CHAPTER

3

CHARACTERISTICS OF COMPLEX SYSTEMS

Learning Objectives

After completing this chapter you should be able to

- discuss how a systems perspective can explain recurrent organizational problems;
- recognize different types of systems and the role of systems thinking;
- describe system characteristics that contribute to dynamic complexity; and
- explain the influence of dynamic complexity on managerial decision making.

As people accumulate years of experience in the healthcare field, they begin to see recurring problems—sometimes in an individual organization and sometimes across the entire field. Problems thought to be solved by one manager may come back at a later time for a different manager. The vice president of nursing at a large hospital may centralize and cross-train nurse educator positions to meet necessary budget cuts for the year; three years later, the new vice president of nursing at the same hospital adds unit-based nurse educator positions to address the unmet clinical orientation needs of its new hires. Consider the following situation (Georgopoulos and Mann 1962, 549–51):

> The hospital faces a number of problems concerning the nursing staff . . . one major problem is . . . attracting and retaining a sufficient professional nursing staff, especially non-supervisory nursing staff. . . . The problem lies in the fact that the number of professional nurses being trained in nursing schools is much too low to meet an ever increasing demand for professional nurses by hospitals and other sources. . . . Being understaffed, hospitals often assign to the professional nurse a rather heavy workload that is not seen as normal or reasonable by many nurses. . . . Another important problem . . . involves the composition of the total nursing staff, the question of optimum balance in the proportions of staff members who are registered nurses, practical nurses, and aides.

Although this situation may appear to address a manager's current challenges with nursing shortages, the excerpt was taken from the book *The Community General Hospital*, which was published in 1962! During the more than 50 years since that book was written, health services organizations seem to have made little headway in issues related to workforce planning and management. Nursing shortages, for example, appeared and disappeared in waves in the 1960s, 1970s, 1980s, early 1990s, and again in the early decades of the twenty-first century. Worker shortages are not limited to nursing. In the 2013 AMN Clinical Workforce Survey, 78 percent of hospital executives report a physician shortage now, 66 percent a shortage of nurses, 50 percent shortages of nurse practitioners and physician assistants, and 43 percent a shortage of allied healthcare professionals (AMN Healthcare 2013).

The projected supply of healthcare workers will not meet the demand associated with future population growth and aging of the population (Anderson 2014). Compounding this problem, the Affordable Care Act of 2010 (ACA) has flooded the already-strained healthcare delivery system with newly insured patients. Individuals are facing longer wait times to see physicians, difficulties accessing specialty care, reduced appointment duration, inadequate services, and overall frustration as a result of workforce shortages. Being short-staffed requires careful management of an organization's healthcare resources. For example, the lack of experienced registered nurses is causing acute care facilities such the Rapid City Regional Hospital in South Dakota to adjust the number of available beds every day based on the number of nurses available for each shift (Grant 2016).

Regardless of how healthcare systems might change in the future, one constant remains. Organizations still need people on the front lines of healthcare delivery—physicians, nurses, advanced practitioners, and allied health professionals. As healthcare delivery systems become more complex, organizations without a sufficient number of skilled and dedicated workers will find it difficult to achieve quality goals.

Why do budget problems and workforce shortages remain nagging issues for health services managers? The reasons lie in the complex nature of healthcare, healthcare organizations, and the healthcare field. In healthcare, as in other sectors, "systems thinking is needed more than ever because we are being overwhelmed with complexity" (Senge 1990, 69). Today, one may rephrase Senge's 1990 comment to read, "Systems thinking is imperative in health services organizations because they are much more complex than they were in 1990."

complex having a large number of variables that interact with each other in innumerable, and often unpredictable, ways

In healthcare systems, the term **complex** refers to the presence of a large number of variables that interact with each other in countless and often unpredictable ways. Considering the multiple determinants of health and the vast number of components that comprise health services organizations, the

possible interactions are mind-boggling. Health and health services organizations are also characterized by situations in which "cause and effect are subtle, and where the effects over time of interventions are not obvious" (Senge 2006, 71). This characteristic represents another type of complexity, known as **dynamic complexity**. In the presence of dynamic complexity, "the same action has dramatically different effects in the short run and the long run . . . an action has one set of consequences locally and a very different set of consequences in another part of the system . . . and obvious interventions produce nonobvious consequences" (Senge 2006, 71).

dynamic complexity complexity in which "cause and effect are subtle, and where the effects over time of interventions are not obvious" (Senge 2006, 71)

When faced with dynamic complexity, managers must select interventions that alter the fundamental behavior of the system that is causing the problem; otherwise the solution is only temporary. As seen in the nursing shortage example, although interventions may offer temporary relief, the problems resurface again and again.

The starting point for altering fundamental system behavior is always a mystery. Every system improvement we now know as being successful started out as a puzzle in which the variables that mattered were unknown and the cause and effect relationships unclear (Martin 2013). Once relevant variables are understood, cause-and-effect relationships can be defined and managed. With study, the mysteries of the dynamic complexities in healthcare systems are becoming clearer. The relevant variables are still not entirely understood and subtleties of the cause-and-effect relationships have yet to be unraveled, but we are not at the mystery stage. This chapter introduces a systems perspective on quality management that is based on the concepts of systems thinking and dynamic complexity.

Systems Thinking

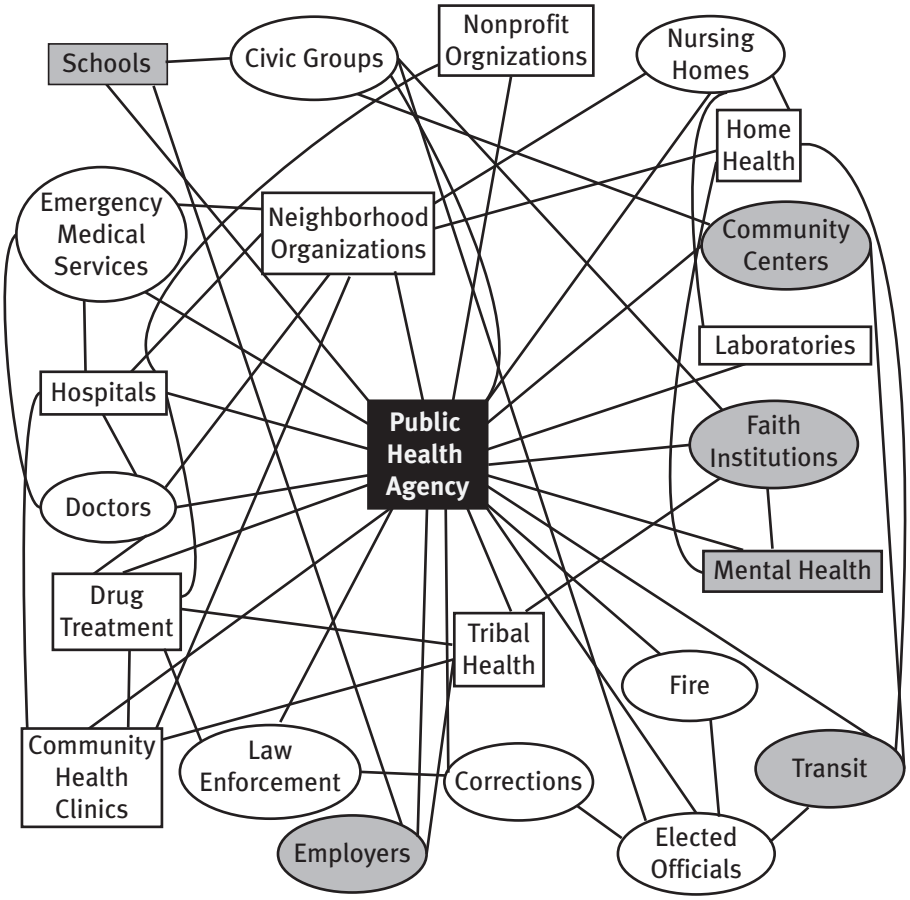
Just as there are a variety of perspectives surrounding the term "quality," the term "system" brings with it numerous connotations and perceptions. While "system change" is often heard in the quality and safety discourse, the term "system" may be defined and perceived in a variety of ways. In this book, a **system** refers to "a set of connected parts that fit together to achieve a purpose" (Langabeer and Helton 2016, 477).

system "a set of connected parts that fit together to achieve a purpose" (Langabeer and Helton 2016, 477)

A healthcare system contains a complex variety of interdependent organizations, as illustrated by the diagram of the public health system in exhibit 3.1. Such a **megasystem** of connected parts is necessary for the purpose of advancing the vision of healthy communities (Institute of Medicine 1996). The importance of understanding these megasystems as interrelated parts of a whole cannot be overstated.

megasystem a complex variety of interdependent organizations

EXHIBIT 3.1
The Public Health System



Source: Centers for Disease Control (2014).

macrosystems organizations providing health services, such as hospitals, nursing homes, community health clinics, and emergency medical services

microsystems "people, machines, and data at the level of direct patient care (the treatment team within the hospital or the physician office practice, for example)" (Schyve 2005, 2)

In the public health system are many macrosystems that provide input to the larger system. **Macrosystems** are the organizations providing health services, such as hospitals, nursing homes, community health clinics, and emergency medical services. These macrosystems are "connected via individuals and teams, regulations and rules, and technology" (Johnson, Miller, and Horowitz 2008, 3). The many health organization mergers, partnerships, and affiliations following passage of the 2012 Affordable Care Act have created a number of regional healthcare delivery systems comprised of multiple macrosystems (PricewaterhouseCoopers 2016).

In each macrosystem are innumerable microsystems. **Microsystems** are made up of the "people, machines, and data at the level of direct patient care (the treatment team within the hospital or the physician office practice, for example)" (Schyve 2005, 2). Just like the parts of a macrosystem, the parts

of a microsystem interact with each other to form an interdependent whole. During research into the frontline clinical teams in various healthcare settings, Godfrey, Nelson, and Batalden (2004, 5) coined the phrase **clinical microsystem** to describe "a small group of people who work together on a regular basis to provide care to discrete subpopulations of patients" 2004, . These clinical microsystems are "the place where patients, families, and care teams meet. . . . They are living units that change over time and always have a patient (person with a health need) at their center" (Microsystem Academy 2016).

clinical microsystem a "small group of people who work together on a regular basis to provide care to discrete subpopulations of patients" (Godfrey, Nelson, and Batalden 2004, 5)

An example of a micro-system (or clinical microsystem, as some would call it) is the team of people working in the cardiac catheterization lab during a coronary angiography procedure. This team often consists of a cardiologist, one or more nurses monitoring the patient's vital signs, a scrub nurse and a circulating nurse, an X-ray technician, and one or more nurses or cardiovascular invasive specialists assisting with recording and other duties. These people have different responsibilities, yet the angiography procedure cannot get done without each of them working interactively with other team members.

A system reflects the whole, and "**systems thinking** is a view of reality that emphasizes the relationships and interactions of each part of the system to all the other parts" (McLaughlin and Olson 2012, 39). Rather than considering each part of the system to be unique and separate, systems thinking acknowledges the infinite number of unique parts and the ways in which the parts interact, as well as the nature of the interactions. Recognizing how each part functions within the system as a whole and how an individual's actions affect all other aspects of the system is vital to unlocking the power of systems thinking.

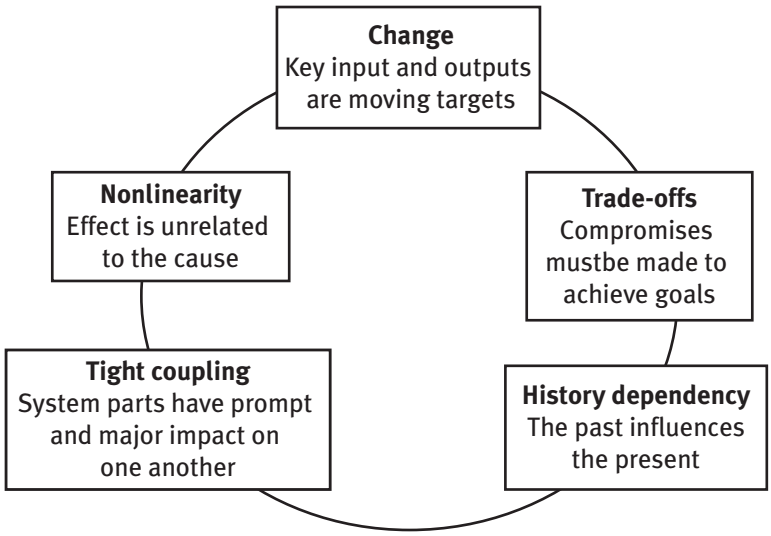
systems thinking "a view of reality that emphasizes the relationships and interactions of each part of the system to all the other parts" (McLaughlin and Olson 2012, 39)

The importance of developing a clear understanding of the parts of a system and how they interact is illustrated by the ancient parable from India about the blind men and the elephant. There are many versions of this story; however, the common denominator is that each man feels a different part of the animal, and only that part, to learn what an elephant is. When the men compare their understandings of an elephant, they are in complete disagreement. This parable demonstrates what can happen when people have distinctly different perceptions about the same system. In these situations, identifying relationships between the elements and understanding how they are connected is more challenging.

Dynamic Complexity

Several system characteristics contribute to the presence of dynamic complexity (Sterman 2000). Five characteristics, predominant in healthcare and health

EXHIBIT 3.2 System Characteristics Contributing to Dynamic Complexity



services organizations, are described in this section: change, trade-offs, history dependency, tight coupling, and nonlinearity (see exhibit 3.2).

Change

Systems are dynamic—that is, constantly changing. Change occurs at different rates and scales within and among systems, especially in healthcare. Consider three levels of this characteristic of dynamic complexity in health services. First, the human body changes continuously. This fact means that key inputs (patients with a clinical problem) to and outputs (patients' status after clinical intervention) of healthcare systems are moving targets. Second, the organizational contexts in which health services are carried out are dynamic in nature. Employees move in and out of organizations, research provides an ongoing stream of new evidence, and technological advances offer new clinical and management approaches. Third, the communities and political environments in which we live and in which healthcare organizations operate change—that is, the environment changes with economic cycles, political ideologies, and election cycles. Unlike other complex systems, such as aviation, the level of change and the degree of uncertainty that characterizes many of the problems faced by practitioners makes it a particularly hazardous complex system (Runciman, Merry, and Walton 2007).

Implications for Healthcare Managers

From the day a person is born to the day she dies, she is in a constant state of change, growing and developing physiologically and emotionally. No two

human systems are alike or precisely predictable in their responses to a medical intervention. As a result, functions that may seem straightforward in other industries, such as product standardization, become more difficult for healthcare managers. For example, the practice of using a standardized list of drug names and brands (i.e., a hospital formulary) to reduce medication expenses is accepted practice. However, when the dynamic nature of patient physiology is introduced, the manager recognizes that in addition to the question, "What are the set of drug names and brands that will be most cost-effective?" he also needs to ask, "How should the approved drugs be selected, and what are the consequences to patients?"

To aid in grasping the subtle but important nuances involved in individualizing treatment plans, consider the process of trying on a pair of blue jeans. People have their own favorite brand of blue jeans that fit well, even though another brand may be advertised as having a similar size and style. The hospital formulary essentially dictates to doctors that the patient may buy only slim-cut size 10 jeans and not relaxed-fit size 10 jeans (Kelly and Pestotnik 1998). Studies on variations in genetic makeup and the nature of gene–environment interactions promise to shed light in yet unimaginable ways on why certain treatments or medications may work better for one person than another. The emerging field of **pharmacogenomics** may permit drug selection in the future to be based on an individual's unique genetic makeup, altering the paradigm on which health services organizations manage **pharmacotherapeutics**. (Medline Plus and Merriam-Webster 2016). Preemptive medicine—"removing the initial molecular event—precluding the possibility of that thing even happening" (Culliton 2006, W96)—will likely alter the fundamental role of healthcare delivery organizations in the future.

pharmacogenomics
"a biotechnological science that combines the techniques of medicine, pharmacology, and genomics and is concerned with developing drug therapies to compensate for genetic differences in patients which cause varied responses to a single therapeutic regiment" (Medline Plus and Merriam-Webster 2016)

pharmacotherapeutics
"the study of the therapeutic uses and effects of drugs" (Medline Plus and Merriam-Webster 2016)

Trade-Offs

The need to understand the nature of trade-offs may seem unnecessary for managers taught to weigh pros versus cons or opportunities versus risks as they consider organizational decision options. Trade-offs may be seen as an accepted attribute of management situations. However, an understanding of dynamic complexity fosters an appreciation for the system consequences of local management trade-off decisions. "Time delays in feedback channels mean the long-run response of a system to an intervention is often different from its short-run response. High leverage policies often cause worse-before-better behavior, while low leverage policies often generate transitory improvement before the problem grows worse" (Sterman 2000, 22).

Implications for Healthcare Managers

Classic examples of low-leverage policies are found in the studies of attempts to reduce health system costs by reducing the length of hospital stays. One

study reported that healthy newborns discharged from the hospital 48 hours or fewer after delivery, saving the costs of a longer stay, had a significantly higher risk for readmission, morbidity, and neonatal mortality (Farhat and Rajab 2011). Another analysis found that hospitals with shorter lengths of stay were more likely to discharge Medicare patients to nursing facilities and inpatient rehabilitation facilities, suggesting that some hospitals may be using post-acute care as a substitute for inpatient care (Sacks et al. 2016).

If a manager in these cases viewed the healthcare system as a microsystem (e.g., the hospital department where patients received care) or the hospital administrator viewed it as a macrosystem (e.g., this hospital), the interventions chosen to reduce system costs might have been viewed as successful. However, if one views the healthcare system as a megasystem that includes not only the acute phase of care (e.g., the department where patient care occurred, the hospital) but also the downstream providers (e.g., other hospitals, emergency services, clinic services, nursing and rehabilitation facilities) and takes into account how the relationships among all providers influence patient outcomes, the longer-term behavior of the system can be observed.

From a systems perspective, the acute care manager is responsible for the acute care unit or hospital and also for the effect those local decisions have on the rest of the system of which the manager's component is a part. This perspective does not mean that the manager of a hospital department or the hospital administrator should not strive to reduce hospital costs. It does mean that managers, financial officers, CEOs, and policymakers should be aware of how decisions made and implemented in their domains of responsibility affect other parts of the healthcare system positively and negatively. When a negative impact on another part of the system is anticipated, the manager should be proactive in the short term to help minimize the negative effects and preserve positive patient outcomes. With emergence of the concept of accountable care organizations (ACOs), managers must learn how to optimize the macrosystems of healthcare delivery while improving the microsystems.

Other common trade-off challenges for healthcare managers surround the differences between expense and investment decisions within organizations and departments. The long-term effect of a manager's short-term decision may not be felt by another component in the macrosystem, but perhaps it will surface in the future in the manager's own department or organization. For example, does the manager sacrifice capital improvements to fund contract workers in the short term? Do managers reduce staff education expenditures to lower current expenses? Although choosing contract workers and reducing staff development activities may meet short-term financial priorities, these efforts fall into the category of low-leverage policies because the problems of facility aging, staff shortages, and the need for a competent workforce will surely be faced by the manager in the future. Without an appreciation of system

consequences, one manager may be rewarded for short-term "success" with a promotion, while his successor inherits the longer-term problem.

In the formulary example, the organization may be willing to trade the rare adverse medication event for dollar savings realized from product standardization. However, this decision could compromise patient outcomes and unintentionally contribute to polarization and conflict between clinicians and managers.

History Dependency

Systems are history dependent. In other words, what has happened in the past influences what is happening right now. "We have always done it this way" methods of healthcare delivery are often perpetuated, despite research-supported knowledge that points to more effective practices. Some of these dated practices include (Melnyk 2016):

- Recording vital signs every four hours at night on stable patients, despite their need for undisrupted sleep for recovery;
- removing urinary catheters only on a physician's orders, though the removal of catheters according to a nurse-driven protocol is more efficient and may prevent urinary tract infections; and
- continuing the practice of 12-hour nursing shifts, when findings from research indicate adverse outcomes for nurses and patients.

Some actions taken in the past are reversible, while some cannot be easily overturned. For example, a strategic decision by a hospital to convert some inpatient beds to skilled nursing beds could be difficult to reverse when more inpatient beds are needed.

Implications for Healthcare Managers

History dependency may be seen in the patient and the organization. Because of advancements in care of chronic illnesses, rather than succumb to complications of one illness, elderly adults are often under treatment for several chronic illnesses concurrently. Persons with cystic fibrosis or born with congenital heart defects now enjoy a life expectancy into adulthood; previously these conditions usually were fatal in childhood. Unhealthy behaviors, such as excessive alcohol, drugs, or cigarettes, even when discontinued, may have long-lasting health consequences. Understanding a patient's history is not only important for clinical providers but also is important for health services managers. For example, a patient's health history influences resources required for his care. An obese patient being treated for asthma, hypertension, and diabetes requires more labor-intensive care when having his gallbladder removed than

an otherwise healthy athlete undergoing the same surgery. In recognition of these differences, managers must be willing to make nurse staffing adjustments for patient acuity (Huston 2013).

The manager must realize not only how past events have shaped current events but also how past decision-making strategies and directions may influence her ability to successfully achieve current and future goals. Using the nursing staff issue example, if the organization has historically rewarded managers for staying within budgetary expectations, a significant increase in nurse salary costs associated with caring for sicker patients without corresponding increases in patient care revenue might be difficult to sell given the organization's history of rewards and decision-making.

Tight Coupling

tightly coupled relating to a system in which the parts "exhibit relatively time-dependent, invariant, and inflexible connections with little slack" (Scott 2003, 358)

A system is characterized as **tightly coupled** when its "parts exhibit relatively time-dependent, invariant, and inflexible connections with little slack" (Scott 2003, 358). An example is an elegantly crafted configuration of dominoes that can be set in motion by a push to the first piece. In a tightly coupled system it can be difficult for people to recognize and correct mistakes to prevent an undesirable outcome. Tight coupling is also present when "the actors in the system interact strongly with one another" (Sterman 2000, 22).

Implications for Healthcare Managers

Organizations in industries outside of health services that are most commonly identified as tightly coupled include nuclear power plants and aircraft carriers (Dlugacz and Spath 2011). Healthcare organizations often demonstrate loosely coupled social structures such as departments, divisions, and professional groups, yet the tasks carried by the microsystems in the organizations are often tightly coupled. For example, cardiologists, nurses, and X-ray technicians belong to separate, distinct, loosely coupled professional groups and departments within the structure of the organization. Yet, when these people come together as a microsystem in the cardiac catheterization lab, the tasks they perform while conducting an angiogram procedure are tightly coupled. In this tightly coupled system, an undetected patient identity mistake or the administration of a wrong medication can quickly lead to disastrous consequences, because the link between actions and outcomes is more direct.

Numerous interactions in and between people, processes, and departments in individual organizations and interactions among services along the continuum of care require managers to be attentive to the concept of coupling. Identifying, designing, and institutionalizing tools that promote task alignment, communication, collaboration, coordination, and strengthened relationships among players are required competencies for contemporary health services managers. Checklists that detail proper patient management practices, bar-coded

patient identification mechanisms, and standardized handoffs between caregivers are just three of the many tools used to improve the quality of patient care in tightly coupled systems (Dlugacz and Spath 2011).

Nonlinearity

The term **nonlinear**, as it refers to a system characteristic, means that the "effect is rarely proportional to the cause" (Sterman 2000, 22). Because the parts in nonlinear systems may interact in numerous ways, these interactions often follow "unexpected sequences that are not visible or not immediately comprehensible" (Scott 2003, 358). In a nonlinear system small deviations may have huge, unpredictable, and irregular effects.

nonlinear relating to a system in which the "effect is rarely proportional to the cause" (Sterman 2000, 22)

Implications for Healthcare Managers

Here is an example of the nonlinear nature of healthcare systems. A respiratory therapist just starting the afternoon shift is the object of an outburst of anger from a patient's family. The therapist relates the encounter to a colleague at the nurse's station: "All I did was say, 'Hello'!" This situation may bring to mind the old idiom "the straw that broke the camel's back." In fact, this cliché is an accurate description of the encounter.

The patient and her family had accumulated a sequence of unsatisfactory experiences during the hospital stay, so all it took was one more encounter to trigger their anger. Although this time was the first that the afternoon therapist had met the family, his was the last in a series of interactions between the patient and the healthcare system that caused this family grief. If the patient complains to the manager about this therapist, what should the manager do? Without an appreciation for the nonlinear nature of systems, the manager may be tempted to discipline the employee. However, if the manager does have such an appreciation, she may try to investigate the sequence of events that culminated in the family's dissatisfaction. Although each event was relatively harmless when considered individually, when linked together with the family's overall experiences, they contributed to an unacceptable encounter. From this investigation, the manager may identify areas that can be improved to enhance the patient's overall experience with the care delivery process.

Another example of the nonlinear nature of systems may be seen in strategies used to reduce personnel expense in healthcare organizations. Because personnel expenses make up such a large percentage of operating budgets, changing the staff mix—that is, reducing the number of professional staff (e.g., registered nurses, medical technologists, pharmacists) and increasing the proportion of assistive personnel (e.g., nurse aides, laboratory assistants, pharmacy technicians)—is a common cost-cutting intervention. When this intervention is studied from a systems perspective, however, the resulting sequences of activities and their interrelationships are more readily seen. The

unplanned consequences of this cost-cutting strategy in one organization included an increase in the overall employee turnover rate because of the frequency with which entry-level, assistive personnel left their jobs. Because this cost-cutting strategy was used by managers across different types of professions and departments, the stress and cost of continuously recruiting, hiring, and training new employees more than offset the savings hoped for from lowering the average hourly wage. When viewed from one department's point of view, the cost-reduction strategy may appear to be reasonable; however, when the compounding effect of this cost-cutting strategy is viewed across the entire organization, the strategy designed to reduce costs actually undermines the organization's ability to do so (Kelly 1999).

Summary

Like the term "quality," the term "system" can carry a variety of connotations. In this text, a system refers to a set of connected parts that fit together to achieve a purpose. The connected parts may be a health system that contains many organizations (a megasystem), an organization (a macrosystem), or a small unit or clinical team in an organization (a microsystem).

Systems thinking, a management discipline, acknowledges the large number of parts in a system, the infinite number of ways in which the parts interact, and the nature of the interactions. The healthcare system, whether the term refers to a single patient care unit, a facility, or all providers in a state or throughout the nation, is dynamically complex. The five system characteristics contributing to the presence of dynamic complexity are change, trade-offs, history dependency, tight coupling, and nonlinearity.

Exercise 3.1

Objective: To practice identifying dynamic complexity.

Instructions: Describe how the following example illustrates one or more of the system characteristics that contribute to dynamic complexity.

Example:
Medical Associates is a for-profit medical group of 40 physicians that operates two facilities and offers services in several medical specialties, including cardiology; ear, nose, and throat; family medicine; gastroenterology; general surgery; pediatrics; and obstetrics and gynecology. Medical Associates is open six days a week in each location from 8:00 am until 6:00 pm. Plans are being developed to extend its hours to 9:00 pm two days a week. For several years, Medical Associates discounted its listed fees by 3–5 percent for its managed

care contracts, but a few years ago it had to accept larger discounts to remain in the networks of health plans. Lower reimbursements led "Medical Associates to change its staffing from relying solely on registered nurses (RNs) to hiring medical assistants (MAs) as well. Currently, all physicians assigned to primary care service are assigned one RN or MA to assist with patient care. Physicians assigned to surgery are assigned one RN for every two physicians. As RNs retire or reassign, they have been replaced with MAs. On five recent occasions, when an RN assigned to a senior physician resigned, the senior physician demanded that the RN assigned to a junior physician be reassigned to him and that a new MA be hired to fill the vacancy with the junior physician. This ad hoc system of job switching has caused internal turmoil between the senior and junior physicians and has led to the subsequent resignation of two RNs who did not want to be reassigned. . . . Confusion exists around staff reporting relationships and who has the authority to change job assignments" (Seidel and Lewis 2014, 215).

Companion Readings

Anderson, A. 2014. "The Impact of the Affordable Care Act on the Health Care Workforce." The Heritage Foundation. Published March 18. www.heritage.org/research/reports/2014/03/the-impact-of-the-affordable-care-act-on-the-health-care-workforce.

Coutou, D. L. 2003. "Sense and Reliability: A Conversation with Celebrated Psychologist Karl E. Weick." *Harvard Business Review* 81 (4): 84–90.

Lipsitz, L. A. 2012. "Understanding Health Care as a Complex System: The Foundation for Unintended Consequences." *Journal of the American Medical Association* 308 (3): 243–44.

Nelson, E. C., M. Godfrey, P. B. Batalden, S. A. Berry, A. E. Bothe, K. E. McKinley, C. N. Melin, S. E. Muething, G. Moore, J. H. Wasson, and T. W. Nolan. 2008. "Clinical Microsystems, Part 1: The Building Blocks of Health Systems." *The Joint Commission Journal on Quality and Patient Safety.* Published July. http://clinicalmicrosystem.org/wp-content/uploads/2014/05/jc_quality_safety_01.pdf.

New England Complex System Institute. 2016. "About Complex Systems." Accessed November 8. www.necsi.edu/guide.

Peters, D. H. 2014. "The Application of Systems Thinking In Health: Why Use Systems Thinking?" *Health Research Policy and Systems.* Published August. https://health-policy-systems.biomedcentral.com/articles/10.1186/1478-4505-12-51.

Senge, P. M. 1990. "The Leader's New Work: Building Learning Organizations." *Sloan Management Review* (Fall): 149–65.

Web Resources

Applied Systems Thinking: http://appliedsystemsthinking.com
Dartmouth Institute Microsystem Academy: https://clinicalmicrosystem.org
Society of Organizational Learning: www.solonline.org
System Dynamics Society: www.systemdynamics.org

References

AMN Healthcare. 2013. *ealthHeClinical Workforce Survey*. Retrieved June 30, 2016. www.amnhealthcare.com/uploadedFiles/MainSite/Content/Healthcare_Industry_Insights/Industry_Research/executivesurvey13.pdf.

Anderson, A. 2014. "The Impact of the Affordable Care Act on the Health Care Workforce." The Heritage Foundation. Published March 18. www.heritage.org/research/reports/2014/03/the-impact-of-the-affordable-care-act-on-the-health-care-workforce.

Centers for Disease Control. 2014. "The Public Health System and the 10 Essential Public Health Services." Updated May 29. www.cdc.gov/nphpsp/essentialservices.html.

Culliton, B. J. 2006. "Extracting Knowledge from Science: A Conversation with Elias Zerhouni." *Health Affairs* 25 (3): W94–W103.

Dlugacz, Y. D., and P. L. Spath. 2011. "High Reliability and Patient Safety." In *Error Reduction in Health Care: A Systems Approach to Improving Patient Safety*, edited by P. L. Spath, 35–56. San Francisco: Jossey-Bass.

Farhat, R., and M. Rajab. 2011. "Length of Postnatal Hospital Stay in Healthy Newborns and Re-hospitalization Following Early Discharge." *North American Journal of Medical Sciences* 3 (3): 146–51.

Georgopoulos, B. S., and F. C. Mann. 1962. *The Community General Hospital*. New York: The MacMillan Company.

Godfrey, M. M., E. C. Nelson, and P. Batalden. 2004. *Clinical Microsystem Action Guide: Improving Healthcare by Improving Your Microsystem*. Dartmouth College. Revised September 2. http://clinicalmicrosystem.org/wp-content/uploads/2014/07/CMAG040104.pdf.

Grant, R. 2016. "The U.S. Is Running Out of Nurses." *The Atlantic*. Published February 3. www.theatlantic.com/health/archive/2016/02/nursing-shortage/459741.

Huston, C. J. 2013. *Professional Issues in Nursing: Challenges and Opportunities*. New York: Lippincott Williams & Wilkins.

Institute of Medicine. 1996. *Healthy Communities: New Partnerships for the Future of Public Health*. Washington, DC: National Academy Press.

Johnson, J. K., S. H. Miller, and S. D. Horowitz. 2008. "Systems-Based Practice: Improving the Safety and Quality of Patient Care by Recognizing and Improving the Systems in Which We Work." In *Advances in Patient Safety: New Directions and Alternative Approaches*, vol. 2: *Culture and Redesign*, edited by K. Henriksen, J. B. Battles, M. A. Keyes, and M. L. Grady. Agency for Healthcare Research and Quality. Published August. www.ncbi.nlm.nih.gov/books/NBK43731/pdf/Bookshelf_NBK43731.pdf.

Kelly, D. L. 1999. "Systems Thinking: A Tool for Organizational Diagnosis in Healthcare." In *Making It Happen: Stories from Inside the New Workplace*. Waltham, MA: Pegasus Communications, Inc.

Kelly, D. L., and S. L. Pestotnik. 1998. "Using Causal Loop Diagrams to Facilitate Double Loop Learning in the Healthcare Delivery Setting." Unpublished manuscript.

Langabeer, J. R., and J. Helton. 2016. *Healthcare Operations Management: A Systems Perspective*, 2nd ed. Burlington, MA: Jones & Bartlett Learning.

Martin, R. L. 2013. "Our Self-Inflicted Complexity." *Harvard Business Review*. Published September 6. https://hbr.org/2013/09/our-self-inflicted-complexity.

McLaughlin, D. B., and J. R. Olson. 2012. *Healthcare Operations Management*, 2nd ed. Chicago: Health Administration Press.

Medline Plus and Merriam-Webster. *Medical Dictionary*. 2016. Retrieved June 30. www.merriam-webster.com/medlineplus/pharmacotherapeutics.

Melnyk, B. 2016. "Evidence-Based Practice vs. Doing It the Way We've Always Done It." *Medscape Nurses*. Retrieved June 30. www.medscape.com/viewarticle/860627.

Microsystem Academy. 2016. "Transforming Microsystems in Healthcare." Dartmouth Institute for Health Policy and Clinical Practice. Retrieved June 26. https://clinicalmicrosystem.org.

PricewaterhouseCoopers. 2016. *US Health Services Deals Insights: Analysis and Trends in US Health Services Activity: 2015 and 2016 Outlook*. Published February. www.pwc.com/us/en/healthcare/publications/assets/pwc-health-services-deals-insights-q4-2015.pdf.

Runciman, B., A. Merry, and M. Walton. 2007. *Safety and Ethics in Health Care: A Guide to Getting It Right*. Burlington, VT: Ashgate.

Sacks, G., E. Lawson, A. Dawes, R. Weiss, M. Russell, R. Brook, D. Zingmond, and C. Ko. 2016. "Variation in Hospital Use of Postacute Care after Surgery and the Association with Care Quality." *Medical Care* 54 (2): 172–79.

Schyve, P. 2005. "Prologue: Systems Thinking and Patient Safety." In *Advances in Patient Safety: From Research to Implementation*, vol. 2: *Concepts and Methodology*, edited by K. Henriksen, J. B. Battles, E. S. Marks, and D. I. Lewin. Agency for Healthcare Research and Quality. Published February. www.ncbi.nlm.nih.gov/books/NBK20523.

Scott, R. A. 2003. *Organizations: Rational, Natural, and Open Systems*, 5th ed. Upper Saddle River, NJ: Prentice Hall.

Senge, P. M. 2006. *The Fifth Discipline: The Art and Practice of the Learning Organization*, 2nd ed. New York: Doubleday Currency.

———. 1990. *The Fifth Discipline: The Art and Practice of the Learning Organization*. New York: Doubleday Currency.

Seidel, L. F., and J. B. Lewis. 2014. *The Middleboro Casebook: Healthcare Strategy and Operations*. Chicago: Health Administration Press.

Sterman, J. D. 2000. *Business Dynamics: Systems Thinking and Modeling for a Complex World*. Boston: Irwin McGraw-Hill.