Fulfilling the Potential of Clinical Information Systems

By Robert M Crane, MPA; Brian Raymond, MPH

Introduction

Since the late 1950s, health care visionaries have predicted an information technology (IT) revolution within medical care delivery—a revolution that would transform the health care industry as it had the finance and retail sectors. The early pioneers of *medical informatics*—the study and use of computers and IT in health care—formulated a vision for literally transforming modern medicine through use of clinical IT systems. Many examples exist that show how such systems support management of health care outcomes, drug interaction checking, order entry, and electronic capture of a patient's vital signs as well as clinical notes made by health care practitioners. Key advances in clinical IT can be a catalyst for early intervention in disease processes, improvement in health care outcomes and care management, reduction of medical errors, and increases in both administrative efficiency and patient satisfaction.

To date, however, the clinical IT revolution has eluded much of the US health care system, and the high expectations of past visionaries remain largely unfulfilled.

Early estimates of the time needed to realize the promise of clinical IT applications in the United States were optimistic. In 1991, the Institute of Medicine's Committee on Improving the Patient Record set a goal of making computer-based patient records a standard use of IT in health care by 2001.[1] To date, however, the clinical IT revolution has eluded much of the US health care system, and the high expectations of past visionaries remain largely unfulfilled.

Today, a few health care delivery systems have positioned themselves to overcome barriers to implementing clinical IT applications and have pioneered their use in US health care. For example, health care delivery systems such as LDS Hospital, the Mayo Clinic, Beth Israel Deaconess Medical Center, Brigham and Women's Hospital, Kaiser Permanente, and the Veterans Health Administration (among others) have successful systems in place that represent multimillion-dollar investments made over many years—or decades. However, most health care practitioners and institutions in the United States are not well positioned either financially or in terms of organizational readiness to implement the IT infrastructure necessary to deploy clinical information systems.

What is a Clinical Information System?

Clinical information system is an umbrella term that has been applied to a broad range of clinical information technology and to various configurations of clinical application components. Additional terms are used to describe information systems that support delivery of health care: *electronic medical record system, health information system, and computer-based patient record system* are a few. In the past, these systems have typically been clinically oriented, homegrown applications designed on legacy platforms and were used primarily by larger hospitals and health care provider organizations to focus on practitioners' need for information.

Use of IT applications in health care is rapidly evolving beyond what was considered a clinical information system. Clinical IT now encompasses new tools and services that are delivered or enhanced by the Internet and by other advanced networking technologies, including telemedicine, wireless handheld devices, speech recognition systems, and home monitoring devices. Many of these new products and services are both component-based and "off-the-shelf" instead of being custom-made by each end-user. As emerging IT applications are introduced into the health care industry, the term "clinical information system"—and even the current MeSH (Medical Subject Heading) term "hospital information system" used by the National Library of Medicine—becomes increasingly inadequate to describe these technologies. A new term will probably be


Robert M Crane, MPA, (left) is senior vice president and director, Kaiser Permanente Institute for Health Policy for Kaiser Foundation Health Plan, Inc. He also has executive responsibility for the Kaiser Foundation Research Institute. E-mail: robert.m.crane@kp.org.
Brian Raymond, MPH, (right) is a senior policy consultant in the Kaiser Permanente Institute for Health Policy where he analyzes emerging policy issues and supports the health policy decision-making process within KP. E-mail: brian.raymond@kp.org.

developed as this technology continues to evolve.

The commercial marketplace for clinical IT products has evolved dramatically in recent years through corporate mergers, acquisitions, and other challenges to fledgling startup companies. Cerner Corporation and Eclipsys Corporation, two vendors of clinical IT solutions, have acquired the greatest share of the market. Other major participants include Epic Systems Corporation (Madison, WI), IDX (Burlington, VT), McKesson (San Francisco, CA), Siemens Medical Solutions (Erlangen, Germany), and Meditech (Westwood, MA).[2,3] Industry analysts estimate that only 5% of the health care IT market has been penetrated, and this estimate has led to optimistic growth forecasts for vendors of clinically focused IT products as the market continues to mature.[2]

Most customers will build an initial foundation of database and data entry capabilities that are gradually supplemented with additional components, such as those featured in Table 1.[4]

A Bridge to a New Health Care Paradigm

Evidence-based medicine provides an explicit framework of scientifically validated information for medical decision making and is the cornerstone for a paradigm shift in health care. Evidence-based medicine supports implementation of cutting-edge programs for health care management and can lead to improved patient health outcomes as well as to cost-effective care. Yet, despite exponential increase in the biomedical knowledge base and revolutionary advances in technology, the health care industry continues to rely on a clinical information distribution framework that has changed little over the past century. We might call this framework the "old paradigm."

The practice of medicine has grown almost unmanageably complex. The limitations of the health care system at the beginning of the 21st Century are such that the old medical care paradigm is less viable and emergence of a new way of practicing medicine is almost inevitable. Four signs suggest that the traditional medical paradigm is not well suited for the 21st Century: nonviability of paper-based systems for supporting clinical care; increasing unreliability of medical practice that depends on human memory; business need for capturing clinical data; and increasing consumer expectations for improved health care.

Nonviability of Paper-Based Systems for Supporting Clinical Care

Paper-based information systems are not a viable long-term option for meeting the changing demands of health care delivery settings. Clinical decision making should be driven by point-of-care information accessed by providers in real time. Paper-based systems for information storage and retrieval have high failure rates[5] that can lead to duplication of service, delays in treatment, increased length of hospital stay, and increased risk of

Table 1. Components that are often featured in Clinical Information Systems

Application	Description
Practitioner order entry • Laboratory Management System • Pharmacy Management System • Diagnostic Image Management System • Referral Management System	A way to help clinicians complete clinical tasks (eg, ordering laboratory tests, prescription drugs, diagnostic imaging, consultation requests). Decision support and alerts are typically integrated into order entry capabilities.[4]
Integrated view of patient data (eg, electronic medical record)	A repository of information about patients that presents an appropriate view of patient information to health care practitioners.[4]
Documentation management	A way that uses either coded data entry or free-text input to allow practitioners to record their diagnostic, case management, and treatment actions. Such an application could collect data, such as nursing notes, physician progress notes, or even the medication administration record.
Clinical decision support	Alerts based on current data from the electronic medical record, from evidence-based practice guidelines, or from more complex artificial intelligence engines for diagnostic support and provided when the clinician assesses the patient's condition and makes ordering decisions.[4]
Administrative data	Access to administrative data (eg, admission, discharge, and transfer records; surgery schedules; demographic data; room assignments) used to track patient movement and often needed to allow accurate generation and delivery of clinical alerts and reminders.
Integrated communication support	Tools that positively affect effectiveness and efficiency of communication among team members working to improve continuity of patient care during transition between multiple clinicians.[4]
Access to knowledge resources	Online information (eg, reference materials or journal articles) used in case management of specific patients when decisions or orders are being made.[4]

medical errors caused by absence or inaccessibility of data.

Increasing Unreliability of Human-Memory-Based Medicine

Health care practitioners are bombarded with changing clinical decision factors and are challenged to stay abreast of an ever-increasing knowledge base in specific areas of expertise. New clinical practice guidelines, research findings, pharmaceutical products, and medical devices surface daily. So much information is now being published that practitioners lack time to read the latest information. In 1966, about 100 articles were published each year from randomized controlled trials; in 1995, nearly 10,000 such articles were published.[6] Current medical practice relies heavily on the unaided mind to recall a great amount of detailed knowledge—a process which, to the detriment of all stakeholders, has repeatedly been shown unreliable.[7]

IT tools can facilitate delivery of convenient, personalized care.

Capturing Clinical Data: A New Business Imperative

As costs of health care continue to rise, purchasers are increasingly impatient with the health care industry's inability to accurately account for its expenses. Now, when other industries develop extensive cost data and detailed accounting systems, the health care industry is finding it increasingly difficult to avoid responsibility for capturing clinically derived information needed for various purposes. As a growing number of provider organizations begin to offer consumers online services for scheduling appointments, refilling prescriptions, and retrieving test results, health care organizations are being subjected to market pressure to invest in clinical data capture.[8] Because disease management programs must stratify chronically ill patients by risk to achieve cost-effective outcomes, these programs are becoming increasingly dependent on clinical information systems. In addition, organizations that fail to invest in systems offering real-time access to clinical information may soon be at a competitive disadvantage when recruiting health care practitioners.

Rising Consumer Expectations for Improved Health Care and Services

Consistent with the trend toward consumerism in health care, people are looking for customized care that fits their lifestyles and health care needs. IT tools can facilitate delivery of convenient, personalized care. Technology such as the electronic patient record can give practitioners a better understanding of a patient's medical history, health status, allergies, vaccination history, and personal preferences—and this understanding may lead to more appropriate care as well as to improved compliance and clinical outcomes. As consumers learn more about clinical IT, they will appreciate its contribution to improving safety and quality of care while increasing opportunity for patients to participate in their health care in partnership with their clinicians. Like other advances in medical technology, clinical IT will raise consumer expectations of what is possible and what should be made available.

Evidence of Benefits from Clinical Information Systems

Since the 1960s, researchers from universities, health care systems, and the federal government have attempted to show the value of clinical information systems. The Kaiser Permanente Institute for Health Policy was established in mid-1999 to provide a focus and resources for Kaiser Permanente to better participate in shaping the nation's health policy agenda. Working in collaboration with foundations, policy institutes, research programs, policymakers, and other organizations, the Institute seeks to develop unbiased information about policy issues and alternatives. To better understand the body of evidence about clinical information systems, the Institute reviewed many of the published studies regarding use of information technology in delivery of health care. This review included the following highlights:

- Particularly in an outpatient setting, reminder systems and order entry systems have repeatedly been shown extremely effective for improving compliance with guidelines for preventive health and disease management.[9-11]
- Ample evidence shows that clinical information tools can improve prescription drug administration and patient safety by improving drug dosing, by reducing the number of adverse drug interactions, and by promoting more appropriate pharmaceutical utilization.[10,12,13]
- We confirmed what at least one other review of literature has found: Studies have shown that specific aspects of clinical information systems are beneficial in small-scale demonstration projects but that few studies provide compelling evidence of this benefit.[14]
- Few studies contain substantial documentation of improved productivity, efficiency, service, or major cost savings in nonclinical areas. However, studies of ad-

verse drug interactions and improved formulary usage have shown cost savings.[15]

Although the literature review suggests real promise from these systems, documenting evidence of benefits remains difficult for a number of reasons:

- Two phenomena—1) process changes associated with IT implementation and 2) human variability—complicate the process of attributing positive outcomes solely to any clinical information system.
- Because much of the research in the area has been done at individual sites on systems customized by an individual end-user, results are difficult to generalize.
- Most studies—such as that of the clinical information system at the National Institute of Health's Clinical Center—have focused on individual computerized processes in isolation;[16] few studies focus on entire care delivery systems. Clinical and economic benefits will probably be shown more easily after systems have been fully implemented and additional processes have been computerized.[17]

Roadblocks to Implementation of Clinical Information Systems

Unlike other information-rich industries, health care—the largest service industry in the US economy—has not fully benefited from the information revolution. Why have health care providers failed to migrate to clinical information technology?

Part of the answer lies in decisions regarding IT resource allocation. In the 1970s, 1980s, and 1990s, IT investments made by health care organizations focused primarily on financial and administrative systems.[12] Applications for patient registration and accounting were introduced to improve efficiency of workflow and billing processes. Avoiding the anticipated Y2K crisis occupied the health care IT agenda during 1998 and 1999. Most health care organizations postponed new IT investment and instead focused resources on preventing projected Y2K problems in financial and administrative applications.[18] Today, a variety of nonclinical IT solutions compete with clinical information technology for the scarce capital funds of health care organizations. These competing technologic applications include practice management applications, supply-chain automation, and Web-based customer relations software.

The high cost of basic infrastructure of clinical information technology is a substantial hurdle for many health care organizations, many of whose income margins have deteriorated after years of decreasing reimbursement (from Medicare and other sources) and whose access to capital for new medical technology is extremely scarce. Diversity of products as well as lack of standards and common architecture further complicate these circumstances. Financial instability and scarce capital resources for IT infrastructure similarly affect small to mid-sized independent practice associations (IPAs) and independent physician offices, the practice venues for most physicians in the United States.

Decisions regarding IT investment are often painstakingly evaluated by health care organizations on the basis of measures such as cost-per-doctor-per-month, cost-per-member-per-month, and short-term return on investment. Return on investment for a clinical information system is neither easy to measure nor necessarily the most appropriate indicator of its success. Benefits such as provider convenience, patient satisfaction, and service efficiency can substantially affect health care operations but are not easily documented as increased revenue, decreased expenses, or expenses avoided. This difficulty has made many health care organizations unable to justify major resource investment in clinical IT without either a strong business case or market forces that dictate such investment.

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Beyond resource constraints, other barriers to widespread implementation of clinical information systems exist in the United States:

- **Data security and patient privacy** (intensely and increasingly scrutinized by both the US Government and the health care industry).
- **Time and cost required to choose, buy, and implement or build a health informatics system.** In addition to explicit costs, hidden costs occur, such as initial reduction in productivity.
- **Integration of legacy systems:** Integrating legacy systems with new clinical information systems is a challenge for organizations hesitant to abandon their large IT investment.
- **Clinician resistance** (particularly if the system is counterintuitive to physicians' practice methods and preferences).
- **Lack of industry standards and interoperability** across the continuum of care in outpatient and inpatient facilities.[19]
- **Risk aversion,** particularly in this era of shrinking income

margins (when health care organizations tend to rely most on approaches with a tested track record).
- **Inability to transfer** benefits of IT implementation (because of differences in care delivery models, leadership factors, and organizational culture).

Public Policy Needed to Enable Implementation of Clinical IT Systems

In the near term, clinical IT is unlikely to be adopted widely in the absence of sound public policy. In our review of these issues we have identified four policy recommendations that deserve serious consideration:

- The federal government should provide leadership to encourage development of a standard clinical vocabulary, standards for exchange of clinical information, and other standards for interoperability. Without established standards, health care organizations will be less likely to implement information technologies because of the difficulties in sharing clinical information among providers or concerns that systems will need to be altered once standards are established.
- State and federal privacy policy should avoid establishing barriers to the legitimate development and use of clinical information technology. A balance must be found between the public's right to privacy and a clinician's ability to coordinate quality medical care in a fragmented delivery system and to perform research that broadly benefits society.
- The cost of health information technology should be shared among those who benefit from it. Public investment is needed to encourage adoption of important technologic applications.
- Research and development focused on implementing and effectively using health information technology should be encouraged and supported. Leadership dynamics, organizational issues, cultural factors, and lessons learned from clinical IT implementations need more focused study.

Conclusion

Despite modest uptake of clinical IT systems in medical practice, growing evidence shows that such technology has substantial potential for positively benefiting delivery of health care. Increasing evidence shows also that the automated medical record and other emerging tools for managing clinical information will lead to a new paradigm of evidence-based, patient-centric health care. Review of the health care literature and experience gained by various health care organizations support the conclusion that such a system can improve clinician performance, enhance clinical outcomes, and decrease medical errors. Many of these applications and the benefit they produce will probably become the "community standard of care" during the next decade and should consequently improve both patient care and patient satisfaction. Thus, health care organizations must encourage broader implementation of this technology, and policy makers must develop sound public policy that identifies and overcomes current barriers and disincentives to implementing clinical IT systems. ❖

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The Truly Wise Person

An optimist is a person who sees a green light everywhere, while a pessimist sees only the red stoplight … The truly wise person is color-blind.

— Albert Schweitzer, 1875-1965, philosopher, physician, musician, 1952 Nobel Peace Prize winner