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## Systems View of Health Care

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The art of medicine concentrates on diagnosis (finding problems) and treatment (fixing problems). The task of physicians might be described as “find it and fix it.” The find-it/fix-it model exemplifies what engineers call linear thinking. The linear model has been the predominant view of the world since the time of Sir Isaac Newton, who focused his attention on discrete components of the world and assumed that these components operated independently from one another. Many things work in a linear fashion. For a complex machine or organism, linear function means that each component operates independently of the others. The environment receives relatively little attention. Ackoff (1994) explained that the industrial revolution, which began in England during the 18th century, ushered in new ways of thinking that dominated nearly all fields for several centuries. This thinking was dominated by three concepts: reductionism, analysis, and mechanism.

*Reductionism* is the belief that everything we experience is made up of component parts. Just as an automobile represents contributions from many factories, we assume that humans are also a conglomeration of component parts. Science has involved the study of taking things apart. The parts become smaller and smaller until the scientist arrives at the ultimate parts, which are no longer divisible. These are the basic elements. Reductionists believe that to understand something it must be disassembled into its component parts. It is usually assumed that these parts function independently of one another.

*Analysis* is the process by which things are divided into their components. These things may be tangible, such as the human body or a machine. However, ideas can also be disassembled.

*Mechanism*, the third basic component of linear thinking, is the belief that cause and effect can be described by one relationship. If  $x$  causes  $y$ , we may understand the mechanism of  $y$  by manipulating  $x$ . For example, if sun exposure causes red skin, we can recreate the red skin by placing a person in the sunlight. The sunlight is the mechanism that causes sunburn. Investigators rarely accept explanations at this global level. Instead, they search for finer mechanisms that explain relationships at a more basic level. In contrast to this linear thinking, a recent and more popular trend is toward “systems” thinking.

Understanding complexity is a fundamental goal of science. During the 19th century, Descartes proposed reductionism as a remedy to being overwhelmed by information. According to Descartes, complicated phenomena could be understood by dividing them into their component parts. It was assumed that this division would not distort the phenomenon that was being studied. This approach has led to many productive sciences. It is also apparent, however, that there are dense interconnections among the component parts of most phenomena. Virtually all sciences have come to this same conclusion (Checkland, 1994).

In contrast to mechanistic understanding, systems thinking considers the whole rather than the individual parts. A *system* is defined as a whole that cannot be divided into independent parts. The functioning of each part cannot be understood independently of the functioning of other parts. The value of individual parts is lost when the whole is disassembled. For example, an automobile broken down into component parts cannot be used to transport people. A human eye cannot see if it is removed from the body, just as a steering wheel does not direct an automobile when it is removed from the machine (Gharajedaghi & Ackoff, 1984).

Traditional scientific analysis represents an attempt to understand organisms by taking them apart and examining each part separately. This can be useful in determining the structure but may not inform about function. The traditional “find it and fix it” medical model builds upon traditional linear thinking. If a prostate gland is too large, it must be surgically reduced, high blood pressure must be lowered, and hyperactive children must be made less active. Mechanistic thinking has certainly produced some sensational successes. Many patients benefit from hernia repairs, total joint replacement, and pharmaceutical control of blood pressure. However, finding and fixing one problem often creates a new one. Easy solutions, even those derived from understanding basic mechanisms of disease, might invite new problems.

Systems thinking has now found its way into virtually all sciences. It has had a profound effect in manufacturing industries and was used to create the astounding rebound in the Japanese economy following World War II. Systems analysts studied variation using formal statistical methods. Many of these ideas were influenced by Shewhart, a physicist and self-trained statistician who worked for the Western Electric Company. Shewhart realized that many resources were used to inspect products. During the 1920s, one in four employees in the Western Electric laboratories were inspectors. Identification of a faulty product might lead to a reprimand of the responsible employee. Shewhart recognized that, even under relatively primitive conditions of manufacturing, there was predictable variation in defects. The distribution of defects remained constant over time. Shewhart recognized that there are random sources of variation that cause some defects. Inspectors and managers were often reacting to random variation. The way to improve the product was to separate the sources of variation that were random from the sources that could be controlled. Inspection alone was not enough to improve the products.

One of the key components in Shewart’s thinking was that quality was associated with reproducibility. Reproducibility meant reducing variation through the

standardization of procedures. He emphasized that a certain amount of variability is expected and that managers or inspectors should understand random variation and not attend to variations within an expected range. Many of the problems, he argued, were caused by overattention to random variation. Shewhart was the intellectual father of many important leaders in the business and manufacturing communities. Most notably, Demming (1994) and Juran (1993) have promoted Shewhart's ideas and have had a profound effect on industries throughout the world. American companies, such as Xerox, Ford, Motorola, McDonnell Douglas, Hartford Insurance, and others, have implemented these ideas. Demming promoted the ideas in Japan, and many believe that the remarkable success of the Japanese economy has benefited from systems thinking.

What does this have to do with health care? Many doctors and patients are offended by the suggestion that concepts from manufacturing science could have anything to do with medical care. Doctors save lives, they do not manufacture bicycles. The difficulty is that many of the problems that characterize poor manufacturing also exist in medicine. For example, consumers want products on which they can depend. If you buy an automobile, you expect it to function for a certain period of time, and you assume it was manufactured under a clearly defined protocol. The manufacturers might be confident enough in their production process to offer a warranty guaranteeing that it will operate for a certain number of miles or a fixed duration of time. We expect that a certain model of automobile manufactured in different plants would have the same level of reliability.

In health care, we expect that a patient with a defined medical problem who appears in the offices of different doctors should get the same diagnosis and treatment. We also assume that the treatment is administered in a standardized way that leads to the best result. However, diagnoses differ among places, and there is high variability in the use of medical procedures and the way they are applied. Consumers cannot expect that the services they purchase will be delivered in a reliable way.

Consider clinical decision making and clinical variation in treatment for the same disease. Berwick (1991) offered the case of Brian, a 16-year-old patient suspected of suffering from osteomyelitis.<sup>1</sup> Although the clinical picture and a bone scan were consistent with the diagnosis, no organism could be recovered from Brian's bloodstream. Antibiotic therapy was started on an empirical basis, but Brian continued to spike fevers for a week. He was transferred for further evaluation. The clinical question of greatest importance was this: Did Brian really have osteomyelitis caused by an organism sensitive to the current antibiotic, or was another entity involved, such as osteomyelitis with a resistant organism or even a different disease, such as lymphoma? The diagnostic strategy included careful observation. Over the next 14 days, Brian was closely monitored, and his temperature was repeatedly measured. During this period, his antibiotic regimen was changed three times, he underwent numerous radiological examinations, and had a biopsy of both the bone and the bone marrow. During those 2 weeks,

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<sup>1</sup>Osteomyelitis: inflammation of the bone marrow and the adjacent bone.

100 temperature measurements were recorded in Brian's chart on 22 pages of nursing notes (Berwick, 1991). On what evidence was Brian's treatment based?

While working at the Bell laboratories, Shewhart observed how machine operators overreacted to variations over which they had little control. When operating machines, different personnel reacted differently to changes on machine gauges. Furthermore, Shewhart noticed that the same technician would react differently to the same changes on a gauge when studied at different points in time. When they overreacted to changes in gauges, they often produced more variability by tampering with the system.

Berwick's patient may be similar. Six house officers and five consultants adjusted antibiotic doses based on a stream of 101 temperature measurements. Is this reminiscent of manufacturing technicians overreacting to changes on gauges? Medical management involves a stream of decisions about starting antibiotics, changing antibiotics, obtaining laboratory tests, repeating tests, and so on. How much of this effort is wasted because it responds to random variation? Berwick challenged his colleagues to think about some of the ramifications of their practice (Berwick, 1991, pp. 1219–1220).

What do clinicians measure and respond to clinically based on what measurements? The list is endless. Measure prothombin<sup>2</sup> and change anticoagulants. Measure oxygen tensions and change respirator settings. Measure fever and change antibiotics. Measure blood pressure and change antihypertensive agents. Measure leukocytes and change chemotherapies. Measure pain and change analgesia. Measure electrolytes and change intravenous fluids. Measure and change, measure and change.

The art of medicine requires each physician to use his or her intuition when ordering measurements and deciding on changes. As a result, different physicians might react to the same case in different ways. Furthermore, because some of the variation is random, the same patient might receive different treatments for the same condition on repeated visits to the same doctor. Physicians are overwhelmed with data and are required to take decisive action, even when they are uncertain about the exact nature of the problem. Random variation may lead to decisions that, in turn, produce more variation. In some cases, this places patients at risk.

## Conclusions

This chapter introduces systems thinking. These ideas are clearly not new in health care and, in fact, are now common in discussions of quality improvement and health care reform. However, it may be valuable to reframe some of the discussion in the "CLINECS" terminology. Much of clinical medicine still uses linear thinking and considers simple inputs and outputs. We manipulate single variables (inputs) and look for responses on output variables. However, some of the

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<sup>2</sup>Prothrombin (factor II) is produced in the liver and is part of the process resulting in blood coagulation.

responses or outputs may not clearly be related to patient outcomes. Inputs may be related to outputs. In the example of Berwick's patient, more tests were related to changes in treatment regimens. Yet, variations in inputs may not lead to better patient outcomes. In the following chapters these issues are explored in greater detail.

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