Building a Better Delivery System: A New Engineering/Health Care Partnership

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A Framework for a Systems Approach to Health Care Delivery

To consider how information/communications technologies and systems-engineering tools can be used to help realize the IOM vision of a patient-centered health care system, we must first understand the challenges facing the U.S. health care system (IOM, 2001). The committee has adapted a four-level model by Ferlie and Shortell (2001) to clarify the structure and dynamics of the health care system, the rough divisions of labor and interdependencies among major elements of the system, and the levers for change. A brief description of the model follows. The remainder of this chapter provides a "systems view" of health care and a brief description of the potential role of information/communications systems.

A FOUR-LEVEL MODEL OF THE HEALTH CARE SYSTEM

In this model, adapted from Ferlie and Shortell (2001), the health care system is divided into four "nested" levels: (1) the individual patient; (2) the care team, which includes professional care providers (e.g., clinicians, pharmacists, and others), the patient, and family members; (3) the organization (e.g., hospital, clinic, nursing home, etc.) that supports the development and work of care teams by providing infrastructure and complementary resources; and (4) the political and economic environment (e.g., regulatory, financial, payment regimes, and markets), the conditions under which organizations, care teams, individual patients, and individual care providers operate (see Figure 2-1).

The Individual Patient

We begin appropriately with the individual patient, whose needs and preferences should be the defining factors in a patient-centered health care system. Recent changes in health care policy reflect an emphasis on "consumer-driven" health care. The availability of information, the establishment of private health care spending accounts, and other measures reflect an increasing expectation that patients will drive changes in the system for improved quality, efficiency, and effectiveness. Overall, the role of the patient has changed from a passive recipient of care to a more active participant in care delivery.

At the same time, the fragmented delivery system, combined with the growing burden of chronic disease and the need for continuous care, have all but forced many patients to assume an active role in the design, coordination, "production," and implementation of their care, whether they want to or not. Unfortunately, most people do not have access to the information, tools, and other resources they need to play this new role effectively. Considering the roles, needs, and objectives of first-level actors—individual patients—and their interdependencies with actors at other levels of the system, opportunities abound for using information/communications technologies and systems-engineering tools to improve the overall performance of the health care system.

A starting point for increasing the "patient-centeredness" of health care delivery is changing the perspective of clinicians to consider patients and their families as "partners" and to incorporate their values and wishes into care processes. The level of responsibility patients and their families assume differs from patient to patient. Some prefer to delegate some, if not most, of the decision making to a trusted clinician/counselor in the care system; others want to be full partners in decision making. In either case, however, patients need a free exchange of information and communication with physician(s) and other members of the care team, as well as with the organizations that provide the supporting infrastructure for the care teams.

For patients to communicate "informed" needs and preferences, participate effectively in decision making, and coordinate, or at least monitor the coordination, of their care, they must have access to the same information streams—in "patient-accessible" form—as their physician(s) and care team. Information that supports evidence-based,

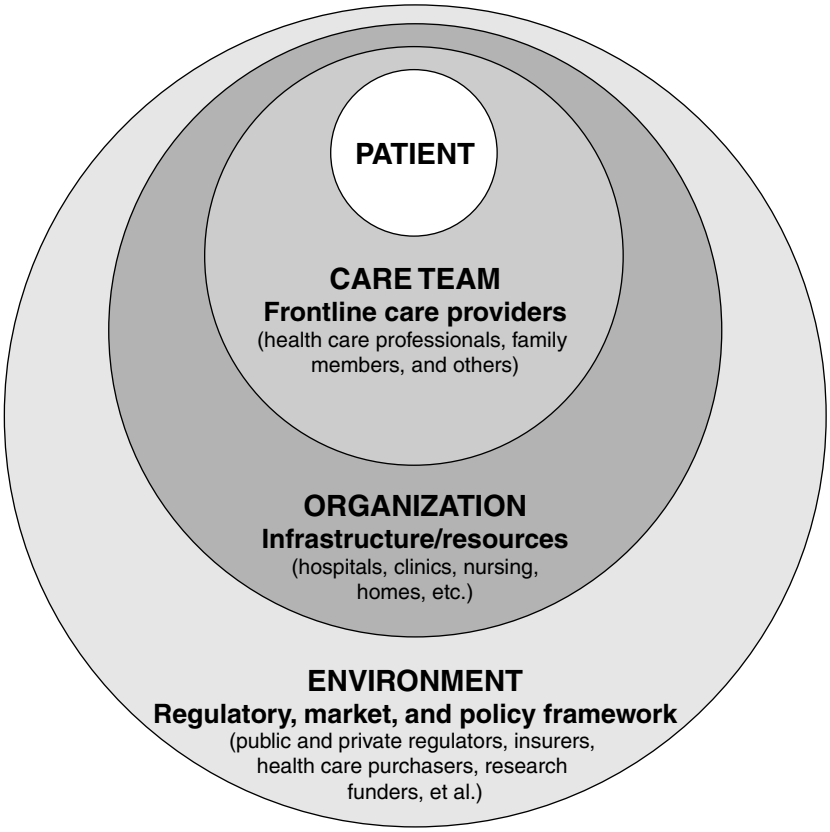

FIGURE 2-1 Conceptual drawing of a four-level health care system.

effective, efficient care encompasses the patient's medical record, including real-time physiological data; the most up-to-date medical evidence base; and orders in process concerning the patient's care. The patient and/or his or her clinician/counselor or family member must also have access to educational, decision-support, information-management, and communication tools that can help them integrate critical information from different sources.

From the patient's perspective, improving the timeliness, convenience, effectiveness, and efficiency of care will require that the patient be interconnected to the health care system. Synchronous communication between patient and physician could improve the quality of care in a number of ways. For example, continuous, real-time communication of a patient's physiological data to care providers could accelerate the pace of diagnosis and treatment, thereby reducing complications and injuries that might result from delays. Remote (e.g., in-the-home, on-the-go) monitoring, diagnosis, and treatment would make care much more convenient for patients, save them time, and conceivably improve compliance with care regimes (see paper by Budinger in this volume). Communication technologies also have the potential to change the nature of the relationship between patient and provider, making it easier for patients to develop and maintain trusting relationships with their clinicians.

Asynchronous communication also has the potential to significantly improve quality of care. The easy accessibility of the Internet and the World Wide Web should enable all but continuous inquiries and feedback between patients and the rest of the health care system (IOM, 2001). The World Wide Web has already changed patients' ability to interact with the system and to self-manage aspects of their care. One of the fastest growing uses of the these communication technologies is as a source of medical information from third parties, which has made the consumer (i.e., the patient) both more informed, and, unfortunately, sometimes misinformed.

Some of the improvements just described are available today, some are under study, and some are as much as a decade away from realization. Thus, research is still an essential component in transforming the current system.

The Care Team

The care team, the second level of the health care system, consists of the individual physician and a group of care providers, including health professionals, patients' family

members, and others, whose collective efforts result in the delivery of care to a patient or population of patients. The care team is the basic building block of a "clinical microsystem," defined as "the smallest replicable unit within an organization [or across multiple organizations] that is replicable in the sense that it contains within itself the necessary human, financial, and technological resources to do its work" (Quinn, 1992).

In addition to the care team, a clinical microsystem includes a defined patient population; an information environment that supports the work of professional and family caregivers and patients; and support staff, equipment, and facilities (Nelson et al., 1998). Ideally, the role of the microsystem is to "standardize care where possible, based on best current evidence; to stratify patients based on medical need and provide the best evidence-based care within each stratum; and to customize care to meet individual needs for patients with complex health problems" (Ferlie and Shortell, 2001). Most health and medical services today, however, are not delivered by groups or teams.

The role and needs of individual physicians have undergone changes parallel to those of individual patients. The exponential increase in medical knowledge, the proliferation of medical specialties, and the rising burden of providing chronic care have radically undercut the autonomy of individual physicians and required that they learn to work as part of care teams, either in a single institution/organization or across institutional settings. The slow adaptation of individual clinicians to team-based health care has been influenced by several factors, including a lack of formal training in teamwork techniques, a persistent culture of professional autonomy in medicine, and the absence of tools, infrastructure, and incentives to facilitate the change.

To participate in, let alone lead and orchestrate, the work of a care team and maintain the trust of the patient, the physician must have on-demand access to critical clinical and administrative information, as well as information-management, communication, decision-support, and educational tools to synthesize, analyze, and make the best use of that information. Moreover, to deliver patient-centered care (i.e., care based on the patient's needs and preferences), the physician must be equipped and educated to serve as trusted advisor, educator, and counselor, as well as medical expert, and must know how to encourage the patient's participation in the design and delivery of care.

At the present time, precious few care teams or clinical microsystems are the primary agents of patient-centered clinical care. Unwarranted variations in medical practice are common, even for conditions and patient populations for which there are standard, evidence-based, patient-stratified "best practice" protocols (McGlynn et al., 2003; Wennberg et al., 1989). Even though many clinicians now accept the value of "evidence-based medicine" and recognize that they cannot deliver evidence-based care on their own, they are many barriers to their changing accordingly: the guild structure of the health care professions; the absence of training in teamwork; the strong focus on the needs of individual patients as opposed to the needs of patient populations; and the lack of supporting information tools and infrastructure. All of these can, and do, prevent systems thinking by clinicians, the diffusion of evidence-based medicine, and the clinical microsystems approach to care delivery. Thus, tailoring evidence-based care to meet the needs and preferences of individual patients with complex health problems remains an elusive goal.

For care teams to become truly patient-centered, the rules of engagement between care teams and patients must be changed. Like individual care providers, the care team must become more responsive to the needs and preferences of patients and involve them and their families (to the extent they desire) in the design and implementation of care. Care teams must provide patients with continuous, convenient, timely access to quality care. One member of the care team must be responsible for ensuring effective communication and coordination between the patient and other members of the care team.

The Organization

The third level of the health care system is the organization (e.g., hospital, clinic, nursing home) that provides infrastructure and other complementary resources to support the work and development of care teams and microsystems. The organization is a critical lever of change in the health care system because it can "provide an overall climate and culture for change through its various decision-making systems, operating systems, and human resource practices" (Ferlie and Shortell, 2001). The organization encompasses the decision-making systems, information systems, operating systems, and processes (financial, administrative, human-resource, and clinical) to coordinate the activities of multiple care teams and supporting units and manage the allocation and flow of human, material, and financial resources and information in support of care teams. The organization is the business level, the level at which most investments are made in information systems and infrastructure, process-management systems, and systems tools.

Health care organizations face many challenges. In response to the escalating cost of health care, government and industry—the third-party payers for most people—have shifted a growing share of the cost burden back to care providers and patients in recent years. As a result, hospitals and ambulatory care facilities are under great pressure to accomplish more work with fewer people to keep revenues ahead of rising costs.

In certain respects, management of health care organizations is not well positioned to respond to mounting cost and quality crises. Compared to other industries, health care has evolved with little shaping by the visible hands of management. Historically, most leaders of health care organizations

were initially trained in medicine or public health. Moreover, except in the relatively few integrated, corporate provider organizations (e.g., Kaiser-Permanente, Mayo Clinic, et al.), the management of most hospitals faces the challenge of "managing" clinicians, the majority of whom function as "independent agents."

Less than 40 percent of all hospital-based physicians are employed as full-time staff by the hospitals where they practice, a reflection of the deeply ingrained culture of professional autonomy in medicine and the deeply held belief of care professionals that their ultimate responsibility is to individual patients. These circumstances have posed significant challenges to the authority of health care management in many organizations, often creating discord and mistrust between health care professionals and health care management. Other challenges to management include the hierarchical nature of the health professions and inherent resistance to team-based care, significant regulatory and administrative requirements (e.g., controlled substances, biohazardous waste disposal, patient privacy, safety, etc.), and health care payment/reimbursement regimes that provide little, if any, incentives for health care organizations to invest in non-revenue-generating assets, such as information/communications technologies and process-management tools.

To support patient-centered care delivery by well functioning clinical care teams or microsystems, health organizations must find ways to bridge the health care professional/delivery system management divide and invest in information/communications technologies, systems-engineering tools, and associated knowledge. Integrated, patient-centered, team-based care requires material, managerial, logistical, and technical support that can cross organizational/institutional boundaries—support that is very difficult to provide in a highly fragmented, distributed-care delivery system.

Financial investments in information/communications technologies and systems-engineering tools alone will not be enough, however. These investments must be accompanied by an organizational culture that encourages the development of care teams working with semiautonomous agents/physicians (see paper by Bohmer in this volume). "Developing a culture that emphasizes learning, teamwork, and customer focus may be a 'core property' that health care organizations . . . will need to adopt if significant progress in quality improvement is to be made" (Ferlie and Shortell, 2001). Finally, health care institutions must become "learning organizations" that are "skilled at creating, acquiring, and transferring knowledge, and at modifying [their] behavior to reflect new knowledge and insights" (Garvin, 1993).

The Political and Economic Environment

The fourth and final level of the health care system is the political, economic (or market) environment, which includes regulatory, financial, and payment regimes and entities that influence the structure and performance of health care organizations directly and, through them, all other levels of the system. Many actors influence the political and economic environment for health care. The federal government influences care through the reimbursement practices of Medicare/Medicaid, through regulation of private-payer and provider organizations, and through its support for the development and use of selected diagnostic and therapeutic interventions (e.g., drugs, devices, equipment, and procedures). State governments, which play a major role in the administration of Medicaid, also influence care systems. Private-sector purchasers of health care, particularly large corporations that contract directly with health care provider organizations and third-party payers (e.g., health plans and insurance companies), are also important environment-level actors, in some cases reimbursing providers for services not covered by the federal government.

Federal regulations influence the structure, level, and nature of competition among providers and insurers. They can also affect the transparency of the health care system by setting requirements related to patient safety and other aspects of the quality of care. By exercising its responsibility to monitor, protect, and improve public health, the federal government shapes the market environment for health care. Federal agencies, the primary sources of funding for biomedical research, influence the research and technological trajectories of health care, and, with them, the education of health care professionals and professionals in other areas invested in the health care enterprise.

At present, many factors and forces at the environmental level, including reimbursement schemes for health care services and some regulatory policies, do not support the goals and objectives of patient-centered, high-performance health care organizations or the health care delivery system as a whole. Although the federal government, the single largest purchaser of health care services, principal regulator, and major research patron, is, in many ways, best positioned to drive changes in the health care delivery system, some private-sector payer organizations and state governments are better positioned to experiment with new mechanisms and incentives for improving the quality of care and making health care more affordable (see papers by De Parle and Milstein in this volume).

A SYSTEMS VIEW OF HEALTH CARE

In Chapter 1, the health care delivery system was described as a "cottage industry." The main characteristic of a cottage industry is that it comprises many units operating independently, each focused on its own performance. Each unit has considerable freedom to set standards of performance and measure itself against metrics of its own choosing. In addition, cottage industries do not generally attempt to standardize or coordinate the processes or performance of Unit A with those of Units B, C, and so on.

Indeed, this is an apt characterization of the current health

care delivery system. Even in many hospitals, individual departments operate more or less autonomously, creating so-called "silos." Many physicians practice independently or in small groups, and ambulatory clinics, pharmacies, laboratories, rehabilitation clinics, and other organizations—although part of the delivery system—often act as independent entities. We often call this arrangement a "health care system," even though it was not created as a system and has never performed as a system.

Moving from the current conglomeration of independent entities toward a "system" will require that every participating unit recognize its dependence and influence on all other units. Each unit must not only achieve high performance but must also recognize the imperative of joining with other units to optimize the performance of the system as a whole. Moreover, each individual care provider must recognize his or her dependence and influence on other care team members (e.g., specialists in different fields, pharmacists, nurses, social workers, psychologists, physical therapists, etc.) (IOM, 2003). These are the underlying attitudes that support a systems approach to solving problems.

Changing attitudes to embrace teamwork and systems "thinking" can be extremely difficult and may encounter resistance. Nevertheless, a concerted, visible commitment by management will be necessary to achieve this new way of thinking as a giant step toward the improvements identified in *Crossing the Quality Chasm* (IOM, 2001).

Optimization

It is easy to show mathematically that the optimization of individual units rarely, and only under highly improbable circumstances, results in optimization of the whole. Optimization is determined by a variety of metrics, including the productivity of a unit, the quality of service, the use of physical resources, or a combination of all of these. Optimization of the whole requires a clear understanding of the goal of the overall system, as well of interactions among the subsystems. The whole must be recognized as being greater than the sum of its parts (Box 2-1).

A handful of health care organizations have embraced the systems view (e.g., the Veterans Administration and Kaiser-Permanente Health Care). These significant exceptions to the general rule demonstrate that the systems view is applicable to health care and could be a model for other health care organizations. The goal of this report is to identify existing tools that can be used to address problems and to suggest areas for further exploration.

In any large system that has many subsystems, achieving high operating performance for each subsystem while taking into account the mutual influence of subsystems on each other and on the system as a whole can be a daunting task. A simple pictorial description of interacting elements in a system may be helpful for understanding how the system works. However, a deeper understanding invariably involves creating a mathematical description of subsystems, their performance, and their interactions. This, in turn, requires a model, that is, an abstract representation of how the system operates (a mathematical form that can be used to analyze the system) that includes parameters that determine the performance of each sub-element of the system, as well as descriptions of interactions. The model is a tool for simulating the performance of the actual system.

The principal objective of a simulation is to ask "what if" questions and assess the impact of alternative actions on the performance of the system to determine which ones might improve overall system performance. For example, if a change is planned in the layout of a facility, a model can be used to determine if it will improve the flow of people and equipment through the facility. A model might help

BOX 2-1
Optimizing System Performance

Optimization of the performance of a large system is often attempted through the optimization of each sub-element of the system. In industry, this is commonly accomplished by creating independent "profit/loss" centers whose performance can be measured independently of the performance of all other sub-elements. Unfortunately, this procedure rarely, if ever, results in optimization of the entire system. In fact, with a simple mathematical formula, it has been shown conclusively that optimization of the whole can only be achieved by optimizing the performance of each sub-element when the parameters that determine performance are independent of each other.

For example, assume that the productivity of a health care system is determined by: (1) the number of supporting staff (*S*); (2) the number of independent physicians (*IP*); (3) the level of capital investment in instrumentation (*I*); and (4) the level of investment in information/communications technologies infrastructure (*IT*). If, and only if, *S*, *IP*, *I*, and *IT* are totally independent, can the system by optimized by optimizing the four sub-elements. Even in this simple example, however, and certainly in practice, such independence does not exist. Therefore, to optimize overall system performance, regardless of whether one is attempting to optimize for safety, customer satisfaction, cost, or for all of these simultaneously, interactions among the parameters must be recognized and included.

determine how much inventory must be kept at Station A to ensure that it can respond to an emergency in less than five minutes. A model might also reveal if a different communication system might reduce the required inventory or the best way to assign a nursing staff when 10 percent of the nurses are not available. As Alan Pritsker, the author of many treatises on large-scale system modeling and simulation, writes, "The system approach is a methodology that seeks to ensure that changes in any part of the system will result in significant improvements in total system performance" (Pritsker, 1990).

Because the health care system involves a myriad of interacting elements, it is difficult, or even impossible, for any individual to have a complete picture of the system without using special tools to perform a systems analysis. A model of the health care system must include a description of "processes," including a wide variety of activities, from nurses administering medication on the hospital floor to examinations by a doctor to laboratory tests to the filling of prescriptions by a pharmacist to follow-on visits by a nurse. The model must include the role of each process in health care delivery and its interactions with other processes in the system. But clinical elements are not the only important elements in an analysis. The interaction between administrative elements (e.g., patient check-in and billing procedures) and other processes can also significantly influence the overall performance of the system from the patient and organization's point of view. All processes must be quantitatively described to be included in the model.

Any attempt to optimize the performance of a system must take into account objectives that are difficult to quantify and that may, in fact, conflict with each other. Quantifying the quality of care, for example, can be difficult, largely because the meaning of quality varies depending on whether the patient, the health care professional, or the clinic or hospital is assessing it. Improvements in productivity may mean an increase in the number of patients that can be accommodated or a decrease in waiting time for the average patient. IOM identified safety, effectiveness, patient-centeredness, timeliness, efficiency, and equity as proper quality objectives for the health care delivery system. Systems analyses can be used to improve the overall performance of systems with multiple objectives because they include possible trade-offs and/or synergies among these objectives. In addition, potentially conflicting goals—for example, cost containment and patient-centeredness—can also be analyzed.

THE ROLE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY

Many industries have attempted to use information/communications systems in place of manual operations, such as record keeping. But information/communications systems can be used for much more than electronic record keeping. With incredible advances in computational speed and capacity and parallel advances in computer software, clinical information and communications systems can provide immediate access to information, including patient-based information (e.g., past laboratory values and current diagnoses and medications), institution-based information (e.g., drug-resistance patterns of various bacteria to different antibiotics), profession-based information (e.g., clinical-practice guidelines, including summaries of recommended best practices in various situations), real-time decision support (e.g., alerts about potential drug interactions or dosing patterns in a patient with a compromised drug-metabolism mechanism), practice-surveillance support (e.g., reminders about upcoming screening tests recommended for a patient), and population health data (e.g., for epidemiological research, disease and biohazard surveillance, notification of post-introduction adverse drug events).

Information/communications systems can also provide important information to the patient for self-treatment of diseases and enable ongoing asynchronous communication between patients and care providers. In the future, with the advent of remote monitoring devices and wireless communication systems, information/communications systems have the potential to support continuous monitoring of a patient's health status at home, rapid diagnosis by clinicians, and timely, effective therapeutic interventions in the home by the patient or a family member, with guidance by health professionals. Furthermore, by capturing process and system performance data for systems analysis, control and design, information/communications technologies can facilitate the use of systems-engineering tools by patient care teams, provider organizations, and environmental actors at all levels of the health care delivery system.

Chapter 3 provides descriptions of a large portfolio of systems-engineering tools and concepts with the potential to significantly improve the quality and cost performance of the health care system. These tools have been widely and effectively used to design, analyze, and control complex processes and systems in many major manufacturing and services industries. In Chapter 4 opportunities are described for accelerating the development and widespread diffusion of clinical information and communications systems for health care delivery that can support the use of systems tools and improve the connectivity, continuity of care, and responsiveness of the health care system as a whole.

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