
Development and Implementation of an Information Management and Information Technology Strategy for Improving Healthcare Services: A Case Study

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ABSTRACT

PeaceHealth is a multistate, not-for-profit integrated delivery network that owns and operates five acute care hospitals, one critical access hospital, and twenty-five outpatient clinics. PeaceHealth employs approximately two hundred physicians and seventy allied health professionals; it has relationships with one thousand affiliated physicians.

In 1990, PeaceHealth developed a set of strategic priorities for delivering seamless care across the continuum, and creating partnerships between caregivers and patient-consumers. A major component of these strategies was development and implementation of the technology, knowledge, organizational, and community infrastructures that would support delivering and using high-quality, timely information when and where it is needed for effective clinical, operational, and financial decision making.

Executing this strategy has resulted in implementation of standard enterprisewide information systems, including a computer-based patient record system in inpatient and outpatient settings, tactical and strategic decision support systems, a well-developed intranet and access to the Internet, and a knowledgeable workforce that have enabled PeaceHealth to support and improve its services and business by bringing interactive information directly to patients, caregivers, managers, directors, and executives.

This case study discusses the drivers behind the development of this strategy, specific components of the information management and information technology infrastructure, examples of the impact they have had on patients, caregivers, and the organization, and lessons learned.

KEYWORDS

- E-health
- Information management
- Internet healthcare

E-health is a term being used with increasing frequency in the healthcare industry. Interestingly, it has come to mean different things to different people. In fact, the question many people ask is “What does e-health encompass?” During the past five years, many articles and reports have been written about e-health, and numerous presentations have been given at national meetings. Historically, the majority of these articles and presentations have focused on how use of the Internet does, or will, affect delivery of healthcare. In addition, the initial focus of these articles and presentations was on the business aspects of healthcare (“e-commerce”).¹⁻⁵ Over time, the focus has remained on use of the Internet; however, it has evolved to include discussions about the role of the Internet and how it is being used to directly improve clinical care, and communication between caregivers, patient-consumers, and payers.⁶⁻¹⁰ This includes caregiver and patient-consumer access to individual patient clinical information; communication between patient-consumers and individual caregivers or healthcare organizations via e-mail; performance of clinical care activities, such as prescription refills, by means of the Web; and access by caregivers and patient-consumers to healthcare knowledge sources, including online textbooks, journal articles, and population-based outcomes data.

Although the Internet has significantly affected the processes of healthcare delivery, it is only one of the tools we are using in “digitizing” and improving the management of healthcare information. Therefore, in our opinion, it is important to broaden the definition of e-health to include other technology, in addition to the Internet. For the purposes of this article, we propose to define *e-health* as the application of all forms of information and telecommunications technology to achieve the goal of improving management and use of information in support of clinical, operational, and financial processes and decision making, and improvement of the delivery of healthcare services and the associated clinical, satisfaction, functional, and financial outcomes. In the context of this definition, this article presents a case study describing how a medium-sized health system has used e-health to support delivery and continuous improvement of healthcare services to the communities the organization serves.

Background

PeaceHealth is a multistate, not-for-profit integrated delivery network that owns and operates five acute care hospitals, one critical access hospital, and twenty-five outpatient clinics. PeaceHealth employs approximately two hundred physicians and seventy allied health professionals; it has relationships with one thousand affiliated physicians. In 1990, PeaceHealth (then known as the Sisters of St. Joseph of Peace Health and Hospital Services) clinical and operational leaders from across the organization and the corporate board developed and approved a "Template for the Future." The stated objective of the template was "to meet the needs of the communities PeaceHealth serves through an integrated approach to healthcare delivery, involving effective, collaborative relationships with physicians and other healthcare providers; providing a broad continuum of services; and addressing consumer and payor demands."

The trends in the healthcare industry that led to PeaceHealth's decision to develop the template and its associated strategies existed in 1990 and continue today. They include the growth of market-driven healthcare, rising consumerism, mass customization of medicine, internal and external restructuring of healthcare delivery systems and payment methods, increasing sophistication in information technology (IT), and the digitization of information.¹¹⁻¹⁵ The factors that have led to development of these trends in healthcare include changes in the demographics of people seeking healthcare services and the epidemiology of the reasons people are seeking care, recognition of "preventable" medical errors,¹⁶ studies documenting marked variation in care and "unnecessary" care,¹⁷ emphasis on wellness, a transition to evidence-based medicine, trends toward self-care and shared decision making, emerging accreditation requirements, federal and state regulations, quality standards (for example, the Joint Commission on Accreditation of Healthcare Organizations' Oryx, the Health Care Financing Administration's Outcome Assessment Information Set or OASIS, the National Committee for Quality Assurance's Health Plan Employer Data and Information Set or HEDIS, and provider profiling or report cards), and economic factors such as changes in entitlement programs.^{18,19} The impact of these trends and the drivers behind them was, and still is, an increase in demands on the healthcare industry to manage and improve access to care, manage and improve processes and outcomes (clinical, functional, financial, and satisfaction) of care, manage and reduce the costs of care, and improve access to and the quality of information for all stakeholders in healthcare delivery processes. The strategic priorities that evolved from the Template for the Future were designed to enable PeaceHealth to meet these demands.

The core strategies are regularly revisited to ensure their appropriateness, as healthcare delivery trends and demands evolve. The process of revisiting and continuously reprioritizing the strategies in PeaceHealth has been

evolutionary over the last ten years. Five years ago, PeaceHealth adopted an approach to strategic planning called “operational planning.” It is based on a combination of Hoshin planning and quality function deployment. The PeaceHealth operational planning process is designed to support continued pursuit of achieving the goals laid out in the Template for the Future. People from all levels of the organization contribute to the annual planning process, from frontline workers to managers and CEOs.

One of the core strategic priorities articulated in the template was to “provide good quality data to patient-consumers, physicians, other caregivers, and payors, through the implementation of standard, corporate-wide information systems.” The PeaceHealth strategy for providing good quality data has evolved from an approach of managing information technology to one of managing information as a key asset of the organization. The information management (IM) strategy includes a focus on Internet usage to deliver information and communicate with all stakeholders in delivering PeaceHealth’s services. The strategy of information management differs from a purely technology-centered (traditional) approach in that it is “process-centered.”

The process-centered approach is broader than the technology-centered approach because it expands the focus to include the people, processes (including workflow), organizational structure, governance, and technology required for ensuring the quality of information and producing, capturing, storing, integrating, maintaining, delivering, and using it.²⁰ The process-centered approach is driven by the business goals and strategic initiatives of the organization. Thus, information management can be defined as “the systematic approach to assessing and addressing the information needs (not limited to computerized information systems) required to enable an organization’s business strategy and optimally support its core processes, by designing and implementing the roles, processes, and systems that facilitate the collection, flow, and use of information within the organization.”²¹⁻²⁴ In the case of healthcare organizations, the way in which information is managed must support easy access to high-quality care at “reasonable” costs, while maintaining and improving the operational performance and financial viability of the organization. The process of IM planning is a continuous cycle:

1. Assessing business goals, the processes required to achieve them, and the information needed to support them
2. Assessing the strengths and weaknesses of current processes, roles, and systems with respect to providing the information (gap analysis)
3. Creating, reviewing, prioritizing, and implementing strategies for filling the gaps between the needs and the current capabilities

Three concepts that are integrally related to information management and the process of strategic IM planning are the information value chain, the corporate information factory, and information quality. The information value

chain, as defined by Larry English, is “the entire collection of processes and computer applications that create, update, extract, interface, and transform data, thus facilitating its final retrieval and presentation as information to the knowledge workers.”²⁵ The information value chain begins by taking data and turning them into information. The next step is for knowledge-workers to apply their knowledge to the information and draw conclusions. These conclusions are used to make decisions. The decisions are used to drive actions, and the actions ultimately have an impact on the outcomes.

Supporting the information value chain (that is, managing information as a product) requires four primary components:

1. Understanding the information consumers' needs
2. A technical information systems infrastructure
3. Planning, developing, and implementing processes (including education for producers, custodians, and consumers of information) for managing the flow and use of information
4. Planning, developing, and implementing a program for monitoring and continuously improving the quality of information^{25–27}

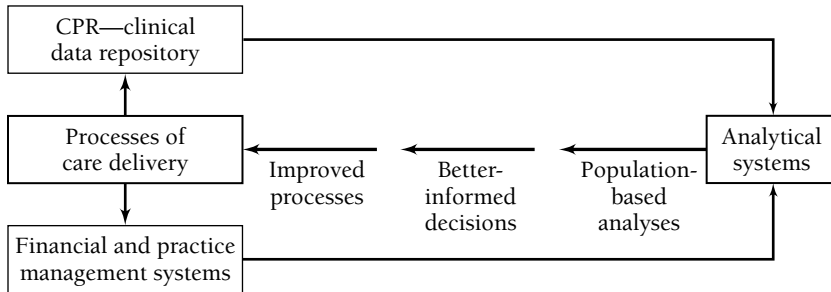
We believe the corporate information factory as described by Inmon, Imhoff, and Sousa²⁸ is a robust conceptual framework that can be used to describe the technical infrastructure required to support the information value chain. The components of the factory include applications (transaction systems), a data integration and transformation layer, a data warehouse, one or more data marts, operational data stores (ODS), metadata, and a communications infrastructure (local area network or LAN, wide area network or WAN, the Internet, and an intranet). The information factory also includes integration of external data with an organization's internal data. The information factory uses the raw material (data), turns that material into the finished product (information), and delivers it to the people who use it in their daily work. Thus it creates a foundation for information delivery and decision-making activities. Building the information factory is an iterative process. It must be built in the context of the people and processes it will be used to support.

Although it is true that information is a strategic resource for most industries and it is essential to have a mature and widely deployed technical infrastructure that facilitates use of the information, without people to use it information has no value. Therefore, in addition to information, knowledgeable people are an important resource in any organization.²⁵ Providing these people with the knowledge and skills to perform their work in a way that allows the organization to achieve its goals requires giving them the tools they need and educating and empowering them to use the tools. Information is one such tool. In the case of information, people must be educated about determining the information they need to make decisions, from where and how to acquire that information, and how to interpret and use it once it has been acquired.

The basic principles of the field of information quality (IQ) and approaches to information quality improvement have been adapted from those used in the practice of total quality management (TQM) and continuous quality improvement. The principles are derived from those of quality pioneers such as Deming, Juran, Crosby, Ishikawa, Shewhart, and others. According to the quality literature, it is the consumer who judges whether or not a product is fit for use, and thus of good quality.^{29–32} The consumer-centric approach to quality is continuing to evolve as evidenced by the recognition, in service industries such as healthcare, that the consumer base is heterogeneous and there is a need to continuously adjust to its dynamically shifting expectations.³³ Therefore, most experts in the field of information quality agree, IQ cannot be assessed independently of the consumers who use it. These experts define quality information as “information that is fit for use by information consumers.” The experts also agree that to be of high quality, information should be intrinsically good, contextually appropriate for the task, accessible to the information consumer, and clearly represented.^{25,34,35}

English further refines the definition of IQ by identifying two primary types, inherent and pragmatic. Inherent IQ is the degree to which data accurately reflect the real-world objects they represent, in other words, the degree to which the data are “correct.” Pragmatic IQ is the degree of usefulness and value the data have in supporting the enterprise processes that enable achievement of enterprise objectives.²⁵ Pragmatic IQ is reflected in the degree of customer satisfaction derived by knowledge workers who use the information to do their jobs. The process of providing quality information therefore requires consistently meeting knowledge-worker and end-customer expectations through information and information services, and enabling them to perform their jobs efficiently and effectively. The process of providing quality information applies to all purposes for which the information is used, including both present and likely future uses.²⁵

The IM strategy at PeaceHealth is supported by three primary infrastructure components: (1) technical, (2) people (knowledge), and (3) community. From a functional perspective, the information systems at PeaceHealth were implemented in a manner designed to support both daily operations and a continuous cycle of improvement (Figure 1). The cycle of improvement begins with the processes of care delivery. This includes administrative, financial, and clinical processes. As a product of these processes, data are generated and captured in the clinical, financial, and administrative systems. The data from these systems are extracted, transformed or cleansed, and loaded into analytical systems. PeaceHealth knowledge workers use the data in the analytical systems, turning it into information that is used for various types of decision making and population-based outcomes analyses. The results of these analyses help produce better-informed decisions, which then result in improved processes, and ultimately better outcomes.

Figure 1. Functional Perspective of PeaceHealth Information Systems

The second component of the PeaceHealth IM infrastructure is the people (knowledge workers). In many ways, the knowledge-worker component of the infrastructure is the most important. The key to supporting this component of the infrastructure is to create an environment of continuous learning and continuous quality improvement. The approach PeaceHealth has taken to build this environment is very similar to the framework described by Batalden and Stoltz in their 1993 article in the *Journal on Quality Improvement*,³⁶ in which they describe integration and application of professional knowledge and improvement knowledge in creating a framework that makes continuous improvement possible for healthcare organizations. In PeaceHealth, the vehicles used to create this environment are the Healthcare Improvement Division (HID) and the Centers for Healthcare Improvement.

The HID was created in 1996 in an effort to create a link in PeaceHealth between information technology, information management, and quality improvement. It is a corporationwide division, with primary responsibility for all information technology and a leadership role in information management as well as process and outcomes measurement, management, and improvement. The division consists of four primary groups: Information Technology, Web Services, Clinical Applications and Quality Improvement, and Information Management (which includes the health services research team). The division is led by three physicians and a nonphysician chief information officer with a traditional IT leadership background. The physicians have practice experience ranging from seven to twenty years, and experience and education in quality improvement. Two of the physicians have education and experience in medical informatics. The senior leader of the division is one of the physicians.

The Centers for Healthcare Improvement, also created in 1996, are individual regional departments that support regional quality-improvement efforts. The centers and the HID work collaboratively on PeaceHealth's healthcare delivery improvement initiatives. Through these components of the organization, PeaceHealth has brought together people with knowledge and skills in healthcare delivery processes, team process, facilitation, leadership, change

management, adult education, systems optimization, medical informatics, IT, process improvement methods, data management, and health services research (including statistics and epidemiology).

The third and final component of the foundation of the IM strategy at PeaceHealth is the organization and community infrastructure. In PeaceHealth, this infrastructure has been implemented through developing care coordination service lines; forming partnerships with various community organizations; and clearly articulating specific and measurable clinical, financial, and operational outcome goals as part of the annual strategic planning process.

The Community Health Record

In 1994, PeaceHealth embarked on a project called the Community Health Record (CHR). The vision of the CHR was to create a single, communitywide, longitudinal medical record available (with appropriate security) to all providers associated with PeaceHealth. The record was designed and implemented to promote clinical integration and “seamless” care across the continuum, and to facilitate cost-effective, data-driven patient care and data-driven clinical quality improvement. A major component of the CHR strategy throughout its development and implementation has been to work collaboratively in our communities, to make the CHR available to all providers affiliated with PeaceHealth, whether or not they are directly employed by PeaceHealth. Recently, the strategy has evolved to include making the information in CHR available to patient-consumers as well as providers.

The primary components of the CHR are clinical transaction systems, clinical analytical systems, practice management systems, and the communications infrastructure (WAN, LAN, intranet, and Internet) for providing access to these systems both within PeaceHealth and to the caregivers and consumers “outside the walls” of the organization. The first three components of the CHR and the network infrastructure are described in this section. The intranet and Internet are described in subsequent, separate sections of this article.

The information focus of the CHR has been, and continues to be, on integrating clinical information across the continuum of care; accessing practice management information; monitoring, maintaining, and continuously improving the quality of the information; and making the information available to providers and consumers where and when they need it. The types of clinical information are lab and ancillary service results reporting, transcriptions, medication, orders, assessments, problem lists, care plans, and all other information necessary for providing patient care and ultimately evaluating and improving the quality of care offered. The practice management information includes but is not limited to patient demographics, insurance information, employer information, appointment scheduling information, provider productivity data, and charge data. The methods for facilitating the goals of cost-effectiveness and data-driven care and decision making include

providing functionality for (1) capturing all clinical, management, and other patient-related information electronically, as a product of work processes by all caregivers and other PeaceHealth knowledge workers; (2) electronic physician order entry; (3) concurrent clinical decision support; and (4) retrospective, population-based analyses of care processes and outcomes.

Because providing patient care and analyzing and improving the care processes and outcomes require integration of operational and financial information with clinical information, the transaction and analytical “business” systems (general ledger, human resource management, materials management, and financial decision support) have been interfaced with the primary components of the CHR. Figure 2 is a diagram of the components of the PeaceHealth information factory, with its CHR, business systems, and communications infrastructure.

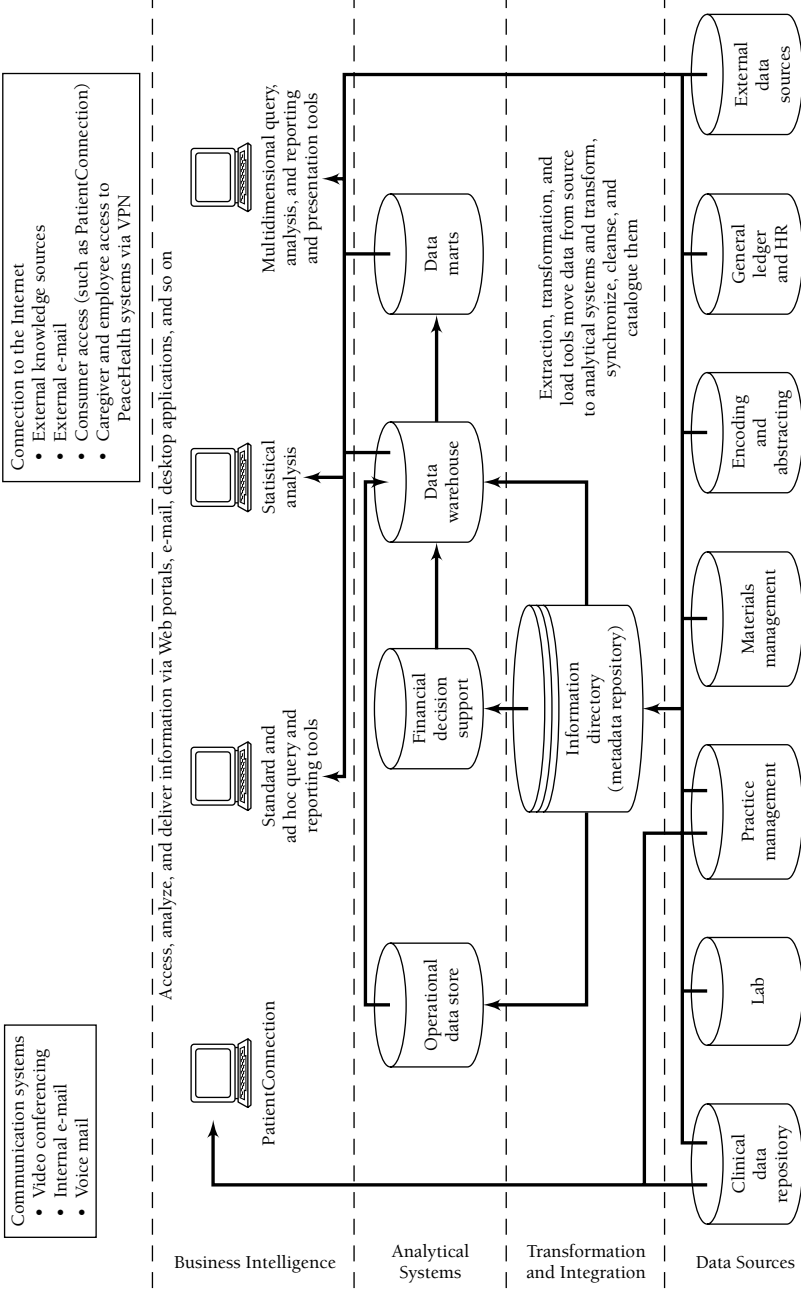
Clinical Transaction Systems. The standard, corporationwide, computer-based patient record system (CPRS) is an integrated commercial vendor system. The system was initially developed to support inpatient clinical care. To support outpatient clinical practice, PeaceHealth worked with our vendor to develop functionality such as chart notes, problem list, electronic prescribing, and an in box for alerts and reminders. Another vendor’s clinical laboratory system is interfaced to the primary CPR system. Both inpatient and outpatient components of the CPRS feed data to, and retrieve data from, a single clinical data repository.

The CPRS has been deployed throughout PeaceHealth facilities in inpatient and outpatient settings. This includes all five inpatient and approximately one-fourth of outpatient facilities, with plans for 100 percent implementation within the next eighteen months. The outpatient portion of the CPRS has been implemented not only in PeaceHealth clinics but also in about one hundred private physician practices, with plans to make it available to all private physicians affiliated with PeaceHealth who desire access. Part of the strategy to enable deployment to private physician offices was a decision by PeaceHealth to offer, at our expense, the technical infrastructure (up to the network port in the physician’s office) for accessing the PeaceHealth network. The private physician’s responsibility was to supply a personal computer workstation (and printer if so desired).

Where the system is in place, we have achieved to a remarkable degree the original vision of an integrated medical record across the continuum of care. Some of our facilities, outpatient and inpatient, have made remarkable strides toward a paperless environment. Many providers (physicians, nurses, pharmacists, and so on) are totally dependent on the system for day-to-day patient care.

Users, primarily physicians, are surveyed on their satisfaction with the CHR within a few months after initial implementation, and then annually. The general response pattern has been moderately negative feedback in the first survey after an implementation, with increasing acceptance over time.

Figure 2. PeaceHealth Information Factory



Note: The thick black lines represent the PeaceHealth network (including the intranet).

Most of the feedback after the initial transition period is related to specific features and functions of the system that users want to see improved, and to issues related to workflow. These issues are particularly noteworthy during the transition from the paper to the electronic record, when providers are required to access both systems to do their work. Though there is always room for improvement, once users have learned to use the system and discover the value it adds to their ability to provide efficient and effective patient care, the great majority of users do not want to work without the CHR and would not support a return to a completely paper-based environment.

Clinical Analytical Systems. The two primary systems used for retrospective, population-based clinical analyses are our clinical data warehouse (CDW) application and the encoding and abstracting system. The CDW is a vendor product for which PeaceHealth was the beta development site. The application includes a database that runs on a Tandem computer using the Non-Stop SQL database management system; a set of tools for extracting, transforming, and loading data into the database; and a Windows-based desktop query tool that primarily offers the functionality of a list generator.

The CDW database is populated biweekly with historical information from our CPR system. Currently, the information includes registration, lab, ancillary (such as radiology), medication, abstracted (for instance, ICD-9-CM and CPT4 codes), vital-sign, input-and-output, charge, problem-list, and clinical-assessment data. The CDW data model is structured to allow ease in performing queries that return large amounts of data. The data in the lists generated by the query tool are exported to other applications, such as Microsoft Excel or Access, for integration with data from other sources along with subsequent analysis and presentation.

In addition to the data warehouse, PeaceHealth has a standard, corporationwide encoding and abstracting system with a single database for the entire organization. The data model—with its data element names and definitions, data entry screens, and reports—was developed by a multidisciplinary team from PeaceHealth, working with the system vendor. The PeaceHealth team included medical record coders, quality improvement analysts, various data analysts, IT staff, and data administration personnel. The reason for using this approach was to ensure development and implementation of an application that could be used for capturing information not only for billing purposes but also for development of clinical protocols and in process and outcomes analysis. Data from this system are another major source of information used in PeaceHealth clinical quality improvement work.

Application of the data contained in the clinical analytical systems in PeaceHealth is varied and has evolved over the past several years. Among the project types for which the data have been used are clinical process improvement, clinical guideline development, disease management, applied clinical research, internal quality assurance, accreditation activities (such as JCAHO's Oryx), utilization management, physician profiling and credentialing, and outcomes

data analysis. Some specific projects have been identified for data analysis: community-acquired pneumonia and congestive heart failure guideline development and impact analyses, adverse drug event monitoring, analyses of trends in medication use and cost, evaluation of clinical effectiveness of an anticoagulant protocol, and support of a diabetes disease management program.

Practice Management Systems. PeaceHealth has adopted a standard practice management system for all its outpatient facilities. This system supports patient registration, appointment scheduling, billing, managed care eligibility, tracking of physician productivity, and several other functions. Using this system and its integration with the CPRS, PeaceHealth is beginning to streamline work processes, thus improving efficiency and patient satisfaction with the practice management services. Use of the practice management system is also enabling PeaceHealth to effectively and efficiently analyze the operational aspects of our outpatient practices, thereby to identify what we are doing right and where we have opportunities for improvement. This includes enabling medical directors to give physicians individual information about the operational aspects of their practice as well as comparison of their data with data from their colleagues. Additionally, in combination with PeaceHealth Internet services, the practice management systems are being used to enable patient-consumers to perform many of the tasks of registration and scheduling online, thus saving patients time and being another source of improving patient satisfaction.

PeaceHealth Network. The PeaceHealth network includes approximately 130 sites and ten thousand workstations. It has been implemented in all PeaceHealth regions, across Alaska, Oregon, and Washington. The sites are PeaceHealth inpatient and outpatient facilities, as well as independent physician offices. Open industry architecture standards have been used in designing and installing PeaceHealth's network. Each site on the network has Ethernet LANs connected together to form metropolitan area networks (MANs). These are based on frame relay services and have 11 megabit radio frequency wireless connections in some locations. The MANs are connected together to form a WAN. The WAN is also based primarily on frame relay services with a transmission rate of 1.544 megabits per second. The WAN features dedicated point-to-point circuits used as backup. The frame relay network cloud connects all MAN sites with a common network. We have three frame clouds within the network. All clouds are connected with multiple T-1 links to ensure the required bandwidth as well as a layer of redundancy.

The network was designed with consideration of both current and future bandwidth requirements, and the need for easy migration from current technologies to higher bandwidth technologies (such as FDDI or ATM). Higher bandwidths communications are required in the future to support applications such as imaging information, video, and multimedia. The PeaceHealth network is used to connect desktop PCs and printers with a variety of host systems. The host systems include Microsoft NT servers (file and print services, special applications, and Exchange messaging), Novell NetWare servers (special

applications), Tandem minicomputers (CPR and CDW), Digital Equipment VAX and Alpha minicomputers (lab and practice management systems), and IBM AS/400 and RS6000 minicomputers (financial systems and interface engine).

PeaceHealth Intranet

The PeaceHealth intranet, called Crossroads, is accessible to all PeaceHealth employees and, with appropriate security precautions and selective site access, providers affiliated with PeaceHealth. The intranet is used for a range of clinical and operational purposes. It supports the PeaceHealth e-mail system, which is one of the main methods of communication within our organization. Examples of other applications and information that users can access are an internal Web-based clinical resource library, an Internet-based commercial service that offers healthcare information for providers and consumers, internal clinical quality information sources, an internally developed Web-based risk management and adverse drug event incident reporting system, information on disease management programs at PeaceHealth, and human resource information (including employee benefits). The impact of the use of the intranet for all these applications has been to improve information dissemination, empower users with knowledge, improve users' ability to perform their jobs more effectively and efficiently, and in some cases improve their job satisfaction.

Quality Improvement Database. PeaceHealth has developed a database, available on our intranet, that enables us to track quality improvement projects across our regions. It is an easy way for quality professionals and providers to learn about work that is taking place in all regions and find out who to contact about a specific project or topic of interest. The goal is to encourage synergy and avoid rework without creating undue bureaucracy. The database contains information on the general nature of the project, current state of the project, a brief overview of the outcome (if completed), and key contacts. It is searchable by several criteria, among them region, topic, and date. This is one of several applications on the intranet that support quality improvement efforts in the organization.

Clinical Quality Indicators. A Web-based dashboard of clinical quality indicators is accessible to clinical and nonclinical operational leaders and executives, and quality improvement personnel in PeaceHealth, by way of the intranet. The dashboard was created using the Clinical Value Compass (CVC) model developed by Nelson, Mohr, Batalden, and Plume.³⁷ Each quadrant of the dashboard is dedicated to one of the points on the CVC: clinical outcomes, patient satisfaction, functional outcomes, and costs. The Clinical Quality Indicator dashboard is a constantly evolving application, changing as the areas of focus for PeaceHealth quality initiatives shift over time.

When a user accesses the dashboard, the initial view shows aggregate-level data for the entire organization. The data in the initial view are presented

in the form of a list of the indicators and an associated current value. By clicking on a specific indicator, the user can drill down to show region-specific data for the last three years, displayed in the form of a bar graph. By clicking on the bar graph for a particular region, the user can continue drilling down to a statistical process control (SPC) chart for that indicator. In addition to the graphs, the data also are presented in a tabular format. Several features of the dashboard have already proven quite valuable anecdotally. Users have commented on the helpfulness of being able to look at the key outcomes for PeaceHealth on a single page, when they first access the Website. They also have found that the first level of drill-down gives them useful, high-level information about how the outcomes have changed over time, or how they differ among the regions. The detail available in the SPC charts further assists the users in determining if the changes or differences are real, or merely part of normal variation. This assists with identifying areas for improvement and areas of best practice that can then be leveraged and implemented across the corporation.

Adverse Drug Events. Adverse drug events (ADE) are unintended, undesirable, or unexpected effects of prescribed medications that may require discontinuing the medication, or modifying the dose; hospitalization; or treatment with another prescription medication; or that may result in cognitive deterioration or impairment, physical disability, or death. Recent studies indicate that 7–10 percent of hospitalized patients have adverse drug events, with half of those cases resulting from medication errors; that two-thirds of ADEs are preventable; that only 5–10 percent are reported; and that each event can add several days to the hospital stay at a cost of thousands of dollars.^{16,38,39} PeaceHealth has had an initiative focused on optimizing the medication process since the fall of 1999. A variety of projects are included in this initiative:

- Physician order entry in the CPR
- Redesign of the medication administration process
- Implementation of various safe medication practices identified from the literature
- Development of a nonpunitive reporting policy
- Development of an online reporting system (using the intranet) with a back-end database designed for analysis of ADEs and potential adverse drug events (PADEs)

Early in the process of evaluating ADEs in PeaceHealth, it was apparent that our system for documenting the information and writing it on three-by-five index cards stored in a file in the pharmacy was inadequate and resulting in inaccurate information. Therefore it was determined that a better documentation and reporting system needed to be developed, to enable pharmacy analysts to document their investigations and conclusions. To ensure data quality, as well as consistency, this system was developed as an additional

component of the existing PeaceHealth Web-based risk management incident reporting system and was interfaced with our computer-based patient record system. The ADE system captures the type, location, drug, provider, and other relevant information for analyzing ADEs. The architecture of the risk management/ADE system is a Microsoft SQL server back end and Web-based front end built using Microsoft Access. There are data entry screens and ad hoc querying screens, as well as standard reports. Pharmacists are given an electronic list, generated from the risk management/ADE reporting system, of new ADEs and PADEs to review. If pharmacists identify, through other information sources, ADEs or PADEs not on the list, they may enter them into the risk management/ADE system manually.

We are now actively using this system in all five PeaceHealth regions and beginning to collect enough data to accurately measure error rates, determine the dominant types of error, initiate improvements in the medication process in PeaceHealth, and give feedback to appropriate regulatory agencies (for example, FDA) about drugs related to high rates of ADE incidence. Some patterns of ADEs that would not otherwise be apparent have been identified using the information from this system and other components of the PeaceHealth medication process optimization project. For example, we identified an unexpectedly high rate of complication related to use of vitamin K in one of our inpatient facilities.

Disease Management. The first PeaceHealth organizationwide disease management initiative began in 1998. The focus was on patients with diabetes. The mission of the project was to improve the health and well-being of diabetic patients and prevent long-term complications. The methods used to achieve this mission were monitoring clinical indicators of the control of diabetes, identifying patients with indicator values suggesting a high risk of diabetic complication, and intervening using a combination of medical treatment and education before complications occurred. The project was planned using a three-phase approach. The first phase is completed; the second and third are in progress.

The focus of the first phase was risk screening. The components were (1) determining standard indicators to monitor; (2) developing and implementing guidelines for the frequency of monitoring the indicators, and for acceptable indicator results; (3) developing and implementing methods for capturing and documenting the clinical indicator results; (4) collecting and documenting (historical) baseline data on the frequency of performance and documentation of the indicators, and on historical indicator results; (5) comparing historical results with the guidelines; and (6) after implementation of the monitoring and documentation guidelines, measuring compliance as demonstrated by improvement in frequency of performance and documentation when compared to the historical data. During phase one, in addition to capturing whether or not the clinical indicator tests are performed and documented in accordance with the guidelines, the results of the tests are captured and interventions are performed where indicated.

Using the clinical indicator results as a proxy measure, the goal of phase two is to determine if the improvement (if any) and interventions performed in phase one result in improved control of the patient's diabetes. The goal of the third phase is to determine if the improvements demonstrated (if any) in phases one and two lead to a decrease in the frequency of long-term complications (retinopathy, nephropathy, cardiovascular, neuropathy, and so on) and other outcomes such as hospitalization.

To accomplish the goals of the three phases, multidisciplinary teams were chartered in each region to provide local leadership. Two members of each regional team (the local physician champion and facilitator), along with members of the IM and clinical applications groups from the HID, were brought together to form the cross-regional diabetes team. The team was charged with the task of overall leadership and guidance for the project, and with ensuring a standard approach to the diabetes disease management process across the regions. The team identified six clinical indicators to monitor, developed the guidelines for monitoring the indicators, implemented monitoring and documentation methods, and set targets for six clinical indicators:

- Hgb A1c
- Dilated retinal exam
- Comprehensive foot exam
- Lipid profile
- Microalbuminuria
- Blood pressure control

A variety of information management tools can be used in the disease management process: direct patient care tools (used to support caregivers at the time of the patient encounter), concurrent decision support and patient outreach tools, retrospective analysis tools, and educational tools. In execution of this project, several tools from all four categories were applied. The direct patient care tools were a paper encounter form, an electronic version of it, and an electronic flow sheet embedded in the CPR. There were two reasons for developing the encounter form on paper first: it is a standard part of our application development process, and not all of our facilities had access to the CPR when we began the disease management project. The paper encounter form is kept in a specific section of the paper chart that is dedicated to the information required for addressing patient needs related to their diabetes.

The process by which the form is used is for the medical office assistant (MOA) to bring the patient into the exam room and complete the fields on the encounter form that were designed to be completed by caregivers other than physicians. The physician then comes into the room, examines the patient, and completes the remainder of the form. The process for using the electronic encounter form is identical, with the exception that the first step is for the MOA to activate the patient's record in the CPR and complete the form

electronically. The process for entering data into the electronic encounter form was designed with the physician's work process in mind. Physicians are able to tab through the fields and in many cases select data entries from a pick list.

Contrary to their original concerns, physicians have not found this to interfere with their interaction with patients. In fact, physicians have found that patients like this method of performing the exam and capturing their information directly into the electronic record. Anecdotally, several patients have expressed a belief that this is improving the physicians' ability to have all their information available when they need it. After completing the encounter form, the physician can pull up a longitudinal flow sheet (over time) of the patient's results. The lab data is automatically pulled into the record when the physician brings up the flow-sheet view.

The concurrent decision support and patient outreach tools that we use are paper and electronic versions of the guidelines and expert-rule-based electronic reminders and health maintenance alerts (HMAs). The alerts are used in several ways. For concurrent decision support, they generate alerts that appear in the chart summary view when an MOA or physician activates a patient's record. For patient outreach, the HMAs are used to generate a list of patients for a case manager, who then contacts those who need to come to the clinic for reasons such as an annual visit or to have their glycohemoglobin test performed. The same list is used to electronically generate labels for mailing reminders to patients.

The retrospective analysis tools used are a CPR embedded query tool, the clinical data warehouse, and an intranet-based diabetes data mart and population-based reporting application. The CPR embedded query tool can be used by caregivers to evaluate their specific patient population. Using this tool, caregivers can choose to perform a query according to HMAs, use a query they have built in the past and stored, or build a new ad hoc query. The query can be on the basis of patient demographics, provider specialty, clinic visits, diagnoses, medications, labs, and ancillary data. Early in the diabetes disease management initiative, before we developed more sophisticated methods for presenting the information, one of the regional medical directors imported data generated from the query tool into Excel and graphed the performance of each physician. This was shared with the physicians in the region; upon review of the information with the participating physicians, immediate practice improvements were put into effect, which enhanced the care rendered to the patients.

Anyone with access to the PeaceHealth intranet can access the population-based reporting application. Data are automatically written from the clinical data repository to the data mart at the back end of this application. Using password security, access to the data mart database is limited to a small group of individuals. In addition, the information in the database is blinded with respect to patient and provider identifiers, unless an appropriate password is input. Users of this system can choose to look at information on their patients only, on patients in their clinic in comparison with their own, or on patients in their

clinic in comparison with patients across the organization. In addition, users can build queries to look for any specific type of information they want on the various clinical indicators. The information available in the various reports is used to help the individual caregivers, physician groups, or medical directors identify opportunities for improvement, as well as confirm those areas in which the care being provided is of good quality. The educational tools currently available are intranet and Internet access, for patients and providers, to current literature and other external information sources on diabetes disease management.

In comparison to the time this program was instituted, we have seen remarkable improvement in compliance with clinical guidelines, clearly demonstrating the value of providing data on performance and guidelines to clinicians. For example, documentation of albumin-creatinine ratios has gone from nearly zero to about 80 percent in one region.

Human Resource Applications. Use of the PeaceHealth intranet to disseminate information to employees has grown from simple posting of static policies and procedures to online, real-time access to information important to staff and management. The first initiative to expand use of the intranet for HR purposes was automation of the annual employee benefits process, including health insurance. The purpose of the project was to reduce administrative overhead as well as time and material costs. The system was available for the fiscal year 2000 enrollment period. There are links to insurance companies for more information regarding primary care physicians and specifics of the healthcare benefits provided. The new system met the targets for reduction in administrative costs. During the first year, at the time of implementation, there was a major increase in help desk calls; the volume was significantly lower in the second year of the implementation, suggesting that most employees had become comfortable using the system. Initial implementation permitted access only from those computers at PeaceHealth facilities. PeaceHealth now is piloting the functionality for employees to enroll online from home. Access from home is highly desirable for many employees, because they need to involve family members in the enrollment process.

The second initiative related to human resources was creation of an employee information center. It was to give all employees online, timely access to their payroll, and all other HR information. In addition, the information center has served to eliminate paper-based personnel action request forms (for pay changes, job changes, and so on); it has dramatically reduced calls to the HR departments for simple information requests. The center provides access to employee demographic information and allows changes to that information in real time, summary of current benefits, paid time-off balance, and paycheck history.

The third HR initiative was to eliminate generation and distribution of paper-based pay stubs. After the financial system has computed the biweekly pay process, an automatic e-mail is sent to all employees notifying them their

electronic pay stub is available. Employees can click the link contained within the e-mail, log on, and access their pay stub online.

The fourth initiative was creation of a manager's dashboard with key, real-time information regarding employees: salary, evaluation due date, training history, and other pertinent management information. The intranet is also used to efficiently capture employee training information. Trainers can use a simple online attendance form, from which information is automatically interfaced to the training tracking module within the financial system.

As a result of the success of the projects we have described here, PeaceHealth has proven to the organization that the intranet, coupled with other Web-enabled applications, can greatly reduce administrative costs, disseminate information faster, and improve employee satisfaction.

PeaceHealth Internet Services

PeaceHealth Internet Site. When creating its public Internet site (www.peacehealth.org), PeaceHealth chose to create an innovative, high-value site for patients, their families, and other healthcare consumers in our communities. *High-value* was defined as providing online services, as opposed to simply promoting services online via static content. As such, along with the expected organizational content and educational content on a variety of health subjects, the initial PeaceHealth Internet site had these interactive features:

- Online personal wellness profile, including immediate online feedback
- Ask-an-Expert service
- Community class schedules with online registration and payment
- E-Mail-a-Patient service
- Online cheer cards
- "Baby@lbum" service, with Web pages for newborns (photos, gift registry, announcements, and online baby-book signing for family and friends)
- Physician directory
- Career opportunity center with online job posting and application process

The PeaceHealth ask-an-expert service is illustrative of our interactive Internet services and is a good example of using technology, both our public Internet site and our intranet, to reach out to our communities. Any visitor to www.peacehealth.org, whether a current patient or not, can access this service, pose a question to our panel of experts, and expect a response within three days. When submitting a question, the visitor specifies the closest PeaceHealth region (as we operate in five distinct geographic areas) and a return e-mail address. The question is sent to a database application on the PeaceHealth intranet and reviewed and triaged by the medical director of PeaceHealth Internet services. Depending on the content of the question and the preferred region, the medical director forwards the question to the appropriate expert on a panel of more than

one hundred participating physicians and other clinicians. The panelists receive an e-mail notification that an ask-an-expert question has been routed to them and click on a supplied hyperlink to access the question and respond. Once the panelist enters an answer, an e-mail including the answer to the question and convenient links to the PeaceHealth Website for details on the panel member who responded is sent back to the originator of the question. As a by-product of this service, we also are able to capture and continuously expand a list of frequently asked questions, grouped by health categories, on our public Internet site. Prior to posting the question and answer to the public site, all personally identifying information is removed. The commitment to offering a broad suite of innovative services by way of www.peacehealth.org was recently recognized by eHealthcare Strategy and Trends, which presented PeaceHealth with a silver award of distinction specifically for our interactive features. Details can be found at their Website, www.strategichealthcare.com.

Since its launch in September 1999, usage for the public Internet site has consistently grown. By reviewing usage statistics collected from our site server, we have evaluated visitation rates across our communities. The results suggest the site is providing added value to our communities, and in some cases beyond our primary service area. Services such as ask-an-expert, e-mail-a-patient, class registrations, baby@lbum, job applications, and others have been consistently used each month. Our online physician directory has had a direct impact on those searching for physicians and making connections with our organization (our first e-mail received after launching the site was from a seventy-five-year-old man seeking a new primary care physician). The Ask-an-Expert service has received several inquiries from individuals outside our primary service areas, inquiring about availability of surgery or other healthcare services PeaceHealth offers. For example, we have received several questions from Canadians (in a secondary service area for our St. Joseph Hospital in Bellingham, Washington) about the availability of surgery in Bellingham, as they wait in long queues within their nationalized healthcare system.

PatientConnection. Looking to the future, PeaceHealth has embarked on a project to further expand our online interactive services. By partnering with our primary clinical systems vendor, we have begun implementing a new service designed to enhance the relationship between patients and their physicians and physicians' office staffs. It is known as PatientConnection. The initial implementation offers these online services:

- Appointment scheduling
- Referral requests
- Registration (personal information) updates
- Account status review and payment
- Secure messaging with physician or office staff
- Prescription refills
- Links to existing PeaceHealth services such as community classes, physician directory, maps and directions, and health resources

In addition, future services will include the ability to review or contribute to personal online medical records, review lab and other test results, review medication history, and so on. All these services are (or will be) integrated with our existing clinical and business systems. The expectation is that these services have a measurable impact on the level of patient satisfaction and streamline operations within our clinic practices. For example, telephone call volumes are expected to drop as routine transactions are migrated to the Internet. In response to growing demand from patients, the new service also allows a secure, documented, and "filtered" approach (using various triage processes) for physicians and office staff to communicate with patients through online messaging.

Because the innovative PatientConnection type of initiative is new to our organization, executives have some questions: "What value is added by these services?" "When will I see a return on my investment?" "Will this require additional staffing resources?" We will answer these questions in two ways for the PatientConnection project: by examining a set of success criteria developed at the outset of this project, and by performing a return on investment (ROI) study comparing workflow processes from our existing systems to those introduced with PatientConnection.

We are examining ten success criteria pertaining to communication, productivity, patient satisfaction, patient retention, and staffing rates. Both quantitative and qualitative methods are being used to examine them. Quantitative baseline measures, using time-motion and other study methods, were performed for various clinic processes (number of phone calls received from patients, average duration of phone calls, number of FTEs required, staffing mix). Patient satisfaction with the PatientConnection services is being measured using a survey specifically designed to address satisfaction with a variety of services (appointment scheduling, physician referrals, billing, financial and insurance account management, pharmacy services, communication with providers, and others).

Focus groups are being used to gather in depth qualitative information. The focus groups are primarily targeted on communication issues from the patient, provider, and office staff perspectives. Baseline information was collected from the focus prior to activation of PatientConnection. Each focus group will be brought together again after PatientConnection has been live for nine months. The identical methodology and probe questions are to be used at the follow-up focus groups, along with a combination of quantitative and qualitative data to determine if the success criteria have been met.

The ROI study was developed and is being performed in partnership with the information system vendor and a major consulting firm. Prior to implementation, organizational and workflow data were gathered: FTEs, operating costs, market share, number of patients served, annual number of visits, number of chart pulls, number of phone calls, and so on. Costs were determined for implementation of PatientConnection (installation, hardware, maintenance, licenses, support staff); and for FTEs for chart pulls, answering general health questions over the phone, making appointments, sending

patient reminders, updating the medical record with demographics or insurance information, billing, lab test results, and prescription refills. The same data are to be reevaluated after PatientConnection has been live for nine months.

Challenges and Lessons Learned

Doing the work PeaceHealth has done in implementing and evolving an e-health strategy is challenging for any organization, but even more so for a multiregional integrated delivery system. In our experience, the challenges fall into three main categories: organizational, data information, and technical.

Organizational Challenges. The organizational challenges are (1) to figure out how to be an integrated delivery system, including how to integrate medical groups with hospital operations, and how to integrate independent physician groups; (2) struggling with the balance between focusing on the bottom line and focusing on the processes and people that allow us to deliver our services to the community; (3) the polarity between centralization and decentralization, and the recognition that standardization does not equal centralization; and (4) a well-thought-out and coordinated approach to process and outcomes measurement; use of guidelines, pathways, and protocols; and care, disease, and case management.

Data Information Challenges. The challenges related to data information are (1) data toxicity (an overload of redundant, inaccurate, uninformative or confusing “facts” leading to incorrect conclusions); (2) standardization of data definitions, representation, and vocabulary, which is complicated by multiple disparate data sources; (3) methods for creating derived information; and (4) processes for capturing, storing, delivering, and presenting information.

Technical Challenges. The technical challenges are (1) bringing information systems to the same level of implementation across the organization; (2) integrating clinical, administrative, and financial systems (transactional and analytical); (3) integrating external data sources; (4) implementing real-time clinical decision support (this also is an organizational and data-information issue); (5) developing and implementing a retrospective decision support infrastructure, including data warehousing and business intelligence environments; (6) supporting Web-based information delivery and the associated growing demands on and for network bandwidth; and (7) balancing security with easy access.

Although we have learned many lessons as we implement and evolve our e-health strategy, several stand out. The lessons and corresponding advice given here are not ranked in any particular order. The first lesson, though, is certainly the most critical and universal in developing an appropriate strategy and tactics to execute in your environment.

1. Begin planning all e-health endeavors by being certain you understand what the stakeholders (be they caregivers, operational healthcare workers,

- or consumers) want and need to do. Once you know this, you can determine the information required to support the stakeholders' efforts, and then the best technology or process solutions can be determined.
2. Look at the big picture first, then identify the individual supporting components, and iteratively implement them in their order of importance.
 3. Maximize the value of the data collected to date through existing information systems.
 4. Do not focus only on data capture; it is equally important to concentrate attention on the output of meaningful data that can be used by clinicians and consumers in decision making.
 5. Be careful not to allow the technology to drive the projects.
 6. Include workflow considerations in developing and executing any project.
 7. Carefully evaluate the issue of process standardization, and determine which processes or components of processes should and should not be standardized. For example, clinical documentation for a particular inpatient service at various facilities can be standardized, but it may not be necessary to standardize the care process.
 8. In a large, complex healthcare organization, there is some level of polarity between the corporate and regional priorities that needs to be effectively balanced.

Conclusion

In summary, PeaceHealth's e-health strategy stems from the definition of *e-health* as the application of all forms of information and telecommunications technology to achieve the goal of improving management and use of information in support of clinical, operational, and financial processes and decision making, and improvement of the delivery of healthcare services and the associated clinical, satisfaction, functional, and financial outcomes. The most significant value of our e-health strategy has resulted from timely information; improved dissemination of and access to information; and improved quality of information for providers, patient-consumers, frontline employees, managers, and executives. This has resulted in decreasing information-related resource utilization and greater ability of leaders (clinical, financial, and operational) and caregivers to measure, manage, and improve processes and outcomes. The PeaceHealth e-health strategy is also enabling our patient-consumers to actively participate in their care.

In the near future, we are focusing our efforts on continued development of a decision support infrastructure that enables users to access and analyze data without reliance on the Healthcare Improvement Division; continued refinement of our ability to measure, manage, and improve the quality of information captured and used; continued collaboration across the regions; refinement of the organizational structure to better support future initiatives; continued education of the organization and our customers; and implementation of physician order entry.

References

1. First Consulting Group. *Health Plans on the Road to E-Health*. Long Beach, Calif.: First Consulting Group, 2000.
2. Coile, R., and Howe, R. "Healthcare E-Commerce and the Internet: Ten Strategies for Healthcare Providers and Health Plans Doing Business on the Web." *Health Trends*, 1999, 11(9), 3–8.
3. Reents, S. *Impacts of the Internet on the Doctor-Patient Relationship: The Rise of the Internet Health Consumer*. New York: Cyber Dialogue, 1999.
4. Bickert, M. *The Impact of E-Commerce on Legacy Health-Care Companies*. New York: Cyber Dialogue, 1999.
5. Gartner Group. "Healthcare and the Internet: An Update." *Healthcare Perspective*, Nov. 9, 1998, no. 61.
6. Lohman, P. "E-Health: Putting Health on the Net." *Informatics Review*, Dec. 1999. <http://www.informatics-review.com/thoughts/ehealth.html>.
7. Fox, S., and Rainie, L. *The Online Health Care Revolution: How the Web Helps Americans Take Better Care of Themselves*. Washington, D.C.: Pew Internet and American Life Project, 2000.
8. Brodie, M., and others. "Health Information, the Internet, and the Digital Divide." *Health Affairs*, 2000, 19(6), 255–265.
9. DeLuca, J., and Enmark, R. "E-Health: The Changing Model of Healthcare." *Frontiers of Health Service Management*, 2000, 17(1), 3–15.
10. Coile, R. "E-Health: Reinventing Healthcare in the Information Age." *Journal of Healthcare Management*, 2000, 45(3), 206–210.
11. Haughom, J. "Transforming U.S. Health Care: The Arduous Road to Value." *Topics in Health Information Management*, 2000, 20(3), 1–10.
12. Millenson, M. *Demanding Medical Excellence: Doctors and Accountability in the Information Age*. Chicago: University of Chicago Press, 1997.
13. Drazen, E., and Metzger, J. *Strategies for Integrated Health Care: Emerging Practices in Information Management and Cross-Continuum Care*. San Francisco: Jossey-Bass, 1999.
14. Herzlinger, R. *Market-Driven Health Care: Who Wins, Who Loses in the Transformation of America's Largest Service Industry*. Reading, Mass.: Addison-Wesley, 1997.
15. Shortell, S. *Remaking Health Care in America*. San Francisco: Jossey-Bass, 1996.
16. Kohn, L., Corrigan, J., and Donaldson, M. *To Err Is Human: Building a Safer Health System*. Washington, D.C.: Institute of Medicine, National Academy Press, 2000.
17. Wennberg, J. "Population Differences Do Not Explain Population Hospitalization Rates." *Med Care*, 1987, 25, 354–359.
18. Hoehn, B., and Perreault, L. *Care Delivery and Care Management*. In M. J. Ball and J. V. Douglas (eds.), *Performance Improvement Through Information Management*. New York: Springer-Verlag, 1999.
19. Coile, R. "Challenges for Physician Executives in the Millennium Marketplace." *Physician Executive*, 1999, 25(1), 8–13.
20. Kramer, R., and Douglas, J. "Planning for Performance." In M. J. Ball and J. V. Douglas (eds.), *Performance Improvement Through Information Management*. New York: Springer-Verlag, 1999.
21. Ricord, L. C. "Meeting the Joint Commission's Information Management Planning Standard: A Primer and Example." *Topics in Health Information Management*, 1995, 15(4), 44–54.
22. Levinson, D. "Information Management in Clinical Practice." *Journal of Family Practice*, 1978, 7(4), 799–805.
23. DesHarnais, S., Marshall, B., and Dulski, J. "Information Management in the Age of Managed Competition." *Joint Commission Journal of Quality Improvement*, 1994, 20(11), 631–638.
24. Krouse, M. (Personal communication.) Seattle, Wash.: First Consulting Group.
25. English, L. *Improving Data Warehouse and Business Information Quality: Methods for Reducing Costs and Increasing Profits*. New York: Wiley, 1999.
26. Huang, K., Lee, Y., and Wang, R. *Quality Information and Knowledge*. Upper Saddle River, N.J.: Prentice Hall PTR, 1999.

27. Redman, T. *Data Quality for the Information Age*. Norwood, Mass.: Artech House, 1996.
28. Inmon, W., Imhoff, C., and Sousa, R. *Corporate Information Factory*. New York: Wiley Computer, 1998.
29. Deming, W. E. *Out of the Crisis*. Cambridge, Mass.: Center for Advanced Engineering Study, MIT, 1986.
30. Juran, J. M. *Juran on Leadership for Quality: An Executive Handbook*. New York: Free Press, 1989.
31. Juran, J., and Gryna, F. *Quality Planning and Analysis*. New York: McGraw-Hill, 1980.
32. Gillem, T. R. "Deming's 14 Points and Hospital Quality: Responding to the Consumer's Demand for the Best Value Health Care." *Journal of Nursing Quality Assurance*, 1988, 2(3), 70–80.
33. Prahalad, C., and Krishnan, M. "The New Meaning of Quality in the Information Age." *Harvard Business Review*, Sep.-Oct. 1999, 109–118.
34. Strong, D., Lee, Y., and Wang, R. "Data Quality in Context." *Communications of the Association for Computing Machinery*, 1997, 40(5), 103–110.
35. Lee, Y. "Why Is 'Know Why' Knowledge Useful for Solving Information Quality Problems?" Americas Conference on Information Systems, Association for Information Systems (AIS), Phoenix, Aug. 1996.
36. Batalden, P., and Stoltz, P. "A Framework for the Continual Improvement of Health Care." *Joint Commission Journal of Quality Improvement*, 1993, 19(10), 424–427.
37. Nelson, E. C., Mohr, J. J., Batalden, P. B., and Plume, S. K. "Improving Health Care, Part 1: The Clinical Value Compass." *Joint Commission Journal of Quality Improvement*, 1996, 22(4), 243–258.
38. Bates, D. W., and others. "Incidence of Adverse Drug Events and Potential Adverse Drug Events: Implications for Prevention." *Journal of the American Medical Association*, 1998, 274(1), 29–34.
39. Classen, D. C. "Adverse Drug Events in Hospitalized Patients: Excess Length of Stay, Extra Costs, and Attributable Mortality." *Journal of the American Medical Association*, 1997, 277(4), 301–306.

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