



# Making the case for a clinical information system: The chief information officer view

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**Abstract** Adequate decision support for clinicians and other caregivers requires accessible and reliable patient information. Powerful societal and economic forces are moving us toward an integrated, patient-centered health care information system that will allow caregivers to exchange up-to-date patient health information quickly and easily. These forces include patient safety, potential health care cost savings, empowerment of consumers (and their subsequent demands for quality), new federal policies, and growing regional health care initiatives. Underspensing on health care information technologies has gone on for many years; and the creation and implementation of a comprehensive clinical information system will entail many difficulties, particularly in regard to patients' privacy and control of their information, standardization of electronic health records, cost of adopting information technology, unbalanced financial incentives, and the varying levels of preparation across caregivers. There will also be potential effects on the physician-patient relationship. Ultimately, an integrated system will require a concerted transformation of the health care industry that is akin to what the banking industry has accomplished with electronic automation. Critical care units provide a good starting point for how information system technologies can be used and electronic patient information collected, although the robust systems designed for intensive care units are not always used to their potential.

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## 1. Introduction

### 1.1. Good decisions require good information

For the chief information officer (CIO) of a health care organization, justifying the need for a clinical information system (CIS) is an easier job today than ever before, but still poses challenges. One key obstacle is nomenclature.

At its most basic level, a *CIS* may be defined as one that captures, stores, and maintains health-related patient information. However, even this simple definition can be interpreted in different ways, depending on the perspective of the health care sector that the information will ultimately serve. What is meant by a *CIS* is, in other words, in the eye of the beholder.

In discussions at the national level, the electronic health record (EHR) is a comprehensive patient-centered *CIS* that contains data from multiple care settings as well as from the patient. For example, when a patient transitions from one care setting to another, the continuity of care record (CCR) becomes the important *CIS*. The CCR is a snapshot of the most relevant information about a patient's health care

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encounter, recorded by one provider and passed on to the next provider to ensure a continuum of care. In a physician's office, the CIS is frequently called an electronic medical record (EMR); and it provides documentation of clinical activities in the ambulatory care setting. In a hospital, the CIS might be only the clinical portion of a larger hospital information system. Within each hospital department, the CIS may be named accordingly, for example, Laboratory System, Pharmacy System, Radiology System, etc. In a hospital's intensive care unit (ICU), the CIS might encompass all of the above, plus the system that captures and stores information unique to critical care.

The common thread throughout each CIS is its ability to provide important clinical information about patients to caregivers. Ideally, this includes access to comprehensive integrated information—wherever and whenever it is needed—to support good clinical decision making. One important limitation of today's typical CIS is its specificity to a single site of service, that is, each physician's office maintains its own records, as does each hospital. In most cases, the CIS, if it exists, supplements the paper chart, which is still most often the official medical record. In some hospitals, however, departmental systems are more fully integrated to present a patient-centered view of clinical information; but access to that data is usually limited to the hospital's information network. Operating in isolation from the rest of the health care delivery system, the typical CIS can only provide a fragmented picture of the patient's clinical information.

Just as in any other business, making good decisions requires good information. A more evolved definition of a CIS might invoke the concept of gathering all relevant clinical information about a patient from all components of the health care delivery system and making it available to every caregiver who needs it—at the time and point of service. This would demand a regionally, perhaps even nationally, networked CIS that is structured in a patient-centered way. Having complete and accurate clinical and patient information available to a physician in real time is expected to improve the odds that the clinical decision made is the best one for the circumstances.

As sensible an argument as this may seem, it is still insufficient justification for hospitals or health care provider organizations, as business units, to deploy their limited financial resources on a CIS. Despite the fact that many hospitals are mission driven and not for profit, they still must generate a bottom line that will keep them in good financial health. Payrolls must be met, suppliers must be paid, facility and equipment issues must be addressed, and long-term investments must be made to assure adequate capacity for future patient care. Information technology is quite costly and competes with other provider needs for scarce dollars. In physician practices and other community health care businesses, freeing resources for implementing a CIS remains a challenge. As in past years, it remains difficult in today to make a case for investing in

information technology that will stand up to internal financial scrutiny.

Despite this obstacle, many providers are considering or planning for CIS implementation. There are currently 5 forces in the external environment moving the health care community toward a patient-centered landscape of CIS design and development. These forces include the following: quality imperative, financial reality, consumerism, emerging federal policy, and regional health initiatives.

## 2. Five drivers for adopting a CIS

### 2.1. Improving patient safety: the quality imperative

The quality imperative is a major driver for adoption of a CIS. One dimension of quality, patient safety, has been a major focus in recent years. In one study of adverse drug events occurring in 2 prestigious teaching hospitals, Bates and colleagues reported that preventable adverse events occurred in 2 of every 100 admissions, each incurring an average cost of \$4700 [1]. According to the 1999 Institute of Medicine Report *To Err Is Human* [2], one of the means of preventing such adverse events is a computerized system for physician order entry that checks orders against the patient's clinical record. The Leapfrog Group, a consortium of more than 90 Fortune 500 companies intent on obtaining the best value for health care expenditures on their employees, identifies several initiatives important to the safety of patients when they are hospitalized [3]. Among their recommendations is computerized physician order entry with decision support capabilities. Adequate decision support requires accessible and reliable clinical information, and it is imperative that health care providers and administrators reach a point where patient safety is taken for granted.

Beyond patient safety, other quality-of-care measures are also addressable by the application of information technology. The 2003 Institute of Medicine Report *Crossing the Quality Chasm* makes the case to adopt fundamental changes in today's health care delivery system, instead of relying on outmoded work processes [4]. The challenge at hand is to provide safe, effective, patient-centered, timely, efficient, and equitable care to everyone. Such a fundamental change requires a strong technology infrastructure that will enable the right information to be in the right hands at the right time. A patient-centered approach will require in-depth knowledge about individuals to assure that the treatment they receive is based on their preferences and values as well as the latest clinical science. This implies availability of patients' clinical information coupled with personal health information. It also implies a level of control on the part of the patient. The 2003 Institute of Medicine Letter Report *Key Capabilities of an Electronic Health Record System* moved the CIS agenda forward another step, stressing that the core

functionalities of an EHR should be maintained by providers and that personal health records (PHRs) should be maintained by individual patients [5].

## 2.2. Investing in information technology: the financial reality

The quality of patient care in all of its dimensions relies on enabling technology, and technology requires financial resources. The health care industry is, unfortunately, arriving late to the information technology game and, according to Gartner Research [6], has been significantly underspending on information technology compared with other industries such as banking and government. The underspending has lagged behind for many years, and an expensive period of “catching up” is anticipated. On the positive side, there is growing evidence that investments in information technology can provide a financial return. The Center for Information Technology Leadership’s recent publication on health care information exchange and interoperability [7] concludes that national implementation of systems that enable clinicians to conduct standardized clinical information exchange could potentially save \$77.8 billion annually, about 5% of the \$1.66 trillion spent on US health care in 2003. The financial benefits arise from reduced resource consumption such as elimination of unnecessary tests and procedures, improved revenue collections, and productivity gains.

A major issue, however, is the question of who will reap the financial benefits. In other words, if providers make the investment, will they capture any portion of the return? According to a joint report by the Massachusetts Technology Collaborative and the New England Health-care Institute [8], the reality may be otherwise. Benefits do not consistently accrue to the providers who make the investment; rather, profits may surface only when the health care system is considered as a whole. The scenario begins with insurers being responsible for lower claims payments as physicians avoid duplicating tests. Self-insured employers would realize the same benefit. Patients without insurance would pay less for the care they need. Thus, it seems as though the payers of health care have the most to gain financially, despite the fact that information technology investments are frequently made by the providers of health care. The financial reality requires collaboration to align incentives so that those who make the investment receive an adequate return on that investment. Conversely, those who receive the financial benefit must participate in the investment.

## 2.3. Consumerism and the role of CIS

Traditionally, health care consumers have been only peripherally involved in the decisions that affect the quality and efficiency of their treatment, although this is likely to change. The National Governors Association Center for Best Practices, for example, presented a white paper at the

2005 winter meeting proposing 5 demonstration projects aimed at improving the cost and quality of health care [9]. One of the 5 seeks to empower consumers to participate in decision making about their health by providing them with information on best clinical practices, disease management, and cost and quality of health care providers. The paper acknowledges that such consumer-centered care will require robust information technology.

Health care consumers have not, as yet, been an active force in demanding the sorts of increased efficiencies that would result from the adoption of CIS technologies. Two important components of consumerism are payment for services and judgment about value received for dollars spent. Health care services are unusual in that the consumers of services (the patients and their families) have not been the principal payers for those services. Most employed people have employer-paid, or at least employer-subsidized, health insurance. Those older than 65 years have health insurance from Medicare. Medicaid provides health insurance for the poor and disabled. However, this arrangement is changing. The Medicare Prescription Drug, Improvement and Modernization Act of 2003, for example, created the new health care financing option of health savings accounts (HSAs). Such accounts are coupled with high-deductible health insurance plans. Consumers with high-deductible plans can contribute tax-free savings to an HSA up to the deductible amount, subject to a cap. Withdrawals to cover qualifying health care costs are not taxable. Unspent HSA savings roll over from year to year. The result is that in each period, the first health care expenditures will be coming from consumers’ pockets, providing an incentive to minimize those costs because any money spent will be their own.

As in any other industry, informed consumers spending their own money will be likely to search out value, that is, obtain the best product for the lowest cost. When consumers are paying their own way, will they patiently wait for a physician to return a phone call? Will they hold for minutes when trying to schedule an appointment? Will they be understanding about the incorrect meal being delivered in a hospital? Will they tolerate an error in their care? Will they continue to accept the current fragmented health care system where each of their health care providers repeatedly asks for the same information and repeats the same tests? It is more likely that patients as consumers will expect a high degree of service, efficiency, and quality of care that can only be provided by a well-organized, collaborative health care delivery system—one enabled by clinical data sharing.

## 2.4. A challenge from Washington: emerging federal policy

This theme of collaboration among stakeholders in the health care system is also evident in the next driver, emerging federal policy. In the January 2004 State of the Union Address, President Bush set out a challenge to have EHRs for Americans within 10 years. He followed up later

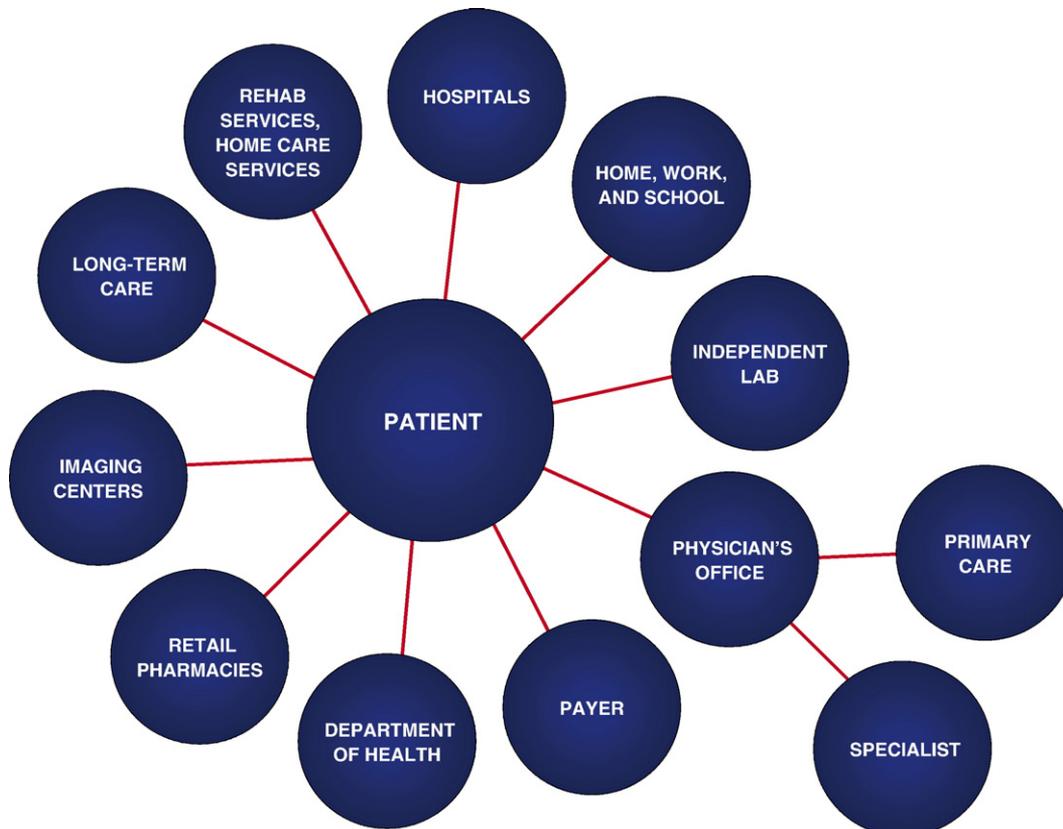
**Table 1** Key capabilities of an EHR system [5]

1. Patient health information and data, including basic information such as allergies, medications, recent tests, a problem list, immunizations
2. Results management for all types of tests
3. Order entry/management, especially for medications, both in an inpatient setting and at the retail pharmacy level, with interaction checking
4. Decision support to assist with detection of adverse events and identification of disease outbreaks and to provide proactive advice for preventive measures
5. Electronic communication and connectivity, specifically, electronic interfaces for the exchange of clinical data among care partners to provide access to integrated health records across institutions and across care settings
6. Patient support, including patient education and home monitoring
7. Administrative processes such as electronic scheduling systems, authorization and prior approvals, validation of insurance eligibility, eligibility for clinical trials, billing and claims management, tools to support drug recalls, and methods to support chronic disease management
8. Reporting and population health management with improvement in the accuracy of reported key indicators

in 2004, creating the Office of National Coordinator for Health Information Technology and appointing Dr David Brailer as its leader. Doctor Brailer initiated a framework for

strategic action, *The Decade of Health Information Technology: Delivering Consumer-Centric and Information-Rich Health Care* [10]. This framework outlines 4 main goals of a new vision of technology-enabled health care delivery (Table 2, definitions).

The first goal, to inform clinical practice, addresses the need to align financial incentives and share the investment required to implement EHRs. It acknowledges the disruptive nature of this technology and the resultant risk to the provider community. It also recognizes that there are underserved areas in this country and targets them for inclusion in the EHR solution. The second goal is to interconnect clinicians. The strategy for this goal is to encourage development of regional collaborative ventures that will have local leadership and reflect local priorities. These regional health information organizations (RHIOs) will ultimately interconnect to form a National Health Information Network that will facilitate secure movement of data among clinicians. The third goal is to personalize care. The strategies envisioned to achieve this goal include PHRs customized to and by patients, tools to enable more informed consumer choice, and technologies that reach out to underserved consumers and clinicians in remote areas. The fourth goal is to improve population health. Achieving this goal would require developing better tools for disease surveillance, creating a data infrastructure that provides timely and accurate monitoring of care quality and



**Fig. 1** Interconnecting caregivers in an RHIO. Courtesy of Lifespan, March 2005.

health status, and accelerating the dissemination of research so that the time from discovery to wide availability of best practice is shortened.

The first goal, to inform clinical practice through widespread adoption of EHRs, is especially pertinent to justification of a CIS. Although there is much work to be done to complete the definition of an EHR, 8 core functionalities have already been defined (Table 1, key capabilities of an EHR system) These functionalities will cover the collection of patient data, test result management, medication order entry/management integrated across inpatient and retail pharmacies, clinical decision support analysis, interinstitutional and interservice connectivity, patient support services, administrative tools, and a public health/quality monitoring and reporting component.

The CIS operating at any one provider location will provide one portion of available information for a patient. If, however, any provider fails to participate, the value of the information as a whole may be diminished because it will be incomplete. Assuming that the barriers to widespread adoption of such a CIS can be overcome, it is important to understand how systems from various locations can be joined to form a complete, patient-centered CIS. This issue is addressed in Dr Brailer's second goal, interconnecting clinicians, which leads to the fifth driver for the adoption of CIS, regional health initiatives.

## 2.5. Interconnecting clinicians: regional health initiatives

If the goal is to break down barriers and share clinical information among caregivers, the challenge begins at the local level and reflects local priorities. The RHIOs will foster the development of data-sharing capabilities. The exact requirements for RHIOs are still under development, but some basic concepts are pertinent and worth articulating. First and foremost, the focus must be on the patient. No one provider comprises the entire health care system, no matter how large and how dominant the provider is in a region. All providers are a part of a larger health care system, and collaboration by all parties is essential to create a complete picture of patient health records. Fig. 1 illustrates key health care system interconnectivities (Table 2, definitions).

Already, local health care leaders are focusing on local priorities and striving to meet the challenge that was set out by President Bush and Dr Brailer to begin at the regional level to build the National Health Information Network that will enable EHRs for Americans. There are 5 states (Colorado, Indiana, Rhode Island, Tennessee, and Utah) [11] that have received contracts from the Department of Health and Human Services Agency for Healthcare Research and Quality to establish capabilities to share clinical information among the members of their health care community. These states will be evaluating the effectiveness of their efforts and reporting what they learn. Other initiatives are also in progress across the country.

As these projects get under way, there is much discussion about what patient centricity and regional sharing of clinical information may imply. First, consumers are of course concerned about the privacy and security of their personal information. Second, access to this information has implications for the patient-physician relationship. And third, there are issues of the preparedness of physician practices to participate in data sharing.

A patient's right to privacy is protected today by state and federal laws that prohibit the widespread sharing of clinical information about a patient without patient consent (ie, the Health Insurance Portability and Accountability Act of 1996). As a network is created that enables sharing of clinical information to an extent greater than that at present, patients will need to decide if they want to participate in sharing their clinical information. If they do consent, they may also determine which physicians can see their information and what information they can see. This raises some procedural (and technical) questions. To what extent should the patient control access? Should all the data for everyone be made sharable? Or should data be made sharable only with the patient's approval? In any event, it is possible that fear of privacy violations or security risks may inhibit patients from consenting to a widespread electronic sharing of their clinical information [12].

Clinical data sharing is a critical component of the patient-physician relationship. That relationship is likely to change when physicians are able to obtain clinical information from a regional or national source. The physician and patient will need to adopt mutual agreements about clinical information sharing. Physicians may not wish to share all the information they have with their patients and vice versa. Both may impose constraints on what they are willing to share with other caregivers. These issues may require compromise and will certainly require planning.

How well prepared will physicians be to engage in widespread sharing of clinical information with patients and other caregivers? Because many physician practices have little investment in information technology in their offices and rely on paper records, the process could be very disruptive. Without an electronic patient medical record, it will be difficult for physicians to share information with others electronically. Likewise, it may not be practical for physicians to incorporate external sources of electronic clinical information into a paper chart. Even if there is an EMR in the office, the external information may not be useful if it is not integrated or compatible with their electronic records and office workflow. Perhaps it will be helpful enough to know that other data exist elsewhere so that these can be requested. All of these issues are expected to be resolved at the local level.

As health care providers contemplate an external environment that soon will have powerful forces compelling action for change, they must reflect on the local priorities applicable to their region. The imperative for quality of care, particularly patient safety, cannot be ignored. The financial

**Table 2** Definitions

Term	Definition	Source
CCR	The <i>continuity of care record</i> is a snapshot of the most relevant information about a patient's health care. It is prepared by a provider at the conclusion of an encounter to prepare the next provider to care for the patient.	ASTM International Technical Committee E31, <i>Continuity of Care Record (CCR) Standard: An Overview</i> , <a href="http://www.astm.org/cgi-bin/SoftCart.exe/COMMIT/COMMITTEE/E31.htm%3FL%2Bmystore%2Brdho7265%2B1068163988">http://www.astm.org/cgi-bin/SoftCart.exe/COMMIT/COMMITTEE/E31.htm%3FL%2Bmystore%2Brdho7265%2B1068163988</a> , September 17, 2004.
EHR	Key capabilities of an <i>electronic health record</i> : 1. Person-centric longitudinal collection of health information, ie, information about the health or health care provided to the individual. 2. Immediate electronic access to person and population health information to authorized individuals only. 3. Knowledge and decision support for improvements in quality, patient safety, and efficiency of care. 4. Support of process improvements for delivery of health care.	Committee on Data Standards for Patient Safety, Board on Health Care Services, Institute of Medicine, <i>Key Capabilities of an Electronic Health Record System, Letter Report</i> , July 2003, <a href="http://www.nap.edu">http://www.nap.edu</a> , copyright 2003, The National Academy of Sciences, The National Academies Press, Washington, DC.
EMR	An <i>electronic medical record</i> is a computer-based health care information record designed to meet the needs of ambulatory care. Major medical record components: Demographics Medical history Current health data, encounters, health risk Appraisal Encounter—progress notes Problem lists Clinical practice guidelines Care plan Prevention Patient education Alerts Orders Results Medications	Bureau of Primary Health Care, Health Resources and Services Administration, US Department of Health and Human Services, <i>Functional Requirements for EMR Systems</i> , version 5.2 9.17.2004, <a href="http://bphc.hrsa.gov/chc/emrspecs.asp">http://bphc.hrsa.gov/chc/emrspecs.asp</a> .
Framework for strategic action	Strategic framework includes 4 goals, each with 3 strategies: Goal 1: Inform clinical practice. Strategy 1: Incentivize EHR adoption. Strategy 2: Reduce risk of EHR investment. Strategy 3: Promote EHR diffusion in rural and underserved areas. Goal 2: Interconnect clinicians. Strategy 1: Foster regional collaborations. Strategy 2: Develop a national health information network. Strategy 3: Coordinate federal health information systems. Goal 3: Personalize care. Strategy 1: Encourage use of PHRs. Strategy 2: Enhance informed consumer choice. Strategy 3: Promote use of telehealth systems. Goal 4: Improve population health. Strategy 1: Unify public health surveillance architectures. Strategy 2: Streamline quality and health status monitoring. Strategy 3: Accelerate research and dissemination of evidence. This strategic framework will guide efforts to develop an IT strategic plan for widespread adoption of health information technology across the nation.	Thompson, TG and Brailer, DJ, <i>The Decade of Health Information Technology: Delivering Consumer-Centric and Information-Rich Health Care, Framework for Strategic Action</i> , July 21, 2004, Office for the National Coordinator for Health Information Technology, Department of Health and Human Services, and the United States Federal Government.

(continued on next page)

Table 2 (continued)

Term	Definition	Source
PHR	A <i>personal health record</i> is a health record that is initiated and maintained by an individual. It includes information provided by the individual and may also include information provided by others, such as health care professionals. Ideally, it provides a complete and accurate summary of the health and medical history of an individual by gathering data from many sources.	<a href="http://en.wikipedia.org/wiki/Personal_health_record">http://en.wikipedia.org/wiki/Personal_health_record</a>
RHIO	<i>Regional health information organizations</i> foster regional collaborations: <ol style="list-style-type: none"> <li>1. Develop, implement, and apply secure health information exchange across care settings.</li> <li>2. Local leadership, oversight, fiduciary responsibility, and governance.</li> <li>3. Reflect local health care priorities.</li> <li>4. Legitimate and trustworthy to clinicians and consumers.</li> </ol>	Thompson TG, and Brailer DJ, <i>Framework for Strategic Action</i> , US Department of Health and Human Services, Office of the National Coordinator for Health Information Technology, July 21, 2004, <a href="http://www.hhs.gov/healthit/framework.html">http://www.hhs.gov/healthit/framework.html</a>
NHII	The <i>National Health Information Infrastructure</i> is a set of technologies, standards, and applications that support communication and information to improve clinical care, monitor public health, and educate consumers and patients. RHIOs make up the components of the NHII.	The National Committee on Vital and Health Statistics Workgroup on the National Health Information Infrastructure, June 2000, <i>Toward a national Health Information Infrastructure</i> , <a href="http://www.ncvhs.hhs.gov/NHII2kReport.htm">http://www.ncvhs.hhs.gov/NHII2kReport.htm</a> , September 21, 2004. Also: <a href="http://aspe.hhs.gov/sp/NHII/">http://aspe.hhs.gov/sp/NHII/</a>

reality is that the needed investment in health care information technology has a significant payoff if incentives are aligned such that those who invest are able to reap the benefit. New proposals encouraging consumers to take a more active role in their health care are emerging. Pressure is emanating out of Washington to create a national health information network. Some limited funding is available in some geographic areas for regional health initiatives to take root. The 5 forces are moving the agenda forward toward adoption of the CIS to improve the quality of patient care.

In this environment, there are 2 categories of projects that individual health care providers might consider: systems inside their institutions and systems for sharing with other participants in the health care delivery system. The first category involves getting their own houses in order. Physicians whose offices lack automation might consider an EMR system. Hospitals might focus on completing systems implementations that can document care and address patient safety issues in each of its departments. Other caregivers might do the same. A health care provider who does not have automated systems will not be able to participate in a health care delivery system dependent on the sharing of electronic patient-centered clinical information. At any rate, the components of the EHR are now defined. Some elements can and should be built within an individual provider's institution, and some can be achieved only by the ability to share information with other providers.

After tending to basic infrastructure for information technology in their own places of business, the second type

of project becomes feasible. Health care providers compelled by the 5 environmental forces for change—patient safety, financial return, consumerism, national initiatives, and regional initiatives—might develop a CIS that is capable of sharing patient-centered clinical information within the community. This would require that available data be based on the patient rather than the site of service.

## 2.6. Building hospital information networks: the example of critical care

The hospital, as part of the regional health care system, must be concerned about continuity of care. When the patient arrives at a hospital, the information necessary for proper care must be obtained from the patient's other caregivers within the region. When the patient is discharged, sufficient information must be provided to the patient and to the caregivers providing follow-up care.

In critical care, clinical decision support has become essential to providing the highest quality of patient care. The most active use of sophisticated biomedical equipment is found in a hospital's ICU, with high-tech devices that monitor the patient's condition and regulate the application of therapy. These devices are also a rich source of information, which if made available to the clinicians in the right circumstances have the potential to change patient outcomes. Although there are robust information systems designed for use in ICUs that take into account the data output from biomedical devices, they are not widely used to their potential. Barriers to

adoption manifest themselves in 2 ways. First is cost: systems designed for critical care are generally more expensive than other departmental systems. The high cost can be attributed in large part to their design, as critical care systems tend to be proprietary rather than open, designed to run stand-alone rather than integrated with other departmental and hospital systems. Proprietary networks and special hardware are sometimes necessary. In today's world of emerging health care standards and the growth of open systems, this may be perceived as a problem with the quality of the software. In the future, vendors of critical care systems will need to be more collaborative in designing products that are capable of integrating with other sources of clinical information.

Today's ICUs do not operate in isolation. Rather, they are serviced by all of the other departments in a hospital, such as laboratory, radiology, pharmacy, cardiology, oncology, dietary, social services, and others, all of which generate substantial information about the patient during their ICU stay. Only if this information is made available to the clinicians caring for the critically ill patient in the most timely manner will outcomes be improved. For example, a timely laboratory result can expedite a change in medication; or a timely radiology result can help expedite treatment or avoid unnecessary treatment. Nor can the hospital as a whole be isolated; it must operate as part of a community that includes other hospitals, primary care and specialty

physicians, long-term care facilities, pharmacies, stand-alone surgery centers, laboratories and imaging centers, public health administrators, and others. If one accepts the idea that good decision making requires having all of the relevant information and knowledge available at the time the decision needs to be made, then it follows that good clinical decision support requires that all relevant information be available to the clinicians caring for a patient in the ICU.

In addition to caregivers, 2 other parties are poised to benefit from the availability of the right information at the right time during delivery of critical care. First, it is the payers. Systems designed to improve and extend the productivity of intensivists by providing tools and decision support to enable remote monitoring of patients have demonstrated a financial return at the Sentara Health System [13]. It is striking that this financial return has captured the interest of the health insurers in some markets to the extent that they are participating in paying for the system, according to comments received from vendors and one customer. This is validation from the payer that the hospital, indeed, does not gain the lion's share of the financial benefit of the investment in such a system. Rather, it indicates that the party who does benefit is willing to invest.

Of course, it is ultimately the patient and their family who benefit by receiving better care and achieving a better outcome. If we accept this belief, then we must place the



Fig. 2 Interconnecting caregivers within the hospital. Courtesy of Lifespan, March 2005.

patient, rather than the place of service, at the focal point of the information-gathering process. To do so requires taking, as a starting point, a view of CIS that spans beyond the ICU. Fig. 2 illustrates this concept for a hospital.

In such a hospital, the ICU also focuses on the patient and recognizes the need for information to facilitate providing the best patient outcome. Such an ICU might be a paperless and wireless environment where information is available from many sources, including directly from patient monitoring equipment in real time. Fundamental to good decision making is having all the relevant information available at the time the decision is made, which means supporting the decision with knowledge bases and systems such as computerized physician order entry and automated medication administration. In such an ICU, the information can be used both actively and passively to prevent errors of omission as well as errors of commission. This convergence of biotechnical equipment and information technology can provide real-time alerts on a patient's condition by automating analysis of data from patient monitoring equipment.

Decision support as a tool for improving the quality of health care has different aspects. At its most fundamental, decision support is a passive tool. This is the situation when information is simply available and facilitates the clinician making an informed decision. Decision support is an active tool when it interacts with the workflow of the clinician and intervenes at opportune times to inform and advise. As an active tool, decision support can prevent errors of both commission and omission. The opportunity to prevent an error of commission occurs as the result of a clinician's action. An example of an error of commission is administering an incorrect dose of a drug. Preventing the error is triggered by the act of electronically checking, at the time of medication administration, that the drug is the correct one for the patient and that it is the correct dose, the correct route, and the correct time. The opportunity to prevent an error of omission occurs when an action that has not taken place, but should have taken place, is detected [14]. Rules engines provide an opportunity to prevent errors of omission. Prevention of errors of omission may be synchronous, that is, happening at the same time, or asynchronous, that is, not dependent on specific timing. An example of a synchronous rule is the following. The physician has opened the patient's electronic chart and is preparing to enter medication orders; the rules engine can advise that allergies have not yet been entered to the system and thus potentially prevent an allergic reaction. An example of an asynchronous rule is the detection of a failure to prescribe an antibiotic for a patient with a high temperature. Preventing the error requires surveillance of the patient's temperature and notification to a caregiver that administration of an antibiotic is indicated. There are information systems designed for the critical care environment that provide asynchronous decision support. They continuously monitor a patient's vital signs using algo-

gorithms to detect changes that signal a problem and alert clinicians to the fact. The key to good decision support is that it is useful in the care of the patient. Trivial rules that are perceived as a nuisance by clinicians are to be avoided. All rules should be specifically approved by clinicians before implementation.

### 3. Conclusion

#### 3.1. Transforming the health care business

Caregivers need complete and accurate clinical information to make the best decisions about a patient's care. Numerous research studies tell us so, business groups such as Leapfrog Group tell us so, federal and state agencies tell us so. Perhaps patients are also beginning to tell us so. There are powerful forces moving toward electronic exchange of health care information, and they are the same forces that have been at the core of other business transformations, such as banking. They include the quality of the product (in this case, health care), the financial return, increased consumerism, and compliance with federal and state direction.

Of these forces, perhaps the most subtle but most compelling is consumerism: protecting and empowering patients. Patients and their families expect the care they receive to be safe. That goes without question. If an organization does not invest in the basic technology known to prevent errors, an informed patient will not seek care there. As families are expected to pay more of their health care costs in co-pays and deductibles and as withdrawals from HSAs, they will have a higher regard for service and quality and will seek care from those organizations that they perceive to be the best. As the federal government leads the country in a discussion of patient-centered EHRs, patients will have an expectation that their clinical information will really be available to them, securely, wherever they go, just as their money is available to them wherever in the world there is an automated teller machine. As regional initiatives take hold and patients become accustomed to having their prescriptions electronically transmitted from their physician's office to their local pharmacy, where they find their medication waiting for them upon arrival, they will soon be wondering why they cannot communicate themselves, electronically, with their physician. It may be that health care providers will soon find it in their own best interests to move toward adoption of health care automation. The forces propelling such action are strong, and providers may soon see that the changing health care landscape requires a CIS as a cost of doing business, especially as financial incentives come into alignment. Some will lead and some will follow, but the destination is there for all to see.

The role of the CIO has changed with regard to CIS. The argument is no longer about whether we should invest in them. It is now about where to start, how to pay for it, how to select it, and how to implement it. As the focus is placed on the needs of the patient—what the needs are now and

what they might be in the future—the picture of the future becomes clear. An empowered patient will expect to receive notification of their laboratory test results online, will expect to use secure e-mail to converse with their physician, and will expect to make appointments and pay bills over the Internet. The CIO must be the patient advocate for such services within the health care organization and then help make it happen. It all depends on good CIS in all components of health care delivery.

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