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Understanding Health Care as a Complex System:

The Foundation for Unintended Consequences

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As the United States Embarks on health care reform, policy makers speak of using a variety of levers to control the health care system and its accelerating costs. These levers include a variety of regulations that are enforced through surveys, certifications, payments, and penalties. However, these mechanical approaches often lead to unintended consequences. This is due to the enormous complexity of the health care system—both in lay terms by its complicated design and in scientific terms by its nonlinear, dynamic, and unpredictable nature. To help guide future policies and avoid the unanticipated consequences of regulation, policy makers and physicians need to understand health care as a complex system and apply the principles of complexity science to achieve its goals.

In contrast to mechanical systems in which component parts interact linearly to produce a predictable output, the components of complex systems interact nonlinearly over multiple scales and produce unexpected results. The output of a mechanical system can be controlled by manipulating each of its parts, while the output of a complex system is dynamic, behaving differently according to its initial conditions and feedback. For example, the health care system comprises networks of components (hospitals, clinics, nursing homes, rehabilitation units, patient homes, families, and patients) that interact nonlinearly on different scales (the patient, family, medical center, and government), and often produce unintended consequences (adverse drug reactions, nosocomial infections, rehospitalizations, and functional decline).

As more regulations are created to control the behavior of a complex system, the more the system may deviate from a desired outcome.[1] Commenting on the complexity of the Australian health care system, Sturmberg et al[2] wrote that the prevailing trends to use disease protocols, financial levers, and siloed programs to manage the health care system are fatally flawed and will lead to unintended consequences. For example, pay-for-performance and value-based payment models that aim to improve hospital care at lower cost may encourage overly aggressive treatment without concern for life expectancy or adverse effects. Contrary to expectation, these models have had no effect on mortality[3] or Medicare spending.[4] Similarly, clinical practice guidelines intended to improve quality of care and reduce health care variations have not reduced socioeconomic disparities in the treatment of diabetes[5] and could increase the medication costs of patients with multiple chronic conditions.[6]

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If health care is viewed as a complex rather than a mechanical system, several of its intrinsic properties can be exploited to influence its dynamic behavior and guide it in a more favorable direction. These properties include nonlinear interactions of component parts, emergent, self-organized behavior, and the dependence on simple rules.

Nonlinear Interactions

Key to the success of a complex system is the nonlinear interactions of its components, such that its output is greater than the sum of its parts. Failure to recognize this property is unfortunately one of the deficiencies of the health care system, which has established silos of care with relatively little attention to the patient transitions and communication channels between them. The current fee-for-service system discourages sharing of responsibility for patient care between venues by limiting payment to only one service at a time. Recent capitation and bundled payment models are a promising step toward fostering shared patient care responsibility, improved interinstitutional communication, and increased operational efficiency.

Emergent, Self-organized Behavior

In complex systems, certain behaviors emerge somewhat spontaneously and are referred to as “emergent, self-organized behaviors.” There are many examples of emergent, self-organized behaviors in biological systems, including the flocking of birds, schooling of fishes, and synchronized lighting of fireflies. The brain self-organizes into neuronal networks with emergent behavior patterns such as the complex rhythmicity of walking, sleep, heart rate, or hormonal secretion. Reflecting on the history of the US system of agriculture, Gawande[7] pointed out that a complex system can transform without amaster plan. During the 20th century, agriculture changed from a disorganized, costly, and inefficient enterprise to a coherent, productive, cost-effective system of farming. This was attributable to a continuous process of experiment, measurement, learning, and encouragement. A similar opportunity now exists to allow a more functional system of health care to emerge through the various demonstrations, innovations, and waivers supported by the Affordable Care Act.

Simple Rules

Complex systems also follow simple rules that can guide them toward a common goal, or attractor. This principle is evident in physiological systems such as heart rate or standing balance whereby healthy behavior occurs within narrow limits. In the Institute of Medicine report *Crossing the Quality Chasm*, Plsek[1] described how 3 simple rules can lead to self-organizing innovation in the health care system: general direction pointing (aims), prohibitions (limits), and resources or permissions (incentives). Recent approaches to health care reform in the United States are applying these rules. The aim to improve health care, improve population health, and reduce unnecessary health care spending is now the mantra at the Centers for Medicare & Medicaid. In addition, a variety of models are being tested to reduce the increase in spending without severely restricting experimentation and choice. These include capitation, bundling, and patient-centered care. In addition, incentives such as shared savings have been introduced.

The 3-day stay rule provides an example of how the complex health care system can lead to unintended consequences and how complexity science can motivate alternative approaches. The rule was introduced in 1965 and was intended to reduce Medicare expenditures for beneficiaries requiring prolonged hospitalization by making them eligible for extended care benefits in a skilled nursing facility if they spent 3 nights in an acute care hospital. However, elderly patients with acute changes in condition that can now be diagnosed and treated in

less than 3 days do not qualify for skilled nursing facility benefits, even if they are unsafe to return home. Consequently, patients must either forgo rehabilitation or pay for it themselves. This rule encourages well-meaning physicians to assign a diagnosis code that justifies a 3-day hospital stay as a medical necessity and potentially results in unnecessary tests, treatments, complications, and costs. However, the rule has persisted because Medicare expenditures increased significantly when it was temporarily waived by the Catastrophic Coverage Act in 1988. How then might a complex systems approach avoid these consequences?

The first property of a complex system requires effective interactions among patients, families, physicians, and hospital and skilled nursing facilities staff to reach mutual objectives such as high-quality, affordable care. These objectives cannot be achieved if hospitals, skilled nursing facilities, and physician practices are reimbursed only for episodes of care, tests, or procedures that occur in one setting or another. Instead, by providing a global payment for the care of a given patient across settings, clinicians and health care centers can experiment, assess what works, and self-organize (the second property) in a fashion that may better achieve a shared objective. With shared goals and incentives in place, the 3-day stay rule could be waived, but some simple rules (the third property) may be necessary to constrain costs. These constraints could include payment limits based on the average historical costs for a similar patient or shared savings when less costly outcomes are achieved.

The US health care system will need to continue to depart from a mechanical, regulatory approach to health care policy and move toward a complex systems approach that permits creative self-organization. This may be accomplished by removing structural boundaries between health care professionals, aligning their goals, enabling experimentation, and establishing simple rules to help limit costs.

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