organ isolation and to subsequent failure of the organ’s ability to stabilize itself.

These complexity concepts of the biomedical system, it is argued, are transferable to the healthcare system. Whether it is the healthcare system or the patient system, we do not observe the whole system. In managing individual patient care, we tend to pay attention to linear episodes of care, one organ at a time. Yet, the body has multiple systems and treatment directed to one of these systems potentially affects all systems.

Healthcare organizations tend to use their resources to treat, restore, and maintain their own system integrity. Like the human body system, the healthcare organization has multiple, nested, and interconnected building blocks. Healthcare delivery organizations are complex organizational forms, and they operate in an environment that is among the most complex of organizational environments. Hundreds of different types of professionals and organizations interact to provide a wide variety of services to patients, their families, and their communities. Fragmentation and specialization, much of it well-intended, characterizes the delivery of services, as well as healthcare policy. We often fail to appreciate how these separate building blocks interconnect. Failure of healthcare organizations to reach their potential, just as multiple organ failure in illness, is the result of failed coupling of relationships and can lead to death of the system.

Complexity and Leadership

Gareth Morgan, Ph.D., drew on his experience as an organizational management theorist to raise issues of complexity and leadership. Complexity Science views individual organizations as part of a connected web of interacting agents embedded in larger networks and systems, distinct from traditional top-down, linear, prescriptive, bureaucratic hierarchies (FIGURE 1). Living in this world of organizational interconnections creates an uncontrollable turbulent environment. The consequences from the random actions of interacting agents in a healthcare system of slim resources often make healthcare leaders feel like they are living in a world of earthquakes, not trends. As they continue to operate in this context, managers will have to become more skilled in managing contradictions and competing demands.

FIGURE 1 COMPARISON OF ORGANIZATIONAL SYSTEM CHARACTERISTICS	
Complex Adaptive Systems	Traditional Systems
Are living organisms	Are machines
Are unpredictable	Are controlling and predictable
Are adaptable, flexible, creative	Are rigid, self-preserving
Tap creativity	Control behavior
Embrace complexity	Find comfort in control
Evolve continuously	Recycle

FIGURE 2

COMPARISON OF LEADERSHIP STYLES

Complex Adaptive Systems	Traditional Systems
Are open, responsive, catalytic	Are controlling, mechanistic
Offer alternatives	Repeat the past
Are collaborative, co-participating	Are in-charge
Are connected	Are autonomous
Are adaptable	Are self-preserving
Acknowledge paradoxes	Resist change, bury contradictions
Are engaged, continuously emerging	Are disengaged, nothing ever changes
Value persons	Value position and structures
Are shifting as processes unfold	Hold formal position
Prune rules	Set rules
Help others	Make decisions
Are listeners	Are knowers

“Leadership is a verb and a process, not a noun.”

GARETH MORGAN, PH.D.

In re-examining the role of the manager within complex adaptive systems, Morgan focused on four messages about complexity and leadership.⁵

- **Emergence and self organization.** Managers cannot be control-oriented, but must encourage self-organization by recognizing and exploiting the unpredictable nature of complex adaptive organizations.

Every individual in an organization has enormous creative potential, and an emerging organization must have the ability to utilize the potential capabilities of all its members. In a complexity view, involving employees, partners and customers to stimulate creativeness and diversity within organizations produces organizational disorder and unpredictability. The key for managers is to discover and promote the capacities for self organization and to be open to the influence of resulting random opportunities.

- **The art of managing context.** Managers must be anchored by their vision and allow that vision to evolve.

Effective leaders and managers must be skilled in the art of managing context. Planning fails in complex, turbulent, political contexts where there are ambiguous objectives and divergent problems. Managers need to provide the vision,

minimum specifications, and boundaries, and allow employees to explore and act on their experience. For long-term organizational survival in rapidly changing organizations, contemporary managers must pursue multiple paths and projects to maximize the organization’s potential, building on the knowledge that is continuously created.

- **Learning to flow with the change.** Managers have limited influence on change processes.

According to Morgan, most people have about 15 percent discretionary influence over their work situations, with the remainder shaped by the broader context of the organization. It is important not to place one’s energies in the 85 percent area where there is no control, as it causes stress and immobilization. In a complex adaptive system, additive changes of 15 percent can result in large outcomes. The key for managers is to mobilize and align multiple independent “15 percent” efforts, guided by a sense of shared vision.

- **The key role of contradiction.** It is important for managers to confront the bases of tension in a changing organization and to see them as opportunities rather than obstacles.

Dilemmas and contradictions are natural to any change process and must be addressed if significant progress is to be made. Managers must look for and articulate these dilemmas and use the solutions, as well as the tension around the dilemmas, as leverage points. The key for managers is to use the contradictions to boost the momentum of change and create new breakthroughs.

Practice, Teaching, and Research Based on Complexity Science

Using Complexity Science as a theoretical framework for work means reconceptualizing the fundamental way we think about our professional roles (FIGURE 2). The language of Complexity Science also helps to articulate our work in a way that may be understood by others and to systematically focus on what is happening in organizations and systems. While leaders are often portrayed as being “in-charge” and making decisions, the basic complexity principles of flexibility, adaptability, and creativity of agents and organizations require that leaders collaborate

“Organizations can’t be organized any more.”

GARETH MORGAN, PH.D.

“We have used Complexity Science as a theoretical framework to organize inquiry and explore organizational issues. Our research on decision-making in healthcare organizations suggests we must pay attention to the organizational patterns of participation in decision-making, not just the amount or frequency. By embracing Complexity Science, we are changing our fundamental intellectual schema to understand their organizational world.”

REUBEN R. MCDANIEL, JR., PH.D.



around tasks, and support shifting leadership roles as processes unfold. This occurs from the level of the relationship with the patient and family to the continuously evolving healthcare system.

A physician who acts within the spirit of a complex adaptive system views the patient as a human organism, not an indication for a procedure; understands the patient is embedded in a variety of systems—physiological, family, political, and social—that continuously recalibrate themselves; and appreciates that small interventions at the correct leverage points can have large results.

Jim Begun, Ph.D., from the Carlson School of Management, is one of the early innovators and adopters of Complexity Science as it applies to healthcare organizations. He set the stage for the second conference day, which was devoted to understanding practice and systems. This more complex view of healthcare management requires more of students, educators and researchers, as well as practitioners. Educators must challenge students to avoid misapplication of mechanistic, quick-fix tools that work well with simple problems, but wreak havoc when applied to complex

problems. Curricula need more attention to skills in relationship and trust building, listening, and organizational learning. For researchers, Complexity Science provides a more insightful perspective on established research issues in healthcare, such as innovation and vertical integration.⁶ A new understanding of complex systems should enable leaders of healthcare organizations to understand and move their organizations in more innovative and effective ways.

At the organizational and system levels, Complexity Science promises new descriptive theoretical models for identifying organizational building blocks; observing organizational behavior, structure, and change; identifying high leverage opportunities; and for studying outcomes. The core theme of the conference was that the era of planned, controlled change in the context of turbulent systems and environments is gone and is being replaced with a new approach, based in Complexity Science and focused on the art of managing the context of organizations.

**For more information
please contact:**

Jessica Haupt
Center for the
Study of Healthcare
Management
321 19th Avenue S.
Minneapolis, MN 55455
phone
612-626-8795
email
jhaupt@csom.umn.edu

Plexus Institute
www.PlexusInstitute.org

Mayo School of
Continuing Medical
Education
www.mayo.edu

¹ Zimmerman, B., Lindberg, C. and Plsek, P. *Edgeware: Insights from Complexity Science for Health Care Leaders*. Irving, Texas: VHA Inc., 1998. P. 263.

² See “Seeking Meaning Through Conversation” in the *Plexus Institute Newsletter*, February-March 2003, <http://www.plexusinstitute.com/index2.cfm>

³ Zimmerman, B., Lindberg, C. and Plsek, P. *Edgeware: Insights from Complexity Science for Health Care Leaders*. Irving, Texas: VHA Inc., 1998. Hoffman, E. “Women’s Health and Complexity Science” *Academic Medicine*. 2000; 75(11):1102-1106.

⁴ See “Compassionate Complexity” in the *Plexus Institute Newsletter*, February-March 2003, about the work of Timothy Buchman, M.D., Ph.D. <http://www.plexusinstitute.com/index2.cfm>

⁵ See the website that features the work of Gareth Morgan, Ph.D.: <http://www.imaginiz.com>.

⁶ Begun, JW, Zimmerman, B., and Dooley, KJ. “Health Care Organizations as Complex Adaptive Systems.” In Mick, SS. and Wyttenback, ME. (eds). *Advances in Health Care Organization Theory*. San Francisco: Jossey-Bass, 2003. Pp. 253-288.