
Revised Edition

THE COMPUTER-BASED PATIENT RECORD

*An Essential Technology
for Health Care*

Committee on Improving the Patient Record

Division of Health Care Services

INSTITUTE OF MEDICINE

Richard S. Dick, Elaine B. Steen, and
Don E. Detmer, Editors

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The committee report and the commentaries were reviewed by groups other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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See page xv for a listing of the organizations that supported the original and revised reports.

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The serpent has been a symbol of long life, healing, and knowledge among almost all cultures and religions since the beginning of recorded history. The image adopted as a logotype by the Institute of Medicine is based on a relief carving from ancient Greece, now held by the Staatliche Museen in Berlin.

**COMMITTEE ON IMPROVING THE PATIENT RECORD IN
RESPONSE TO INCREASING FUNCTIONAL
REQUIREMENTS AND TECHNOLOGICAL ADVANCES**

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Preface—Revised Edition

The publication of a revised edition of an Institute of Medicine (IOM) report is atypical. In this case, the high, persisting demand for the original report and continued interest in computer-based patient records (CPRs) led the IOM to endorse the production of a second edition 6 years after the release of the original report. The initiation of the second report corresponded with the midway point of the target set in the recommendations of the Committee on Improving the Patient Record for achieving widespread implementation of CPRs in 10 years. Financial support from both the public and private sectors made the publication of the second edition a reality. This edition contains a new Preface, two commentaries that report on the state of CPRs today, and the full text of the original report published in 1991. The commentaries are individually authored and are

not the product of a study committee, but like all IOM publications, they did undergo the standard National Academy of Sciences/National Research Council report review process. The authors of the commentaries are distinguished leaders in the field of medical informatics and are particularly well known for their work on CPRs. Drs. Paul C. Tang and W. Ed Hammond are past chairs of the Computer-based Patient Record Institute (CPRI), Dr. Jan H. van Bommel edits the annual *Yearbook of Medical Informatics* for the International Medical Informatics Association, and Drs. Astrid M. van Ginneken and Johan van der Lei have written extensively on CPRs.

Six years has proven to be a long time in the world of health care. When the original report was released in 1991, the genetic locations of mutations that result in several major diseases were still unknown and laparoscopic surgery was just coming into widespread use. We had essentially nothing to offer AIDS sufferers in the way of treatment, neither did we use umbilical cord blood for bone marrow transplantation. During these past few years comprehensive government-led health care reform reached its pinnacle, was defeated, and market-driven changes in health care financing and delivery permeated much of the country.

There have been equally significant changes in information technology. Between 1991 and 1997, there was a 8-fold increase in power and capacity of personal computers and comparable improvements in peripheral devices with the result of making powerful workstations more affordable. The dramatic strides in computer technology have been accompanied by the massive growth of the Internet, as well as of local and regional networks that link communities, schools, health care providers, and individuals to information resources around the world.

Despite this milieu of rapid change, the vision outlined in this report by the Committee on Improving the Patient Record remains remarkably on target, and the case for CPRs is stronger today than it was 6 years ago. The demand for timely, accurate health data continues to grow. The changing demographics of the population are placing more demands on the information capabilities of health care providers and systems. The increasing volume of data collected and the continued growth of medical knowledge have created a dramatic need for information technology appropriate for the task of sorting through all the information available, assessing the strength of the evidence, and bringing it to practitioners whenever they need it, particularly at the time they are making care decisions. Further, the evolution of health care delivery organizations into integrated delivery systems means that those organizations need a way of managing their services. And, of course, citizens and other purchasers need better tools for assessing the performance of health care providers as well as for managing their own health care decisions.

Looking ahead, current trends in health care delivery, management, and research will likely broaden the vision of CPRs in two areas: population-based management of health through computer-based population records and citizen-based management of health through another variant of the CPR, the computer-based personal health record. First, CPRs will play an increasingly important role in supplying data for computer-based

population data bases. High-quality data are essential to the management of care for individuals; however, such data are equally critical for research, to support public health activities, and to track the performance of health care providers—both individuals and institutions. Second, as people continue to become more active consumers of health care and assume greater responsibility for managing their own health, and as information technology becomes available in more homes, individuals will increasingly use elements of the CPR and CPR-related technology to search through the health literature, communicate with their health care professionals, access data on their health care history, track the costs and value of the services they receive, diagnose acute conditions, and manage chronic conditions. The emergence of personal health information systems—customer-based personal health records—that are responsive to a variety of needs of individuals raises new opportunities for systems developers to provide complicated information in an easily understood format. Moreover, integrated delivery systems may increasingly view customer-based personal health record systems as a means of attracting new members, streamlining communication with patients, and diagnosing and monitoring patient conditions remotely and cost-effectively.

The demand for CPR systems has steadily increased since the release of the first edition of this report. CPR innovators—in the United States, Europe, and elsewhere—are proving not only that CPRs can meet users' needs, but also that there are significant benefits to be gained from their use. Recent experience has shown that access to data and information at the point of care and the ability to analyze data for management and research purposes improve the quality and reduce the costs of care. These capacities are critical for any health care provider—whether a group practice, hospital, or integrated delivery system—to function successfully. Thus, CPRs are, and will continue to be, an essential technology for health care.

Today there are several examples of quite robust hospital-based CPR systems developed by individual institutions, and commercial systems have moved toward achieving the 12 attributes of CPRs outlined in the original report. Plenty of room remains, however, to combine the depth of systems developed by institutions with easily modified, modular architecture, readily available technology, and the use of national standards. Even as CPR systems become increasingly robust, there is not, nor is there likely to be, a single CPR product that meets all the needs of a provider organization. Thus, organizations seeking CPRs face significant challenges in integrating various systems to achieve the full functionality they need. Moreover, CPR diffusion goes far beyond technology within an organization and relies at least as much on a change in culture that requires motivated, educated leadership within institutions.

Until CPR use becomes the norm for all practitioners across all provider settings as recommended in the original report, we will continue to lack the tools needed to manage the quality and costs of health care, the scientific basis for health care will continue to be undermined, and the dramatic transformation of health care so urgently required will be impeded. Thus, a major challenge facing us is to determine how to advance from where we are to where we need to be with respect to the development and diffusion of CPRs. How can we take full advantage of the lessons learned by the leaders in CPR

development and reduce the problems for future CPR users? Where should we as individuals and organizations interested in achieving the potential of CPRs devote our time and financial resources?

The two commentaries give readers an opportunity to reflect on these questions. In the first chapter of this edition, Drs. Tang and Hammond describe environmental changes that reinforce the need for CPRs, review developments in the United States since 1991, and provide insight into remaining challenges. In the second chapter, Drs. van Bommel, van Ginneken, and van der Lei describe the state of CPRs in Europe. In so doing, they highlight areas in which efforts in the United States can benefit from European experience; for example, the entire European community has a ubiquitous privacy law whereas the United States cannot seem to accomplish this important objective. They also report that there has been more activity on CPR systems for generalists compared to the United States, where the early focus of CPR development efforts was heavily tilted toward the hospital environment. Not surprisingly, both chapters emphasize the need for collaboration to further refine CPRs.

The commentaries also provide a sense of the impact of the recommendations in the original report. Briefly, varying degrees of progress can be observed on the seven recommendations originally made in Chapter 5 of this report. First, some institutions have implemented computer systems that fulfill many of the desirable functions of a CPR as their standard record for patient care; other institutions and providers are using both paper and computer systems, but see CPRs as inevitable. Second, since its creation in 1992, CPRI has been a focal point for CPR issues and has grappled with the challenges of expanding the understanding of the pivotal role of CPRs in health care delivery and of eliminating key barriers to CPR diffusion. Toward that end, in November 1996, CPRI organized a CPR summit with other major health informatics organizations to ratify and endorse actions that will overcome barriers to effective use of information technology in health care. The summit was successful in generating a high degree of consensus for immediate action.

Third, support for CPR research and development for CPRs exists, but it has not been provided in the scope and scale necessary to enable major breakthroughs. Federal funding in the United States has been modest and inconsistent; it is typically focused on research issues and is not always directly related to the development of working CPR systems. In general, private health foundations have been distressingly slow to invest their resources in this critical area and the potential for collaboration between the public and private sectors to direct policy and to leverage resources has not been achieved.

Fourth, although work on various standards has been steady and limited progress is evident, setting standards remains an arduous process with limited financial support. Moreover, a greater focus on international standards is needed. Fifth, federal laws related to CPRs (e.g., data ownership, responsibility, and confidentiality) are still lacking. At least in the case of protection of personal health data, lively discussion and debate have prevented a consensus leading to the enactment of sound policy. On a more positive note, however, the United States Department of Health and Human Services has created a

high-level data council, and its National Committee on Vital and Health Statistics is refocusing its efforts on the handling of data in part through the mandate of Public Law 104-191, the Health Insurance Portability and Accountability Act.

Sixth, no progress can be reported on the recommendation that the costs of developing and implementing CPRs should be shared among those who benefit from them. The cost of capitalizing CPR systems remains a significant hurdle for individual institutions, and it is a serious policy issue that must be addressed. Finally, anecdotal evidence indicates that there are better educational opportunities for health care professionals to acquire the skills necessary to develop and use CPRs. There is, however, an equally important need to educate administrators and other people involved in allocating resources to and selecting CPR systems about both the benefits and complexities of CPR systems.

An important issue emerges after reviewing the limited impact of the committee's seven recommendations over the past 6 years. What else needs to be done to advance CPRs? What would help to jumpstart this process and expedite progress toward the committee's original goal of widespread implementation of CPRs by 2001? Again, the commentaries shed light on these questions. The original report called for federal support of CPRI, public and private support of research and development, federal laws related to CPRs, and collaboration among various public and private groups to explore CPR reimbursement mechanisms.

As Drs. Tang and Hammond report, individual federal agencies have played a role over the past few years, but a coordinated, comprehensive, funded policy has not emerged. In contrast, Drs. van Bommel, van Ginneken, and van der Lei report on several specific ways in which the European Union is supporting CPR development. Thus, in the United States, we need to establish the appropriate role of government, particularly the federal government, in advancing the development and implementation of CPRs.

A coordinated national program for CPR advancement in the United States could be based on the seven recommendations presented in the original report. Such a program would build on existing private-sector efforts and strengthen them by bringing both policy and funding leverage that the private sector cannot provide alone. As was emphasized in the original report, the federal government should not take exclusive control of CPR development and implementation; the private sector's perspectives are vital to a sound approach to CPR development.

Several of the remaining critical impediments to CPR development outlined in the commentary by Drs. Tang and Hammond are not just intractable, but virtually impossible to overcome, if pursued by the private sector alone. Moreover, crucial incremental efforts are more likely to succeed in the context of a comprehensive national program. There is every reason to push for increased government involvement without delay so that quality, cost, and access to modern, evidence-based health care can be achieved. The original 10-year target remains within reach, but only if a national effort is undertaken immediately.

Significant challenges abound: building the requisite infrastructure, optimizing the available technology (including integrating various systems), ensuring the availability of enough people with the right skills, addressing organizational culture and change issues, and confronting financing and policy issues. Clearly, this most essential of all elements of modern health care—a robust CPR—has a growing body of advocates. The challenge is to coalesce these parties into a public-private partnership dedicated to creating through the information infrastructure a better health care system for all Americans. As the Preface to the first edition concluded,

Success will require cooperation and coordination, and perhaps some sacrifice and compromise as well, but we are fully convinced that the outcomes will be well worth such an effort. What we believe will emerge will be a more caring, more scientific, and no less important, more cost-effective health care system. (*Pp. vi-vii*).

We hope that this report will continue to be a catalyst to encourage people to take advantage of the opportunity at hand. We must move from debate and discussion about the remaining impediments to education, investment, and most important, to action by both the private and public sectors to realize the potential of the CPR as an—perhaps the—essential technology for health care.

Don E. Detmer, M.D., and Elaine B. Steen, M.A.

Preface—Original Edition

Health care professionals and policymakers seeking to ensure greater value in health care services face many boundary conditions that are fixed and a host of problems that are not. Today, the opportunity to affect one of those boundary conditions—the information management capabilities in health care—is within our grasp. This report advocates the prompt development and implementation of computer-based patient records (CPRs). Put simply, this Institute of Medicine committee believes that CPRs and CPR systems have a unique potential to improve the care of both individual patients and populations and, concurrently, to reduce waste through continuous quality improvement.

We are not suggesting a simple automation of the current patient record. Rather, we envision the next generation of CPRs and CPR systems as essential to the full maturation of the scientific basis of health care. The report outlines the basic components of future CPRs and a strategic plan for achieving widespread CPR implementation. Further, it identifies the key organizations that will need to play major roles if the plan is to succeed.

The vision of the patient record of the future that emerged from the committee's deliberations seems uniquely appropriate for a nation that values pluralism and privacy and has a mobile population with growing levels of chronic illness. CPRs are a key infrastructural requirement to support the information management needs of physicians, other health professionals, and a variety of other legitimate users of aggregated patient information. It is this vision, as much as any other message, that the committee hopes will engage the reader. We believe that if enough individuals become embued with this sense of the possible, the reality will emerge.

Our report is intended for a very broad audience. We see it as especially pertinent for physicians and other health care practitioners; health care managers; medical record professionals; health services researchers; medical informatics researchers; computer vendors; third-party payers; the legal community; federal, state, and local health care agencies; state legislators; members of the federal legislative and executive branches of government; and, finally, interested citizens. All these parties, we believe, have much to gain from the success of CPRs and CPR systems.

Happily, this report complements and is complemented by several other recent activities that convinced us, as we proceeded with our work, that the time was ripe for a major CPR initiative. The Office of Science and Data Development of the Agency for Health Care Policy and Research (AHCPR) is leading efforts to improve the quality and quantity of data available for health services research—particularly effectiveness, appropriateness, and out-comes research. In addition, the AHCPR Forum on Quality and Effectiveness in Health Care, the American Medical Association, and other professional organizations are playing a major national role in the development of clinical practice guidelines. The CPR will be a boon to both these endeavors.

The activities of several other groups also lend support to the move toward widespread implementation of computer-based records. The General Accounting Office recently released a forward-looking report on the potential benefits of patient record automation. Several Institute of Medicine reports published over the last two years cite the need for improved patient data collection to support quality assurance, utilization management, and effectiveness research. The National Science Foundation recently issued a report on the benefits of a national system for very high speed data communication, including health data. Finally, the National Research Council's recently released report on safe computing in the information age outlines problems and opportunities in computer security.

Given this apparent climate of opportunity for CPR development and implementation, the committee came to the end of its work eager to disseminate its message regarding the feasibility and potential of CPRs and CPR systems. The natural ebullience common to the conclusion of a study was tempered, however, by the untimely death of committee member Nicholas E. Davies. Dr. Davies saw more clearly than many of us what needed to be done to implement the vision of fully developed patient records and had committed his considerable personal energies to achieving our collective goals for CPRs and CPR

systems. For this reason we feel it appropriate to dedicate this report to him and to his belief in our vision.

If this project is to succeed, we must soon see organizational efforts that adopt and implement, or refine and implement, our recommendations. Success will require cooperation and coordination, and perhaps some sacrifice and compromise as well, but we are fully convinced that the outcomes will be well worth such an effort. What we believe will emerge will be a more caring, more scientific, and, no less important, more cost-effective health care system. We hope that this report will be a catalyst to encourage you to join with us to address the opportunity at hand.

Finally, on a personal note, the enthusiasm, involvement, and support of the many individuals and institutions acknowledged elsewhere in this report were deeply appreciated.

Don E. Detmer, M.D.
Chair

Acknowledgments—Revised Edition

This revised report was an unusual effort stimulated by both the widespread interest in the original committee report and the rapid pace of developments since the publication of that report. In addition to the authors of the two commentaries, the editors want to acknowledge the contributions of Octo Barnett, M.D., Harvard University, who substantially strengthened the commentaries through his rigorous review. At the Institute of Medicine, Marilyn J. Field, Ph.D., Deputy Director of the Division of Health Care Services, offered to steer the revised report through the various stages of fundraising, editing, report review, and publication. Karla Saunders worked with drafts of the national and international commentaries to prepare them for review and for publication. Claudia Carl, Mike Edington, and Mona Brinegar provided additional assistance at various stages in the process. Margret Amatyakul, Executive Director of the Computer-based Patient Record Institute, was instrumental in helping to raise funds and otherwise support this revised edition.

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American Health Information Management Association, Ernst & Young LLP, and Hewlett-Packard.

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Acknowledgments—Original Edition

The committee would like to express its appreciation for the contributions of many individuals and organizations to this project. In addition to the subcommittee members listed in Appendix A, more than 200 individuals representing organizations throughout the health care sector attended subcommittee meetings or submitted written information, providing the committee with a broad base of information from which to draw. Several subcommittee members led work groups or prepared papers and presentations. Subcommittee chairs and assistant chairs in particular devoted significant amounts of time preparing for their meetings and writing reports of subcommittee findings for use by the full study committee.

Several individuals prepared background papers that were most helpful to the study committee and staff. In addition to Adele Waller (whose paper appears in this volume), the committee acknowledges the contributions of Paul Tang, Donald Lindberg and Betsy Humphreys, Margret Amatayakul and Mary Joan Wogan, John Silva, and Orley Lindgren and Don Harper Mills. The committee also expresses its gratitude to the participants of a workshop on overcoming barriers to patient record development who provided the committee with a sounding board for its ideas about an organizational framework to accelerate such development.

This study would not have been possible without financial support from many entities. Within the private sector, we acknowledge generous support from the American Medical Record Association, Baxter Healthcare Corporation, Booz-Allen and Hamilton, E. I. du Pont de Nemours and Company, Gerber Alley and Company, the John A. Hartford Foundation, Hewlett-Packard Company, IBM Corporation, Kaiser Foundation Hospitals,

and Science Applications International Corporation. Within the public sector, the Department of Veterans Affairs, the Health Care Financing Administration, and the Health Resources and Services Administration provided important funding for the study. The Agency for Health Care Policy and Research (AHCPR) sponsored a workshop on overcoming barriers to patient record development that provided valuable information for the committee's deliberations. Preliminary staff work on the study was supported in part by the Institute of Medicine Council on Health Care Technology, which received financial support from AHCPR's predecessor, the National Center for Health Services Research and Health Care Technology Assessment.

We are indebted to several Institute of Medicine staff members. Enriqueta Bond and Richard Rettig oversaw the initiation of the project. Maria Elena Lara and Ethan Halm provided staff support, and Clifford Goodman (now with the Swedish Council on Technology Assessment in Health Care) provided guidance in the early stages of the study. Karl Yordy, and particularly Kathleen Lohr, helped steer the study through its later phases. Elaine Steen and Richard Dick provided staff support throughout the study and were responsible for preparing this report on behalf of the committee.

All studies rely on the efforts of administrative and financial staff for day-to-day operations. The committee appreciates the contributions of Holly Dawkins, Suzanna Gilbert, Evanson Joseph, Theresa Nally, Delores Sutton, and H. Donald Tiller in project administration and Cynthia Abel, Lisa Chimento, and Nina Spruill in financial administration. Finally, we thank Leah Mazade for her editorial comments on this report.

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Adele A. Waller

Commentary

A Progress Report on Computer-Based Patient Records in the United States

Paul C. Tang and W. Ed Hammond

Much has changed since the release of the first edition of *The Computer-Based Patient Record: An Essential Technology for Health Care*. The current environment in which health care is practiced and the information technology available to its practitioners are significantly different from that which existed when the study was completed in 1991. Changes in the health care environment produced fundamental shifts in the delivery of health care, favoring outpatient care over inpatient care, primary care over specialty care, and guidelines-driven care over autonomous decisionmaking. Technological advances have overcome some barriers to computer-based patient records (CPRs) (e.g., World Wide Web, applications that operate across distances on many different computers) and heightened the visibility of others (e.g., confidentiality policies and legislation). In this commentary, we describe some of the environmental and technological changes that have occurred since publication of the first edition and highlight the challenges that remain to be addressed. Probably the most significant nontechnological change that occurred since 1991 was the change in the health care practice environment. We begin by addressing the new environment.

THE CHANGING HEALTH CARE LANDSCAPE: REINFORCING THE NEED FOR CPRs

As health care costs in the United States approached \$1 trillion in the early 1990s, businesses, consumers, and payers began to call for mechanisms to manage the escalating costs (IOM, 1993). This issue was so much at the forefront of U.S. business and political priorities, that the 1992 presidential election was dominated by discussions of health care costs and debate on effective ways to control them.

Although efforts at full-scale health care reform led by the federal government gained momentum, peaked, and then disintegrated, market-driven changes in health care delivery were already under way and steadily moving forward. Managed care plans continue to gain increasing shares of the market (Hoechst Marion Rousell, Inc., 1995). The need to examine and manage the health needs of a population has dramatically increased the demand for information systems that capture clinical data. The health care information systems industry has shifted its attention from financial systems to clinical

systems, particularly CPR systems. Two core tenets of managed care that impact the demand for CPR systems have been the central role of primary care and the emergence of integrated delivery systems.

The Evolving Role of Primary Care

Managed care has redefined the primary care provider as the principal provider of care and, in many instances, a gatekeeper for access to certain diagnostic tests and specialty care. To efficiently carry out these roles, the clinician needs ready access to both clinical and administrative data. At the same time, guidelines are being promoted to reduce the variances among clinical practices. When guidelines are integrated into a CPR system, they can streamline the steps necessary to adhere to them and simultaneously document that compliance. CPR systems that integrate clinical guidelines in the order-entry process have the best acceptance among providers (Sittig and Stead, 1994; Sullivan and Mitchell, 1995; CPRI, 1996c, 1997). However, despite the abundance of guidelines, few can be implemented in a computer as written (Tierney et al., 1995). Software tools are needed to help author guidelines that are internally consistent, include precise definitions of eligibility criteria, and accommodate a variety of patient conditions.

One of the major goals of managed care is to provide more of the care outside of the hospital. However, the inpatient and the outpatient settings differ substantially. There are differences in the temporal nature of information, the responsibilities of each member of the health care team, the need for a communications infrastructure to facilitate coordination of care, and other logistical concerns which impact the detailed design of information systems. Consequently, vendors of information system products for hospitals find that there is a steep learning curve to understanding the information needs of physicians in the ambulatory care setting. Deliberate analysis of the information needs and work flow requirements in ambulatory care will help system developers design information systems that increase the efficiency and effectiveness of clinical practice throughout the continuum.

The Integrated Delivery System

Another fundamental concept that heightens the need for CPR systems is that of an integrated delivery system (IDS). An IDS is composed of health care providers, service providers, and facilities organized to provide a continuum of health care services to a defined population. These systems of health care were created in response to payers' desire to contract with single entities that provide comprehensive health care services for their clients. To manage the delivery of care in an IDS, a health system must have efficient and accurate ways of capturing, managing, and analyzing clinical data collected at all the different sites where care is provided.

In addition, payers and regulators are requesting "report cards" on quality, outcomes, and costs of care provided by the integrated delivery system. For example, the National

Committee for Quality Assurance (NCQA) developed the Health Plan Employer Data and Information Set (HEDIS) as a standard report card to help employers evaluate different health plans. Initially focused more on administrative data, the evolving HEDIS criteria are increasingly targeting clinical processes and outcomes. Gathering the data to prepare these reports can be immensely time-consuming and costly when they are manually abstracted from paper records, but with a CPR, reporting on aggregate data can be a byproduct of capturing data electronically.

NCQA advised health plans to "move to fully implement the information framework, including the automated patient record" in order to meet the clinical reporting requirements of forthcoming regulations (NCQA, 1997). As outcomes reporting requirements become more sophisticated and deal with complex, multifaceted diseases, it will be essential to have electronic access to the record and tools to efficiently analyze practice patterns and patient outcomes. NCQA will develop HEDIS measures that assume health plans and provider organizations use CPRs by 2002.

In short, since the release of the first edition, the demand for clinical data has become a business imperative. The organizational complexities of these large, diverse, and geographically dispersed health systems add new challenges—and new opportunities—for developers and implementers of CPR systems.

Technological Advances

Computer processing power doubles in performance and halves in cost about every 2 years. These past 6 years have been no exception. Although it is not our intent to review all the developments in information technology (because technology has not been the critical impediment to adoption of CPR systems), three striking technological shifts have occurred that favorably impact the foundation for CPR systems. We briefly describe these developments below.

The Internet and the World Wide Web: Widespread Connectivity

Perhaps the single biggest technological change since the first edition of the report is the rising importance of the Internet. Although the Internet dates back to 1969 when the first node of ARPANET was installed at the University of California at Los Angeles, several changes have coalesced to bring together a paradigm shift that now touches all segments of society. The World Wide Web (WWW) has transformed a research network into the fabric of a new information age. Internet service providers have made access convenient and reasonably inexpensive. As much as 50 percent of the U.S. population will have access to the Internet by early in the next century (National Research Council, 1996). It is precisely this kind of ubiquitous connectivity that enables IDS organizations to share data throughout their geographically dispersed clinical delivery sites, and even to reach the consumer or patient at home. To the extent that health care becomes dependent on access to computer networks, however, policymakers need to pay special attention to the needs

of the medically underserved population to ensure that lack of network access does not further impede their access to care.

Connectivity is not the only requirement for transmitting patient data to remote sites. Confidentiality and security safeguards need to be developed and enforced. Fortunately, the requirements of business to protect electronic commerce over the Internet will drive technical solutions and policy standards, which health care applications can leverage. Technology dedicated solely to health care applications risk being orphaned due to the lack of a mass market. The market drive of consumerism must pave the information infrastructure for health care applications.

World Wide Web Browsers: A Universal View on the Internet

Probably the most important tool that led to the domestication of the Internet was the development of software that made it easy to connect to, search, browse, and download information from anywhere on the network as if it were located on the user's personal computer. Commonly called browser software (e.g., Netscape NavigatorTM, Microsoft Internet ExplorerTM), these programs give a graphical, intuitive, and common interface to functions that locate and interact with remote data on the Internet without the user having any technical knowledge of how it is done. Browser user interfaces have become so commonplace that they are being adopted as the interface to desktop computers.

Another fundamental breakthrough associated with WWW browsers is that the software runs on almost any computer (Cimino, 1995). One of the critical problems that had been plaguing computer users since the invention of electronic computing has been the general inability of programs written for one machine to run on another machine or to use data generated by another program. Efficient and cost-effective use of computers suffered due to the incompatibilities caused by a lack of standards. The WWW defined standards for document formats (hypertext markup language, HTML) and transfer protocols (hypertext transfer protocol, HTTP). Compliance with these standards permitted independent developers to write programs for heterogeneous computers and operating systems, yet have them all seamlessly access information on the WWW.

The success of the WWW demonstrates the market-expanding potential of adopted standards. It also demonstrates the remarkable leverage provided through natural entrepreneurial forces complying with industry standards. The benefits to the consumer, including clinicians, are tremendous.

The Intranet

A variant, but powerful spin-off, of the Internet is the Intranet, a controlled-access version of the Internet. Like the Internet, Intranets use industry-standard document formats, data exchange protocols, and browsers. The prolific development of new tools and products for the Internet can be directly applied to Intranets. An estimated 80 percent

of the Internet products are purchased for use on an Intranet. The Intranet, however, typically has better bandwidth, security, and administration because it is controlled and operated by the private enterprise. These advantages are particularly important for health care applications, and most health care organizations are exploring the use of Intranets as a component of their information strategy.

Network-Centric Computing

Industry is at the cusp of another major change—network-centric computing. The predominant paradigm for computing today uses personal computers (PCs) to perform most of the computational work using software that resides on local disks. The hardware, software, and support costs for this type of operation require large budgets and staffs.

Network-centric computers are diskless computers that attach to a network and load software stored on a server computer. The capability to manage hardware and software more centrally reduces the acquisition and operating costs for the enterprise. Although this new architecture has not been used extensively in production, it has the potential to revamp distributed computing.

Having noted the significant changes in the health care environment and advances in information technology, we next discuss the current state of the CPR.

THE CURRENT STATE OF CPRs

As discussed in Chapter 4 of the report, the development and diffusion of a new technology are separable but interrelated events. In discussing the state of CPR development and implementation in the United States today, it would be desirable to examine two questions. First, to what extent have CPRs, as defined by the study committee, been developed? Second, to what extent have the available CPRs been adopted? Unfortunately, a comprehensive review of the industry does not exist, and it would soon be out of date if it did. Alternatively, one could rephrase the questions from the perspectives of providers and vendors. From the perspective of system purchasers, do the CPR systems that are available in the market meet the needs of health care institutions? And from the perspective of vendors, is the market ready to buy CPR systems? Although in neither case is the answer a resounding "yes," promising signs can be reported.

The CPR Market

One must be careful when describing a "CPR market" not to tether the concept to a single, static idea whose incarnation can be purchased "off-the-shelf." In some sense, it is precisely the static nature of the paper-based record that has been such a great burden to the practice of medicine. Instead, a CPR system is a constantly evolving concept whose

value and function is expected to grow with the constantly changing demands of the health care environment and the improving technology upon which the system is built. The level of CPR development activity has definitely increased significantly since 1991. The number of commercial systems addressing various attributes of CPRs has increased and most major health care information technology vendors now offer CPR-related products. However, comprehensive information system products that seamlessly integrate data and coordinate processes across the entire continuum of health care services do not exist. Most health care information system vendors, whether their products were formerly based in the inpatient or the outpatient side, are working to extend their products to cover the needs of integrated delivery systems. Developers generally start from the data end of the system and work toward the human side where the clinician interacts directly with the system. Hence, one way to trace the evolving functionality is to look at the transformation of data into information that clinicians use to make decisions. Although the path is not necessarily sequential, five hallmarks of this transformation are enumerated below:

1. Integrated view of patient data,
2. Access to knowledge resources,
3. Physician order entry and clinician data entry,
4. Integrated communications support, and
5. Clinical decision support.

Integrated View of Patient Data

This is one of the earliest benefits of CPRs—improving access to all patient data whenever and wherever clinical decisions are made independent of where the data was originally acquired. Observational studies of clinicians' information needs provide details on the kinds of information physicians require to make decisions regarding the care of their patients (Tang et al., 1994). Up to 81 percent of the time, physicians could not find all the available patient information desired to make patient care decisions during an outpatient encounter. Limited by a format that has not substantively changed in close to a century, the paper record is ill-suited to the information demands of modern clinical practice. Most CPR system vendors offer products that combine data from various sources and present an integrated view to clinicians.

Access to Knowledge Resources

Providers often need other information in addition to patient data and their own personal knowledge (Covell et al., 1985). The guidelines, rules, and regulations in the managed

care environment have intensified this need to access medical and administrative knowledge at the time decisions are made. CPR systems sometimes provide methods for organizations to incorporate access to local knowledge resources, but generally, this knowledge access is passive. That is, the user searches for the needed information electronically but has to abstract the pertinent content and enter any relevant orders manually into the clinical system. Ideally, access to knowledge resources should be integrated with clinical decision support in ways that directly influence physicians' ordering behavior, as described below.

Physician Order Entry and Clinician Data Entry

Physician orders initiate clinical interventions. Proactively influencing physicians' orders is the most efficient way to influence patient outcomes (McDonald, 1976, 1984). Systems that physicians use routinely to enter orders, whether in the inpatient setting or outpatient setting, can produce significant effects on quality and costs of care (Barnett, 1984; Tierney et al., 1987, 1990, 1993; Sittig and Stead, 1994). In addition, when clinical data are entered and maintained by the clinicians responsible for care, the accuracy and quality of data are high. Very few commercial systems, however, are used by physicians to write all their orders. Human-computer interface issues and perceived benefit substantially affect the success of this function. Some of the reasons are discussed later under remaining barriers.

Integrated Communications Support

With an increasing emphasis on outpatient care, coordinating the activities of health care professionals from multiple organizations at different sites, including the home, becomes more important. No longer confined to an acute care facility where proximity between the health care team members and the patient was the rule, the patient and care team in the outpatient setting meet more by appointment than by clinical demand. Relying on paper-based mail is inefficient and fallible. Clinicians need integrated communications support for effective functioning of the multidisciplinary outpatient health care team (Tang et al., 1996). A communications infrastructure that is linked to the shared patient record facilitates overall coordination of care and timely response to changing patient conditions.

Clinical Decision Support

Few, if any, commercial systems provide a high level of proactive decision support. Drug interaction checking and simple abnormal laboratory-test result alerts are available, but the richness of applying a broad range of knowledge to influence physicians' orders is still under development (Johnson, 1994).

Only when both patient data and clinical knowledge reside in the system in machine-understandable format can the system provide additional support to the clinician making decisions. For example, encoded medical knowledge about the meaning and significance of changing laboratory-test results would allow a system to provide alerts, an active function, in addition to the passive data retrieval function. Similarly, if the system could match the patient context with relevant clinical guidelines, it could present ordering options consistent with the appropriate guidelines. The clinician is responsible for the definitive decision, but the system can actively provide options and explanations that improve the clinician's efficiency and compliance with accepted guidelines of practice.

In summary, since the first edition, there has been a significant increase in development efforts on CPR systems. We remain optimistic that the remaining years of the decade-long challenge will deliver on the promises of computer-supported decisionmaking.

At the Fork

In 1991, the Committee on Improving the Patient Record reported that the most advanced CPR systems were found in several academic medical centers or teaching hospitals affiliated with universities as well as in the Department of Veterans Affairs and the Department of Defense. Not surprisingly, today the most advanced CPR systems implemented in the United States can be found in the same places. Of the seven institutions that have been recognized as part of the Computer-based Patient Record Institute Davies CPR Recognition Program (described below), four are academic medical centers and one is the Department of Veterans Affairs. One of the distinguishing factors of institutions that have been recognized as having advanced CPRs is the clear organizational leadership and commitment to CPR system implementation that helped make their efforts successful (CPRI, 1995c, 1996c, 1997).

A comic saying attributed to Yogi Berra states: "When you come to the fork in the road, take it." In contrast to the early CPR system adopters, most health care institutions are standing at the fork, trying to decide whether or not to begin implementing a CPR system. Those who have made the decision to invest in a CPR system are grappling with the complicated issue of how to do so. Many organizations implement the CPR system in some, but not all areas. Others implement a partial system and depend on a combination of paper and electronic documentation. All adopters of CPR systems must address how to integrate the components of the CPR and how to integrate the CPR with other institutional information systems. The challenge of implementing such an expansive, robust system is daunting, but the option of continuing to manage the clinical and administrative data of an IDS on paper is increasingly becoming a nonviable alternative.

Recent Activity to Advance CPRs in the United States

Against the backdrop of technical and nontechnical changes, interest in and incentives to develop CPR systems have increased.

The National Library of Medicine (NLM) has been at the forefront in stimulating research on the effective use of CPR systems and networked access to shared data (Lindberg, 1995). NLM conducts intramural research that is directly applicable to technological and infrastructural needs of CPR system development and effectively uses its extramural research grants and contracts to apply the results of academic research to health care. Through its High-Performance Computing and Communications contracts, NLM has been a leader in facilitating the use of information technology by health care professionals of rural, urban, community, and statewide networks around the country. NLM's extensive work on the Unified Medical Language System (UMLS) has been a major contribution in the medical terminology arena. NLM and the Agency for Health Care Policy Research (AHCPR) are sponsoring a large-scale vocabulary test to assess the "extent to which a combination of existing health-related classifications and vocabularies covers vocabulary needed in information systems supporting health care, public health, and health services research" (Humphreys et al., 1996). NLM is further extending the reach of shared computer-based patient data and systems through its telemedicine program.

Due to AHCPR's role in developing scientifically based clinical guidelines, it has long recognized the importance of standard data definitions and capturing clinical data in structured form. AHCPR has also played an active role in facilitating standards development. Widespread use of CPR systems would not only facilitate the collection of aggregate data in support of guidelines development, but also make effective the dissemination and use of clinical guidelines in clinical practice.

In addition to the efforts undertaken by NLM and AHCPR, other federal agencies, including the Department of Defense, and the National Institute of Standards and Testing have internal and extramural activities in CPR systems. However, a cohesive federal policy to speed the development of a health information infrastructure and the diffusion of CPRs has not emerged in the United States (Shortliffe et al., 1996).

One focal point for accelerating the development of the infrastructure for CPR systems (e.g., confidentiality policies, standards, evaluation criteria) in the private sector has been the Computer-based Patient Records Institute (CPRI). CPRI was formed in response to the recommendation of the Institute of Medicine (IOM) study committee to promote and facilitate the development, implementation, and dissemination of the CPR. Led by many of the initial supporters of the IOM committee, CPRI was incorporated in January 1992, as an association of organizations representing the various stakeholders in health care. In its first year, 22 organizations became members of CPRI. Over the subsequent years, the organization has grown to more than 70 members. CPRI was charged by the IOM committee with the following objectives:

1. Support the effective, efficient use of computer-based patient records.
2. Educate change agents and stakeholders about the value of CPRs in improving patient care.

3. Foster the CPR as the primary vehicle for collecting patient data.
4. Promote the development and use of standards for CPR security and data content, structures, and vocabulary.

Despite efforts in the public and private sectors, however, significant barriers impede the development and use of CPR systems in the United States. Many of the remaining critical barriers to CPR system development and routine use concern problems that are most effectively dealt with by cooperative, focused activity. We describe some of these barriers below.

Remaining Barriers or Challenges

Technology has continued to move forward at a rapid pace. By comparison, the human and organizational sides of the challenges have remained relatively stagnant. In 1991, the committee stated that informational, organizational, and behavioral barriers must be addressed to advance CPR systems, and that these barriers overshadowed the technical barriers. Below, we elaborate on some of the critical barriers to CPR development and diffusion.

Definition of the CPR

Although work on a common definition of a CPR and CPR system is under way by various groups, a universal understanding of the concepts embodied in a CPR does not exist. Without a clear understanding, users have a difficult time selecting systems that will meet their needs and vendors have difficulty supplying such systems. CPRI described a CPR as "electronically stored information about an individual's lifetime health status and health care." It replaces the paper medical record as the primary record of care, meeting all clinical, legal, and administrative requirements. A CPR system provides reminders and alerts, linkages with knowledge sources for decision support, and data for outcomes research and improved management of health care delivery. It is worth repeating a point made earlier that a CPR system is an evolving concept that responds to the dynamic nature of the health care environment and takes advantage of technological advances.

Beyond the first set of definitions, however, few details have been worked out and agreed upon. For example, there is no common data model for the CPR, no common set of data elements, no common vocabulary, and no common set of scenarios that are supported. These requirements are fundamental if developers are to create a person-centered CPR that links care across different sites, specialties, and circumstances.

Many systems still follow the traditional organization and characteristics of the paper-based system and have simply automated that system. Narrative documentation, for example, is far more prevalent than structured text. Even though most new CPRs support

a multimedia record, new data forms have not been smoothly integrated into the record, and little has been done to evaluate their true worth. Finally, the concept of incorporating patient-derived information (e.g., health status) as part of the patient record has not been implemented to any significant degree.

Meeting User Needs

In order for clinicians to rely on data in the system, they must be the direct users of the system. The emphasis on clinical data is a fundamental change from the previous era of hospital information systems, where clerks were the main users because the primary motivation was to capture charges and generate bills.

Analysis of the common questions concerning patient information that physicians ask (e.g., what evidence supports the diagnosis, has a patient ever had a specific test, and has there been any follow-up because of a particular laboratory test result?) provides insight into the difficulties clinicians have had finding the answers in the paper-based chart. Although current computer-based tools installed in health care institutions can typically help clinicians retrieve laboratory test results, they are not designed to answer many of the common questions clinicians ask about patient data. CPR system developers will need to address these needs to satisfy the new clinician users. The maker of the Swiss Army Knife describes the key to inventions as follows: "Make it useful. Very useful. Conveniently useful. . . ." Likewise, key to gaining clinician user acceptance is providing efficient tools that help clinicians retrieve and understand data relevant to their decision-making tasks.

Clinicians also need answers to many questions regarding medical knowledge (Covell et al., 1985). Diagnostic decision support tools are available as stand-alone microcomputer programs (e.g., QMR, Iliad, DXplain) or are available over the Internet (e.g., DXplain; Miller et al., 1986; Barnett et al., 1987; Feldman and Barnett, 1991; Berner et al., 1996). However, their greatest use would occur when proven diagnostic decision support tools are integrated with CPR systems.

Among the more challenging issues confronting CPR system developers is the issue of effective user-computer interfaces. Physicians must be the users of the system, performing data entry (e.g., orders, progress notes) as well as information retrieval, if they are to realize the benefits of interactive, on-line decision support. Progress must be made in understanding the "cognitive processes involved in human-computer interactions in order to design interfaces that are more intuitive and more acceptable" (Tang and Patel, 1994). Cognitive issues are also relevant to designing the presentation of clinical information in ways that facilitate rapid assimilation and analysis. Ultimately, good solutions to the human-computer interface will require changes not only in how the system looks but also in how humans interact with the system. What information the provider needs and what tasks the provider is performing will influence what is presented as well as how it is presented. Templates that reflect providers' work flows will aid them in using the system efficiently. Defaults that represent common, desired selections, for

example, not only improve efficiency but also help increase compliance with practice-defined guidelines (CPRI, 1996c, 1997).

Although user acceptance was a major barrier in the past, more and more users are demanding that organizations implement computer-based means for accessing and managing patient data. This is not to say that the cultural and organizational challenges associated with major change are not substantial barriers to overcome, but the users' awareness of the potential benefits will become an increasing catalyst for change.

The change in users and uses has a dramatic impact on the applications desired and the kinds of user interfaces required. The industry must now focus on a completely different set of users and must define and address their information needs. Proactive and informed user participation will be necessary for implementations to succeed. The attention to clinical data and clinical users described in this report is even more important today than it was 6 years ago.

Standards

Rather than existing as a monolithic system, contemporary health care information systems are made up of multiple-component systems manufactured by multiple vendors, owned by multiple entities. To share data, which is required in an IDS, industry-adopted standards must be defined for interfaces between components (AMIA, 1994; Hammond, 1994).

Health systems must have a unique health identifier (UHI) to accurately and reliably link all the data on a single individual. Until last year, striving for a national UHI had been an elusive goal. Public Law 104-191 (The Insurance Portability and Accountability Act of 1996) calls for the secretary of Health and Human Services "to adopt standards for unique health identifiers, confidentiality policies, and terminology." To build support for addressing these pivotal issues, in November 1996, CPRI convened a national Summit of over 80 senior executives representing health care providers, health systems, government agencies, information systems vendors, businesses, regulators, and quality assurance professionals. The organizations participating in the Summit developed consensus recommendations regarding a unique health identifier, confidentiality legislation and policies, and standard health terminology. CPRI was charged with follow-up actions to work with government agencies and industry groups to implement the recommendations.

The need for standards governing the content, vocabulary, and format of data remains a high priority. So far, most of the progress has been made in the development of messaging standards. Standards for data exchange have continued to be expanded and are increasingly being adopted by provider organizations and vendors. Standards now exist for exchanging clinical data (Health Level Seven [HL-7], 1994), images (ACR/NEMA), clinical observations (ASTM Committee E-31), bedside instrument data (IEEE, 1995), prescription data (NCPDP, 1992), and administrative data associated with claims (Accredited Standards Committee X12N). It is important to note, however, that even with

standards that define message formats, implementation of messaging standards may differ among vendors. The next step is to call on industry to provide standard implementations for messaging standards such as HL-7. That would be a major step toward "plug-and-play" capability.

Although there has been progress in developing individual coding standards for data elements, none has emerged as a comprehensive standard. More than 150 different coding sets defining terms for use with the medical record have been created. Among these coding sets are ICD9-CM, ICD10, SNOMED III, CPT, NANDA, Read Classification, LOINC, and MEDRA, to name a few. Not only findings, but also results of laboratory tests must have standard terms (e.g., results of a Pap smear or mammogram). Additional coding sets are being defined by specialty groups that recognize the need for a common vocabulary. The NLM has expanded its UMLS to map many of these coding sets into a common set. Names for every element that must be exchanged among systems should be standardized. For the CPR, a clinically rich vocabulary that accurately describes patient problems and findings is mandatory. In addition, physicians must feel comfortable with the standard vocabulary if they are to use it for entering data. CPRI has published an evaluation of existing comprehensive codes (Chute et al., 1996).

In addition to standards for patient data, medical knowledge must be encoded in CPR systems with decision support capability. The Arden syntax has been used to exchange medical knowledge encoded as simple rules (Hripcsak et al., 1990). Further work must be undertaken to represent medical knowledge in standard, transferable form.

Leadership at the federal level is required to ensure that standards necessary to preserve and enhance health care in the United States are developed. Until standards exist for uniquely identifying individuals and coding and exchanging health data, the value from capturing and aggregating data will go unrealized and each organization will be its own pioneer.

Legal and Social Issues

Security, privacy, and confidentiality concerns have become major barriers to widespread implementation of CPR systems and sharing data. There is, as yet, no agreement on what must be done to establish the balance between appropriate use of health care data and the individual patient's rights to privacy (Detmer and Steen, 1996). The issue of who owns the data in a CPR is still being debated. Of equal importance to preserving patient privacy and confidentiality is the necessity of preserving institutional privacy. No institution will be willing to share data if those data can be used to provide a business advantage for a competitor. Again, the human factors outweigh the technical solutions in dealing with this issue (Barrows and Clayton, 1996).

Privacy and confidentiality are concepts that involve people, policies, and legislation. Information security technology plays an enabling and facilitating role by helping

organizations prevent unauthorized access to confidential information. In addition, properly designed and monitored audit trails can enhance user accountability by detecting and recording unauthorized access to confidential information. CPRI has produced position papers on user authentication and access to patient data and provided substantive guidelines on security policies, security education programs, job descriptions for information security managers, model confidentiality policies, and security functionality requirements for CPR systems (CPRI, 1995a,b, 1996b,d). CPRI and the American Health Information Management Association have been instrumental in developing model policies and legislation regarding confidentiality and privacy. Public Law 104-191 establishes legal sanctions for wrongful disclosure of individually identifiable health information. It also calls on the secretary of Health and Human Services to provide detailed recommendations on privacy of health data and procedures and rules for authorized disclosure of such information. The recently revitalized National Committee on Vital and Health Statistics (NCVHS) advises the secretary on this and other standards related to health information. Federal legislation is necessary to overcome many of the inadequacies and inconsistencies between the state regulations and laws that are described in this report.

Whereas stringent security measures should be applied to protect the confidentiality of patient information, it is also in the patient's best interest for the CPR to be accessible for appropriate, legitimate uses by authorized users. The measures used to protect the confidentiality of patient data must not be so onerous that clinicians taking care of a patient do not have ready access to the patient's health data. This balance must be carefully crafted in the enabling legislation and policy standards, and enforceable through system security functions. In addition to clinicians, researchers, quality assessment professionals, and health care managers need access to aggregate data to continuously improve health and the delivery of health care. Most of the time, these secondary uses of data can be satisfied without access to individually identifiable information.

Costs and Benefits

Certainly, the cost of developing a CPR system remains a significant barrier, but this barrier has been offset at least in part by three trends. First, as CPR-related technologies continue to advance, greater performance can be obtained for equivalent costs. Second, as integrated delivery systems become more prevalent, the demand for CPR and related information systems will increase, thus reducing the risk to developers. Third, some federal funds have been made available (e.g., through NLM and AHCPR) to address specific development challenges associated with CPRs. The stability and level of federal funding in the future, however, are uncertain.

Much of the enthusiasm for the CPR is based on the belief that a CPR system will reduce the cost and improve the quality of care through the existence of better-informed health care providers and patients, the elimination of duplicate testing, and better coordination of treatment by more than one health care provider. Since the first edition, additional data have been published on the positive impact of CPR systems on the cost and quality of

health care. As existing clinical systems continued to accumulate data, new studies have demonstrated improvements in the quality of care or reductions in the cost of care (Classen et al., 1991, 1992; Evans et al., 1992; Schoenbaum and Barnett, 1992; Tierney et al., 1993; Grandia et al., 1995). However, most of the carefully done empirical studies presented in the literature have examined the benefits of systems that are not commercially available. Like other enabling technologies (e.g., electronic mail, cellular telephones, computers), it may be difficult to identify and reliably quantify the direct and indirect benefits attributable to the CPR system. It is hard to quantify what is better, when so much may not even have been possible without the enabling technology.

Although discrete benefits of CPR system features have been quantified in selected environments, the comprehensive capital and operating costs have not been fully articulated. It is known, however, that the costs are substantial. One estimate for a capital budget (including capitalized labor costs) for an integrated health care information system with \$1 billion to \$2 billion in revenue is \$75 million to \$275 million (Council on Competitiveness, 1996). At a time when health care organizations need to reduce their costs, allocating capital to information systems is still a challenge. Although it is tempting to propose that large empirical studies be conducted to produce definitive cost-benefit data, it may be unrealistic to expect that such studies can be undertaken, or that they could truly represent the diverse health systems in the United States.

Many health care organizations are aware of the benefits of CPR systems, but have questions on how to implement and use this new technology. Recognizing that experience with these systems is not widespread, CPRI developed a program to help disseminate the knowledge of those who have previous experience with CPR systems and to provide a tool to help organizations undertake new projects and initiatives. Modeled after the Malcolm Baldrige Quality Award Program, CPRI developed a program to promote quality in CPR system projects. The program is named after Nicholas E. Davies, a member of the IOM Patient Record committee who was tragically killed in an airplane crash just as the committee was concluding its work. The Nicholas E. Davies Annual CPR Recognition Symposia provide recognition for organizations demonstrating exemplary measurable impact of CPR systems on health care at their organizations (CPRI, 1995c, 1996c, 1997).

The objectives of the Davies CPR Systems Recognition Program are to: (a) promote the vision of CPR systems through concrete examples, (b) provide visibility and recognition for excellence in CPR system implementation and demonstrated results, (c) provide a forum for discussing critical success factors and lessons learned, and (d) provide criteria for evaluating CPR system projects (CPRI, 1996a). A comprehensive set of evaluation criteria was developed in an iterative fashion by CPRI and external experts. Emphasizing the fact that successful CPR system projects require a comprehensive, multidisciplinary team approach led by senior management, the evaluation categories are divided into four categories: (1) management, (2) system functionality, (3) technology, and (4) impact on quality, costs, and access. These categories reflect the notion that a CPR system implementation project is more than a selection or development of an information system product, it is the conceptualization of a new recordkeeping system that efficiently and

effectively supports the delivery of health care and health promotion by the health care team. Existing organizational structures, departmental cultures, and an inward focus may have to be transformed to efficiently deliver high-quality care and effectively compete for managed care contracts. The CPR system is an essential tool to accomplish these broader goals.

Leadership

Due to the barriers described above, leadership of and commitment to CPR system projects must come from the top of an organization. The organization's Board of Directors must fund and support the implementation and use of CPR systems as a business imperative. Often, chief executive officers must act on personal conviction, existing evidence of benefits, and the desire to capitalize on a strategic differentiator—the value of data. In the new managed care market, a CPR system is not only an essential tool for health professionals, it is a business imperative. Time will tell whether investing in clinical systems provides a strategic advantage or is a minimum requirement to "stay in the game." Neither outcome favors continuing the status quo. It takes a combination of leadership conviction, organizational fiscal strength, and medical informatics and systems expertise to implement CPR systems effectively. Where such leadership exists, CPR systems are more likely to be acquired and successfully implemented.

CONCLUSION

A careful reading of *The Computer-Based Patient Record* by all stakeholders in health care is still fruitful. We believe that the original vision described by the IOM Committee on Improving the Patient Record was correct and remains timely and essential to the success of the new health care delivery system. Widespread use of CPRs would serve both private- and public-sector objectives to transform health care delivery in the United States. Equally important, early evidence indicates that the introduction and use of robust CPRs will enhance the health of citizens and reduce the costs of care, and in so doing, the use of CPRs will strengthen the nation's productivity.

Technological advances aside, progress toward CPRs as envisioned in this report has been slower than anticipated. The IOM committee expressed its strong belief that the early phase of CPRI's activities should be federally initiated and funded. A major coordinated national effort with federal funding and strong advisory support from the private sector is needed to accelerate the pace of change in the United States. Health care is a public good and many of the barriers to widespread implementation of CPR systems require national mandates, policy changes, or, in some cases, new legislation. Leadership in government and the private sector must be galvanized to make sweeping changes where possible (e.g., a national UHI, confidentiality legislation) and to instigate, motivate, and provide incentives to accelerate development of solutions to other impediments (e.g., terminology standards).

Data are the currency of quality management and the endowment for continuous quality improvement of patient care. Only by capturing primary clinical data from health care providers in a way that they can be applied to health care decisions for individuals and to policy decisions for populations can the United States achieve its goal of providing high-quality, affordable health care for all. A computer-based patient record is essential to accomplishing that goal.

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A Progress Report on Computer-Based Patient Records in Europe

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After more than two decades of pioneering efforts, in both the United States and Europe, a new era in the use of computer-stored patient data has clearly begun. The proliferation

of inexpensive personal computers and workstations, the development of more user-friendly interfaces, the standardization of network technology, the original release of this report 6 years ago, and the stimulation of health care telematics (i.e., network communications) in Europe have contributed significantly to this growing interest. Equally important, developers of systems have acquired much experience since they first attempted to develop electronic patient records, and their subsequent attempts have become more successful and gained momentum.

In this commentary we discuss some recent developments in computer-based patient records (CPRs) in Europe and review some CPR developments in Europe that fall within the Framework Programs on Research and Development of the European Union. Specifically, we review European developments in CPRs for primary care, clinical care (i.e., hospital care), and shared care. We also address the use of CPR data beyond patient care and two barriers to CPR development: protection of patient confidentiality and standards development for data.

THE CURRENT STATE OF CPRs IN EUROPE

Computer-based information systems are now abundant in a large percentage of European hospitals as well as in primary care settings. Systems support general tasks such as patient administration, scheduling, and billing, as well as specific tasks such as in the clinical laboratory, radiology, or the catheterization laboratory. Hospital information systems are primarily administration oriented and seldom contain patient record data other than, for example, laboratory results, drug prescriptions, or diagnostic codes. Some systems store patient data, but none of them fully replaces the paper-based patient record. Many existing systems are not connected or are only loosely interconnected in networks. CPRs are being developed as part of a hospitalwide network (Degoulet et al., 1991; Van Mulligen et al., 1994; Scherrer et al., 1995) or as stand-alone or interconnected applications, such as in primary care (Westerhof et al., 1987; Branger et al., 1992; van der Lei et al., 1993). Increasingly, systems are being interconnected by electronic data interchange.

The field of hospital information systems in Europe consists, on the one hand, of mainly homemade systems (e.g., Bakker, 1984; Scherrer et al., 1995) sometimes supporting a group of hospitals and, on the other, of systems offered by industry, mainly of U.S. origin. A wide variety of information systems are operational on different platforms. Information systems in Europe reflect the differences in health care organizations which arise from the different historical developments, legislation, education, and languages among European countries. Therefore, systems developed in one European country are rarely installed in another country. This is also why the European hospital information system industry, with few exceptions, is virtually absent from the global market.

The differences in health care structures of different European countries might pose less of a problem for patient-centered approaches, such as CPRs. In all countries, patient care itself is quite similar. Europe has succeeded early at its attempts at CPR development and

has since made considerable progress in the use of CPRs, especially in the primary care setting (van der Lei et al., 1991a; Millman et al., 1995). On the basis of these successes, several collaborative projects were started in health care; these were financially subsidized in part by the European Union (EU, 1994). Three developments related to CPRs in Europe deserve attention: the use of CPRs in the primary care setting, in hospitals, and for shared care (i.e., collaboration between care providers). In addition, in the area of standardization in health care, the European Union plays a pivotal role on a global scale as well (De Moor, 1993).

Network technology and communication (in Europe the latter is called *telematics*) are now prominent developments in information technology and have a large impact on health care (Branger et al., 1992; EU, 1994). By using standard communication networks and standard software (De Moor, 1993), data interchange between the four levels of health care delivery (i.e., the region, the institution, the clinical department or outpatient clinic, and the individual physician, nurse, or patient) is more efficient. A fully operational exchange of patient data between systems, with proper authorization, is one of the present challenges in European health care.

The data in CPRs are not begging to be used for electronic data exchange, research, and shared care. The use of CPRs for purposes other than direct patient care has been associated with several problems (van der Lei et al., 1991a; Vlug and van der Lei, 1995). These limitations are, for instance, the lack of a common terminology for patient data collection, or the use of different modes for the CPR systems. As the knowledge gained from experience accumulates, CPR developers learn important lessons, particularly the need to develop structured patient records based on a clear conceptual model. If CPR systems are not based on a conceptual model, and if the data in CPRs are not well structured, it will not be possible to use CPR data for different goals, nor will it be possible for such data to be exchanged between health care providers to support shared care. Therefore, if CPR systems are to be used for these other goals, care providers should realize that it is not sufficient that the systems merely support their own practice or clinic, but they should take care that patient data can be exchanged over the entire health care domain and be used, for instance, to support clinical research, decision-making, the assessment of the quality of care, or management and planning.

A variety of CPR applications and projects have been completed or are ongoing including those supported through Framework Programs on Research and Development of the European Union. They concern computer-based records for primary care, in hospitals, and for shared care, as well as the use of data in CPRs for research, assessment of the quality of care, and decision support. Other projects focus on what the Institute of Medicine (IOM) Committee on Improving the Patient Record classified as barriers to CPR development: privacy and confidentiality and standardization of terminologies and data-exchange formats.

Several developments related to CPRs in Europe are discussed below, including the status of CPRs in the primary care settings, in hospitals, and in shared care (i.e., collaboration between care providers). The final sections consider more specific uses of

CPR data and remaining barriers to wider use of the computer-based patient record.

CPR SYSTEMS IN PRIMARY CARE

In some European countries, especially The Netherlands (van der Lei et al., 1993) and the United Kingdom (Millman et al., 1995), there has been a rapid increase in the use of information systems by general practitioners (GPs) in primary care (Figure 1). CPRs are incorporated into these information systems and are quickly replacing existing paper-based records. The use of CPRs by GPs in particular is rapidly increasing. At the beginning of 1996 it was estimated that more than 90 percent of all GPs in The Netherlands and the United Kingdom used information systems in their practices. About 50 percent of Dutch GPs had implemented a CPR system for the support of patient care and about 25 percent of GPs had a paperless office.

Similar figures apply to the United Kingdom (Millman et al., 1995). This is directly related to the fact that in both the United Kingdom and The Netherlands, GPs are the "gatekeepers" in health care. Most GPs run a practice by themselves or with a small number of colleagues. In contrast, specialists work in large institutions in more complex settings, involving many more departments and personnel. Furthermore, GPs keep less extensive records so that data entry is less time-consuming and less detailed.

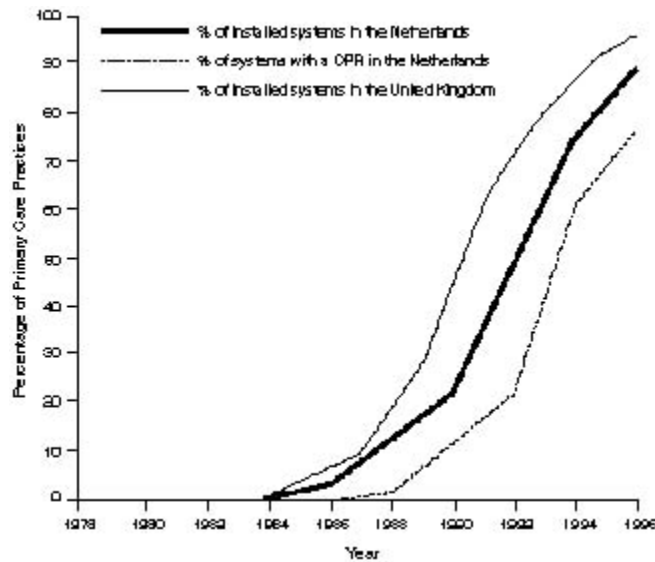


FIGURE 1 Growth of installed information systems and computer-based patient records in primary care in The Netherlands (100% represents 6,500 general practitioners [GPs]) and England and Wales (where 100% represents 9,000 GPs) as a function of time. The values for 1996 are extrapolations. Not indicated is the growing number of primary care systems that are electronically connected to other health care systems (see also the text and Figure 3).

The actual situation in The Netherlands offers a good example of both the success and the potential use of CPRs (van der Lei et al., 1993). This can be attributed to four factors: (1) the role of GPs, (2) physician training, (3) the structure of health care, and (4) population-based care.

Role of GPs

From the outset, professional organizations of GPs have played an active role in setting guidelines for information systems in general practice and in assessing the systems available in the market. This active role was started in the early 1980s, when they identified the basic needs of GPs for using systems in their practices and set the first broad guidelines for systems tailored specifically for primary care. Furthermore, these organizations announced to industry that they would recommend to their members that they use only those systems that would meet their requirements. In this way, a de facto standard was established. Since then, systems requirements are refined and extended every 2 to 3 years, and vendors must submit their systems for reevaluation by professional organizations. This iterative way of refining guidelines and assessing systems gives potential buyers of systems a basis on which to judge the available information systems. It also gives vendors clear-cut standards for their products. During the last 15 years, the definition of standards started with requirements for patient administration and evolved into standards for diagnostic coding (in all systems the International Classification for Primary Care has been implemented [Lamberts and Wood, 1987]), drug prescriptions (all systems use the same national thesaurus for drugs), and the type of data to be contained in a basic CPR and requirements for electronically interchanging patient data between different systems in the primary care setting, that is, from one GP's system to that of another.

Training

The success of information systems is largely determined by physicians' expectations. Education at medical faculties of universities prepares physicians in the use of computer-based information systems and patient records. Early on, students get acquainted with how to use computers for the documentation of patient data in CPRs. Professional organizations have also ensured that postgraduate training of GPs conveys a realistic set of expectations. These expectations must be realistic, because if they are too high they lead to disillusionment, and if they are too low they may impede the introduction of systems. The training emphasizes that the proper use of systems and CPRs reduces administrative work-load, increases the accuracy of billing (no accountable patient data are lost), and enables the production of referral letters, the use of electronic data interchange, and the tracking of certain categories of patients.

Potential users should realize that, certainly at the beginning, investments must be made. The investments must be expressed not only in financial terms but also in time and personal efforts. For instance, for a typical practice of about 2,300 patients, it takes about

2 years for all patient data to be entered into the system's CPR. This data transcription from paper to computer is most often done at the time that patients come for a consultation, since the majority of patients pay a visit to their GP once every 2 years. A GP who is just starting to use a CPR system needs an extra 2 to 3 minutes during the consultation. The GP's assistant enters data related to all administrative operations, such as patient admission and patient scheduling, but the GP enters the patient care-related data into the CPR.

Structure of Health Care

The factors described above are related to the role and training of GPs in using CPRs and may be useful for other countries. A third factor, however, is strongly related to the structure of health care in The Netherlands, which in many ways is comparable to that in the United Kingdom and Scandinavian countries. Patients in The Netherlands and the United Kingdom have a single GP who coordinates their health care, acting as a gatekeeper to other specialists; the latter report back to the GP. Several projects are now under way to use electronic data interchange for this GP-specialist communication (see the section on "CPR Systems for Shared Care," page 32). Thus, in principle, the GP coordinates the health care-related data for a single patient over the patient's lifetime and is requested by other specialists to share that information. The GP's role as coordinator eases the introduction of CPR systems because the demands of care are easier to meet when the data are available in electronic form. This factor may be increasingly relevant in the United States as managed care and capitated reimbursement continue to penetrate the health care delivery market.

Population-Based Care

A fourth reason for the success of the acceptance of CPRs in the primary care setting is the fact that Dutch general practice is population-based care, in contrast to institution- or physician-based care. The Dutch primary care system can be characterized as providing services that are responsive to the needs both of the individual patients and the population at large. Such a population-based orientation creates demands that are easier to satisfy when CPRs are introduced. For instance, CPRs with properly coded data greatly facilitate the creation of a gender-age register to report on statistics in primary care or active case finding (e.g., for periodic cervical smears or cardiovascular risk assessments). The availability of CPRs facilitates studies on the use and effects of drugs in the population and postmarketing drug surveillance (see the section on "Use of CPR Data," page 34).

CPR SYSTEMS IN HOSPITALS

Electronic information technology has been introduced in all hospitals in Europe. This is no longer restricted to special areas of care, such as radiology or the laboratory. In principle, the available technology allows central and monolithic hospital information

systems to be transformed into hospitalwide networks with "intelligent" workstations or personal computers throughout the hospital, from the consultation room to close to the bedside. This transformation is just beginning, however. At present, graphical workstations and network technology are the latest developments in the computer industry. Client-server protocols ease the integration of systems and distribution of processing tasks (Degoulet et al., 1991; Van Mulligen et al., 1994; Nowlan et al., 1994). In principle, workstations offer an environment in which, from the user's perspective, all applications running either locally or through a network act as a single integrated system. Several institutions are developing health care workstations that enable the integration of patient data scattered throughout different systems (Degoulet et al., 1991; Van Mulligen et al., 1994; van Bommel et al., 1996a). In principle, such systems offer to the clinician on one computer screen patient data, images, and biological signals, regardless of the computer on which they are stored or the system on which they are processed.

Yet, although the technical issues involved in the integration of various systems were slowly being solved, the absence of a conceptual model for a CPR was increasingly becoming a stumbling block, particularly as the amount of available data increased. Thus emerged a trend in which a technical infrastructure (the platform for the CPR) takes care of the communication with the numerous systems available in the hospital, including legacy systems, such as a laboratory system, a picture archiving and communication system (PACS), or an electrocardiogram (ECG) interpretation system. CPRs are developed at the core of this integration platform. This distinction is not trivial. When developing the platforms, questions such as how an existing legacy system should be embedded are addressed on a technical level. On the level of CPR development, questions relate, for example, to how the data will be presented to the user in a consistent manner or what additional data the physician must record are addressed.

Platforms for CPRs

Both the Helios (Degoulet et al., 1991) and the Hermes (Van Mulligen et al., 1994) integrated clinical workstations offer an environment for systems integration. Communication between applications is automatically performed by the workstation and follows ISO¹ standards (ISO, 1987). Instead of having one large central database of patient data, all existing databases and applications are left unchanged and patient data are combined by the workstation on demand. This has two advantages over one large integrated database. First, data can remain distributed and stored at places that are most convenient (i.e., close to where the data are collected and used). Second, commercially available applications can be used for data processing without modifying them.

The Hermes workstation was initially developed to support clinical data analysis, but its architecture has also been extended to support patient care. It is integrated with the generic CPR system ORCA² (van Ginneken, 1996). Hermes is also able to integrate with legacy systems by encapsulation.

The Helios workstation, similar to Hermes in many respects, also integrates alphanumeric data (text), images, and biological signals. The Helios platform is being used as one of the building blocks of a new generation of hospital information systems. The Hermes approach, originally developed on a Unix platform, has now migrated to a Windows NT/95 environment, forming the basis for the European project I4C (van Bemmelen et al., 1996), as explained below.

Integrated CPRs

As an example of the introduction of a CPR in a clinical department, we briefly describe the European project I4C (Integration and Communication for the Continuity of Cardiac Care). Although I4C is intended to support cardiology, it uses a generic CPR, ORCA, which is also applicable to other departments. In this way, the CPR used in the I4C project can be used by many other clinical departments (van Ginneken et al., 1995; van Ginneken and Stam, 1995), because it contains a variety of patient data: patient history, physical examination findings, laboratory test results, images, biological signals, and so forth. Real-time data, such as from the catheterization laboratory, are also intended to be incorporated into the CPR. Data are meant to be used by more than one physician (e.g., the cardiologist often must coordinate his or her treatment with that of other specialists in the hospital or with GPs in primary care).

Figure 2 presents the CPR structure that forms the basis for the I4C project, together with its branches to other systems in the hospital or elsewhere. Patient record data, as well as images such as echocardiograms and coronary angiograms, or signals such as ECGs or blood pressure curves are collected, stored, and presented by using the workstation.

The I4C project in principle is intended to support cardiac care, from prevention and treatment to follow-up and rehabilitation. This is accomplished by: (a) consistently recording patient data in the CPR; (b) accessing diagnostic and therapeutic information; (c) accessing patient data, images, and biological signals wherever they are stored and irrespective of where the inquiry originates; and (d) collecting well-defined reference sets of patient data.

Data are to be used not only for patient care, research, and education but also for the assessment of the quality of care and for management and planning. The fourth issue is similar to the data collection that resulted from the European CSE³ project that preceded I4C (Willems et al., 1991). The project is carried out by centers in The Netherlands—which provides coordination—the United Kingdom, France, Germany, Italy, and Greece.

CPR Data Entry

For a CPR to have benefits, the data in that record need to be structured and coded, at least to a certain degree. Obtaining structured and coded data, however, has proved to be a significant hurdle. Physicians are accustomed to paper records. How physicians use

these records has been the subject of several European projects (e.g., Nygren and Henriksson, 1992). From such investigations it became apparent that physicians are far more likely to use computers to consult the data in present patient records than to enter patient data. This is not surprising: Data entry requires more effort from the physician than browsing through the record. Some researchers have argued that direct input by physicians will have to wait for radical improvements of the human-machine interface, such as speech input. Experience in a number of countries where GPs are particularly using CPRs (e.g., The Netherlands, the United Kingdom, and Sweden) has shown, however, that physicians will accept the limitations of the current human-machine interaction.

Views of CPR data for patient care, decision support, scientific data analysis, or assessment of quality of care require patient data to be highly structured and unambiguous. It is difficult to fulfill these requirements with narrative (textual) data (e.g., Moorman et al., 1994). Ideally, therefore, patient data should be acquired directly from the physician in a structured format and, preferably, should also be entered by the physician. To accomplish this, different approaches to data entry have received attention: form-driven data entry, natural language processing, and structured data entry. The last two methods are also the focus of several research projects in Europe (Nowlan and Rector, 1991; Baud et al., 1992; Moorman et al., 1994).

Natural Language Processing

Natural language processing intends to automatically extract coded medical data from free text. European research in this area has mainly been done by Baud and colleagues in Geneva (1992). The basic advantage of natural language processing is that physicians do not have to alter the way in which they express their findings or document their decisions. Only when its application domain is strictly confined can natural language processing offer advantages. A fundamental disadvantage of natural language processing is that the data-capturing process itself cannot be influenced and improved. Data that the physician has not written or spoken remain unknown. Freedom of expression is inherent to free text (Moorman et al., 1994). Therefore, it is difficult to impose structure on data that are used as input for natural language processing.

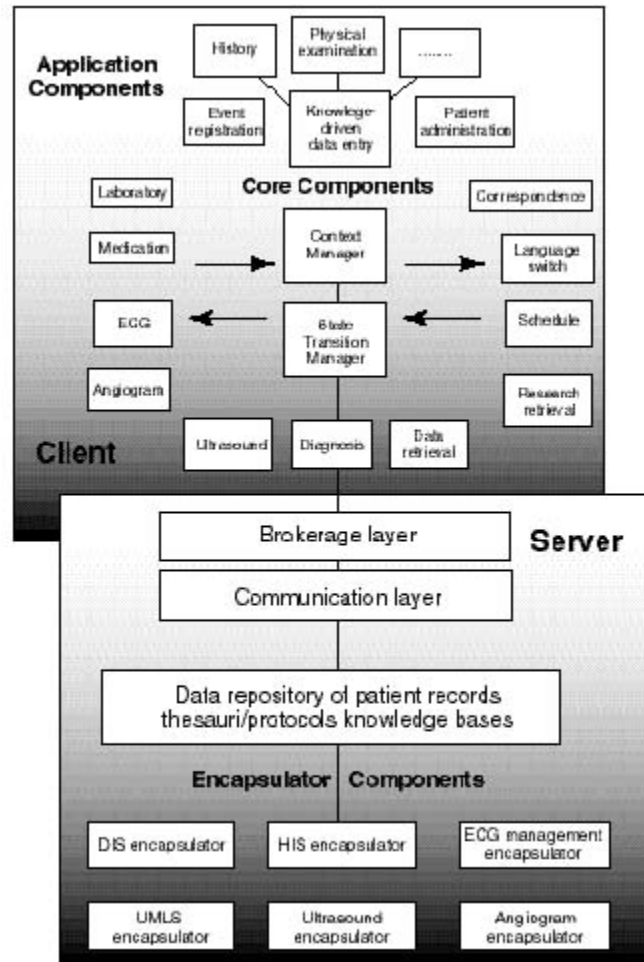


FIGURE 2 Example of the integration of a computer-based patient record (CPR) (ORCA; van Ginneken, 1996) in a clinical network of information systems being developed in the European project I4C (van Bommel et al., 1996), in which centers from six countries collaborate. At the core of the CPR (called the client here) are three generic core components: the state transition manager, the context manager, and knowledge-driven data entry. The first two deal with all data acquisition, storage, and presentation and communication with the application components of the CPR system and the legacy systems elsewhere in the hospital. Communication is controlled by a brokerage layer and a communication layer, which are part of a group of servers. The broker follows protocols such as those agreed upon by the Common Object Request Broker Architecture (CORBA) Group (OMG, 1996); the communication layer provides data exchange via Electronic Data Interchange for Finance, Administration, Commerce, and Trade (EDIFACT) or HL-7. In the data repository, CPR data and knowledge bases are stored, together with coding systems and thesauruses for diagnoses and drugs. The six systems at the bottom are examples of "legacy systems" from which data (e.g., from a departmental or hospital information system), images (e.g., from an angiogram server), or biological signals (e.g., from an ECG management system) are to be transported to the CPR for presentation or processing. Integration with the legacy systems is provided by encapsulation (Van Mulligen et al., 1994).

Structured Data Entry

Another way of data entry is context sensitive and is adaptable to different clinical domains. It is called structured data entry and consists of forms whose content is knowledge driven. In a structured data entry-oriented European project, the forms are structured, but their contents can continuously be adapted to accommodate the user's requirements and personal preferences (Moorman et al., 1994). In addition to a knowledge model, it contains a predefined vocabulary and specifications on how the terms of the vocabulary may be combined into meaningful expressions. The knowledge base keeps track of the individual physician's definitions of expressions with a nontrivial meaning, such as "the heart is normal" or "gastroenteritis complaints." When such expressions are used for the first time, the system will prompt the physician-user for an explicit description. Upon later use of such expressions, the system will store its explicit substitute. In this way, efficiency and completeness can be reconciled.

Structured data entry is also an efficient tool for enhancing data completeness and testing for data reliability (Whiting-O'Keefe et al., 1985; Wyatt, 1994). Graphics and voice input may also serve to enhance the capabilities of structured data entry.

CPR SYSTEMS FOR SHARED CARE

An environment in which patient record data can be electronically interchanged regionally (Figure 3) is a necessary condition for a shared care environment (Branger et al., 1992, 1994; Branger and Duisterhout, 1995). Local and regional networks are increasingly used for the exchange of patient data between health care institutions. They are also used for communication with, for example, health insurance bodies, governmental organizations, libraries, and research institutions. Orders and payments are exchanged by electronic data interchange, databases are consulted remotely, and laboratory data or referral letters are mailed electronically. Communication between specialists and GPs is also increasingly taking place via telecommunication. In some instances specialists and general practitioners communicate directly with a patient in the patient's home, for example, patients with pacemakers, undergoing hemodialysis, or receiving palliative care. For some purposes, remote medical consultation (telemedicine) is also envisaged. Several regional shared-care networks are under development in Europe within the Framework Programs for Research and Development in health care telematics, as will be discussed below. Such regional networks are a logical extension of networks within hospitals.

With the existence of a computer-based shared care environment, new applications for patient-centered care have arisen, such as:

1. GPs are able to send a patient's data to the hospital to obtain results or diagnostic advice instead of referring the patient.
2. Patients' hospital stays are shorter and specialists may offer teleconsultation services.

3. Outpatient clinics increasingly function as diagnostic screening and ambulatory care centers. Patients are referred to these clinics only when specific diagnostic tests or interventions must be performed.

4. Patient admission and scheduling are greatly facilitated, resulting in better planning and decreased waiting times for examinations.

In the next two sections we provide two examples of European projects involving the use of CPR data for shared care. The first describes the project CoCo, concerning the coordination and continuity of health care (Bernstein and Jensen, 1994). The second describes a project that deals with the exchange of data in health care by smart cards, in this case, Diabcard (Schaefer and Sembritzki, 1996).

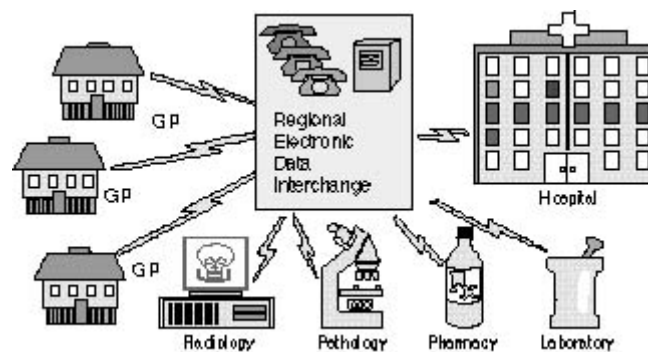


FIGURE 3 Regional electronic data-interchange network to support shared care. General practitioners (GPs) in primary care are interconnected with other health care providers, such as the clinical laboratory, pharmacies, pathology laboratories, radiology departments, and departments in the hospital. Usually, such an electronic data-interchange network makes use of public telephone lines or special lines (e.g., ISDN). In Europe, growing numbers of such networks are in development as part of European projects, such as the CoCo project (see text).

CoCo

The intention of the European project CoCo (Coordination and Continuity in Health Care) is to establish large-scale interconnected regional health care information networks, with the purpose of improving the coordination and continuity of health care (Bernstein and Jensen, 1994; van Bommel et al., 1996). It uses available CPR-based systems and telecommunication infrastructures in the participating countries, European EDIFACT⁴ standards, and electronic mail techniques. The project will not interfere with regional regulations and will not impose new rules on the users of the networks. A major effort is dedicated to ensuring that the project will be implemented in a coordinated and standard way. The practical guidelines and the experiences with the collaboration within CoCo should also be usable for other applications in Europe. CoCo has two goals:

1. Establishment of networks for the regional exchange of health care information. Each region will establish running networks that will allow for communication between all the major actors in health care: GPs, laboratories, radiology departments, hospitals, pharmacies, regional and national authorities, and social services and home care providers.

2. Establishment of links between the regions through CoCo Link. CoCo Link ensures coordination between the regions to facilitate a common methodology, to start concerted developments, and to use standardized communication in all regions. For instance, it will provide guidelines, it is responsible for developing an electronic test bed that can be used to test EDIFACT solutions, and it will also establish networks between networks.

Many countries within the European Union, such as Denmark (coordination), The Netherlands, the United Kingdom, Ireland, Spain, and Greece, participate in CoCo. There is also an extension to Canada. A typical application within CoCo is shared care provided to patients with breast cancer. In this setting, GPs in primary care, internists, surgeons, and radiotherapists in secondary care collaborate with nurses in home care, covering the entire period from the first patient visit to the GP up to chemotherapy or surgery and, eventually, palliative care. All care providers have access to the same CPR; nurses in the home care setting use portable computers to exchange data with the system in the clinic.

Diabcard

In Germany, health insurance cards are regulated by law. During 1993 and 1994, more than 70 million smart cards (chip cards) were issued to German citizens, and about 165,000 read-write stations were installed in, for instance, practices, hospitals, and emergency rooms. The insurance cards are primarily used for administrative purposes, but debate is ongoing about the use of these smart cards as carriers of patient data. The German project Diabcard, which has also been extended to other European countries, uses smart cards for the storage and exchange of data for patients suffering from diabetes (Schaefer and Sembritzki, 1996). Other projects, such as for patients with cancer, are also being introduced in the German health care system. Standardization of the health care data on such cards is of utmost importance.

USE OF CPR DATA

Once patient data are available from CPRs in primary care centers and hospitals, the data can be harvested. We briefly discuss here a project dealing with critiquing a physician's care (van der Lei et al., 1991; van der Lei and Musen, 1991; van Bommel, 1993). Another European project intends to integrate treatment protocols with CPR systems. It is oriented toward the support of clinical oncology. The third project deals with the assessment of care by using large collections of CPR data harvested from operational CPR systems in the primary care setting. This project is directed toward the postmarketing surveillance of

drugs (Vlug and van der Lei, 1995).

Critiquing a Physician's Care

Automated review of CPRs is expected to limit errors in the delivery of care and to control costs. Two projects, carried out with GPs in The Netherlands, have investigated whether CPRs contain sufficient information to support direct care by assessing CPR data and generating critiques and decision support. In the first project (HyperCritic [van der Lei et al., 1991; van der Lei and Musen, 1991]), a system of critiquing the treatment of hypertension was developed. The second project (AsthmaCritic [Kuilboer and van der Lei, 1997]) covers the area of chronic obstructive respiratory diseases. Both systems rely on CPRs for patient data. HyperCritic was assessed in a research project, and we summarize here some of the main outcomes (van der Lei et al., 1991).

The critiquing systems generate comments in two stages. First, CPR data are automatically interpreted to review the actions of the GP at a given visit (e.g., starting a new drug, continuing treatment with a drug, or replacing one drug with another). Second, each action is assessed. The system searches the CPR for conditions that contraindicate that action (e.g., contraindications to specific drugs), determines whether the preparations required for the action have been performed, determines whether the GP has performed the routine monitoring required by the action, and searches for any undesirable condition that might have resulted from the action. Review of the CPR requires detailed knowledge of drugs, such as customary dosages, contraindications, side effects, interactions, workup requirements, and criteria for judging the efficacy of the treatment. Computer-based critiquing of patient care was compared with peer review-based critiquing in the area of mild hypertension. The comparisons revealed the following:

1. Automated assessment of CPR data by the computer-based critiquing system could compete successfully with peer review.
2. The system was not able to reproduce some comments of experts. This was the result of insufficient CPR data, the lack of sufficient medical consensus, or omissions in the knowledge base of the critiquing system.

On the basis of the outcomes of this and other studies reported in the literature, the following can be concluded:

1. Systems for the assessment of patient care should be able to acquire patient data automatically from the CPR.
2. Ideally, the care assessment system should be functionally integrated with the CPR system.

INTEGRATION OF PROTOCOLS WITH CPR SYSTEMS

In many patient care areas, protocols are used to increase both the efficiency and the quality of care. In principle, such protocols are not limited to certain hospitals, regions, or countries. This was the reason for starting a large European project on the use of protocols in health care (both in the clinic and in the primary care setting) called Prompt (Lagouarde et al., 1996; van Bommel et al., 1996), which was based on the earlier European project Dilemma (Thomson, 1995). The project has been established by centers from the United Kingdom (which performs the coordination), France, and The Netherlands and intends to integrate these protocols with CPRs and to deliver and evaluate a set of tools for supporting the use of protocols. The initial focus of the project is oncology; this is now followed by a focus on the primary care and shared care settings.

The clinical objective is to install systems for supporting the treatment of cancer in specialty hospitals in the participating countries. Applications will be based on state-of-the-art therapeutic protocols. By the end of the project it is anticipated that the technology should be ready to be installed in centers in other countries as well. The following are other objectives of Prompt:

1. extensions to each hospital system, to support GPs, interconnected by regional networks for shared care;
2. initiation of comprehensive studies of the effects of the protocols on clinical outcomes; and
3. generic versions of the protocols for other clinical disciplines.

Review of CPR Databases

It is expected that CPRs will increasingly be used to improve the quality of care in practices, departments, and institutions as well as, for instance, to support postmarketing surveillance studies. Pressure from law enforcement bodies, third-party payers, peer-review organizations, hospitals, and physicians and patients themselves may lead to this use of automated review of CPRs. We briefly discuss a large ongoing project on the assessment of drug prescriptions in the population (Vlug and van der Lei, 1995; Visser et al., 1996). The project that is reported runs in The Netherlands, but similar projects have been started in other European countries (e.g., Germany and the United Kingdom).

Postmarketing surveillance examines the beneficial and adverse side effects of drugs on human health from the time that these drugs are marketed. Post-marketing surveillance consists of two stages: a hypothesis generation stage in which an effect or side effect is suspected and a hypothesis verification stage in which the hypothesis is tested. Hypothesis generation is typically based on the spontaneous reporting of potential side effects by physicians. Studies have indicated, however, that this spontaneous reporting

leaves much to be desired. For instance, Classen and colleagues (1991) studied the prescription of drugs in cases in which the drug prescription was changed, increased, or stopped. It was shown that computerized monitoring of adverse drug events in hospitals by using computer-stored patient data offers many advantages over the voluntary reporting of such events.

An extensive project that analyzes prescriptions in primary care to support the postmarketing surveillance of drugs is under way in The Netherlands. To test a hypothesis, large populations need to be monitored. Reports of patient contacts with GPs are anonymously sent to a research database. The data in that database are subsequently used to conduct postmarketing surveillance studies (Vlug and van der Lei, 1995). The Dutch authorities responsible for drug safety are investigating the potential use of this type of database. Preliminary results indicate that the CPRs can be used as a way to track large numbers of patients and that use of CPRs will allow researchers to build longitudinal databases (Visser et al., 1996). At the end of 1996, about 250,000 patients were followed longitudinally; this number will increase to about 1.5 million in the next few years.

ADDRESSING BARRIERS

Privacy and Confidentiality

Now that CPR data are becoming available for the different goals mentioned in the introduction to this commentary, it is of great importance to protect these data, to guard the privacy of patients, and to protect the professional interests of health care providers (van Bommel, 1992; Barber et al., 1996). Many parties (employers, insurance companies, etc.) are interested in permanent patient data,⁵ and these data should be extremely well protected in CPR systems. In Europe there may be more sensitivity toward the improper use of patient data than elsewhere; this sensitivity could even impede the introduction of CPRs in some countries, and for some purposes could hamper the use of CPR data for goals other than patient care. In the different European countries, privacy laws control health care data, but privacy laws also exist in Europe as a whole. European law supersedes the laws of the individual countries. The right to privacy has been anchored in the *Treaty for the Protection of Human Rights and Fundamental Freedom* (Treaty of Rome, 1954) and in European law (EU, 1995). Yet, it will be difficult to totally prevent the improper use of data stored in CPRs.

Because modern health care often requires shared care instead of care by a single physician only, the individual physician is no longer capable of personally guaranteeing the privacy of a patient's data. For that reason, after implementing regulations related to ensure the secrecy of patient data, modern societies must ensure the right to privacy. This means that in the different countries written regulations related to requests for personal data, including patient data, are required. These regulations should be supervised by a privacy committee and should contain descriptions of the purpose of the data registration that is maintained. It also should describe when data can be provided to third parties, and

the right of all persons concerned to inspect, alter, and destroy their own data. In principle, these regulations do not concern data that have been made anonymous.

It is of utmost importance that in all (future) CPR systems proper measures be taken to protect the privacy of patients and their data. This issue is also the subject of discussions at the EU level, for example, in the standardization committees established for health care informatics and telematics. Some of the standardization activities related to CPRs are summarized in the following section.

Standardization

As discussed above, it is essential that standards for the acquisition, storage, and exchange of patient data be available. In health care this pertains to both administrative data and patient data. On the basis of the experiences over the past decade, a technical committee (TC 251 [De Moor and van Maele, 1996]) falling under CEN (*Comité Européen de Normalisation*, the "European Committee for Standardization") was established. This committee defines preliminary standards and compiles reports on the standards to be introduced in the different countries of the European Union (De Moor, 1993; De Moor and van Maele, 1996). For instance, the ability to link systems via standard interfaces is widely recognized as a necessity. Especially in Europe, where data cross regional and national boundaries, agreement on how to exchange patient data is urgent. Directly and indirectly, such standards will contribute to the quality and efficiency of patient care.

From the long list of preliminary standards that have been or are being elaborated by Technical Committee 251, a few examples specifically dealing with data in CPRs are provided in the following sections (De Moor, 1996).

Electronic Health Care Record Architecture

Work on defining the basic architecture for data contained in an electronic health care record has begun. Standardization is necessary if patient data are to be exchanged between different health care professionals. It is also necessary so that patients can travel or move from one region or country in Europe to another. The architecture should enable physicians to use CPRs that are adapted to their own requirements and should therefore support a variety of formats. The aim of this standardization effort is not to specify the CPR system as such but to bring structure to the data stored in such records.

Coding Systems for Drugs

Standardization of coding systems for drugs concerns prescribing drugs and the effects of drugs on patients. A conceptual model for the correct labeling of drugs is foreseen within Technical Committee 251. The standard covers the identification of generic drug

products as well as the drugs themselves. A coding system itself, however, is not intended.

Syntax for Health Care Data Interchange

Electronic messages in health care can be coded in many different ways. Therefore, consensus is required on the exchange formats for health care data between different systems. This has many advantages, because the systems' vendors can then handle the different data formats. The standard intends to define and adopt syntaxes for this exchange of information.

Exchange of Medical Images and Related Data

The medical image exchange standard concerns the exchange of high-volume data such as images or similar data. The Technical Committee 251 standard has adopted the industrial DICOM⁶ 3.0 standard for medical images, enabling the possibility of standardized storage and global exchange of such images, which is important for supporting, for example, teleradiology or similar services.

User Identification

As open systems are gradually installed in hospitals and regional networks become operational, it will be important to prevent patient data from being used illegally. To ensure the proper use of patient data, it is necessary to positively identify authorized users. Software systems should therefore make use of automatic procedures for user identification, for example, by the use of passwords and different technical measures. Smart cards are other means of positive user identification (e.g., fingerprints or face recognition are possible techniques that could be standardized and that may eventually replace the more vulnerable passwords).

CONCLUSION

Significant progress has been made in Europe toward the primary recommendation of the IOM Committee on Improving the Patient Record's report over the past 6 years. Several factors account for the success to date. First, in those countries where CPRs are most prevalent, the health care delivery system or structure relies on a gatekeeper model and emphasizes primary health care and the health of the population. Thus, there is a recognized need for individual and aggregate patient data and a willingness to invest at both macro- (i.e., government) and microlevels (i.e., a practitioner) to make such data available. Second, CPR development projects are ideal for the EU insofar as they offer benefits both within and across countries and collaboration in their development may well speed up visible success. The evidence of political support and support by the

medical professional organizations for CPRs sends a strong message to system developers and users, as well as to the general public.

Third, the emerging focus on conceptual models that build upon rather than are driven by the technology is a significant breakthrough in CPR development and will likely result in systems that can be adopted throughout Europe. Ultimately, this conceptual focus, which is also evident in the United States, may increase the ability of generic CPR systems to be transported globally. Fourth, collaboration between end-users and developers in system specification is a critical element of a sound CPR development process, aiding both the developers and users of the systems. Finally, the readiness of users with realistic expectations eases the implementation and increases the likelihood that CPRs will be used to their full potential. Thus, the education of health professionals is an important strategy in speeding CPR diffusion.

Like in the United States, important challenges remain to be addressed for CPR developers. First, continued support of CPR development efforts by supra-regional and national organizations is absolutely essential. Second, the issues surrounding the operational exchange of patient data must be fully explored and addressed. Third, protecting the confidentiality of patient data in the information age is a global issue that must be a priority in all countries and will ultimately require greater collaboration among countries as the technologies that support CPRs continue to evolve and are exploited in ways that we have not yet identified. Fourth, flexible, user-adaptable generic models for the generation of CPRs are needed to overcome the great variety in specialized care, the differences in culture among various clinics, and particularly in Europe, among countries.

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NOTES

¹ISO: International Standards Organization.

²ORCA (Open Record for patient CARE) is a generic CPR system in which the knowledge model consists of a predefined vocabulary and knowledge about how the terms of that vocabulary may be combined into meaningful expressions (van Ginneken, 1996). ORCA is used in the framework of different (European) projects (van Bommel et al., 1996). ORCA contains a powerful model for structuring a CPR and a knowledge model for capturing patient data. Moreover, because it is generic, ORCA can be used for different areas of health care and is user-adaptable. The relationships between the terms in the knowledge model are semantically defined (van Ginneken et al., 1993, Moorman et al., 1994), for instance, in an acyclic directed graph.

³CSE: Common standards for quantitative electrocardiography.

⁴EDIFACT: Electronic Data Interchange for Finance, Administration, Commerce, and Trade.

⁵Medical data can be categorized into permanent data (e.g., one's genetic profile) and variable data (e.g., a blood pressure). The privacy aspect of permanent data is perhaps the most crucial. Generally, these two types of data are used in different ways: variable medical data (including alphanumeric data, biological signals, and pictures) are primarily used for the diagnosis and treatment of transient diseases, whereas permanent data are often strongly related to an individual's life and may possibly predict his or her future health. The latter category is also of interest for one's next of kin: parents, brothers, sisters, and children. Genetic data, for instance, do not change or age; they are valid for an entire lifetime.

⁶DICOM: Digital Imaging and Communications standard (ACR-NEMA, 1985).

Summary

The patient record touches, in some way, virtually everyone associated with providing, receiving, or reimbursing health care services. This wide range of application and use has led to efforts to automate the collection, storage, and management of the data that constitute these records. But in spite of more than 30 years of exploratory work and millions of dollars in research and implementation of computer systems in health care provider institutions, patient records today are still predominantly paper records. This evident lack of diffusion of information management technologies in the health care sector has limited the tools available for effective decision making from the bedside all the way to the formulation of national health care policy. Given the importance of patient data to the activities of all portions of the health care spectrum, the Institute of Medicine (IOM) undertook a study to improve patient records, acting in response to expanding demands for information and for increased functional capacity of patient record systems, as well as the considerable recent technological advances that bring the benefits of computer-based patient records within reach.

As its first step, the IOM study committee examined why previous work had not resulted in widespread improvement of patient records and asked whether and how another effort might be successful. The committee identified five conditions in the current health care environment that increase the likelihood of success.

1. The uses of and legitimate demands for patient data are growing. Part of this growth can be attributed to increased concern about the content and value of clinical therapies and a recent intense focus on health services research.
2. More powerful, affordable technologies to support computer-based patient records are now available.
3. Increasingly, computers are being accepted as a tool for enhancing efficiency in virtually all facets of everyday life.

4. Demographic factors such as an aging population (which results in a growth in chronic diseases) and the continued mobility of Americans create greater pressures for patient records that can manage large amounts of information and are easily transferable among health care providers.

5. Pressures for reform in health care are growing, and automation of patient records is crucial to achievement of such reform.

The combination of these factors led the committee to conclude that computerization can help to improve patient records and that improved patient records and information management of health care data are essential elements of the infrastructure of the nation's health care system.

USER NEEDS AND SYSTEM REQUIREMENTS

The patient record of the future will have many more users and uses than it has at present. Direct providers of care (physicians, nurses, dentists, and other health care professionals) will remain the users of highest priority in design considerations. However, with the expanded functions projected for patient records (e.g., their use in supplying data for research or for insurance claims), the range of users considered in record system design will widen. The needs of all users will be met to an extent not possible in current record systems. Ultimately, of course, the most significant beneficiary of improved patient records should be the patient.

The committee identified five objectives for future patient record systems. First, future patient records should support patient care and improve its quality. Second, they should enhance the productivity of health care professionals and reduce the administrative costs associated with health care delivery and financing. Third, they should support clinical and health services research. Fourth, they should be able to accommodate future developments in health care technology, policy, management, and finance. Fifth, they must have mechanisms in place to ensure patient data confidentiality at all times.

To achieve these objectives, future patient records must be computer based. However, merely automating the form, content, and procedures of current patient records will perpetuate their deficiencies and will be insufficient to meet emerging user needs. The committee defined the computer-based patient record as an electronic patient record that resides in a system specifically designed to support users through availability of complete and accurate data, practitioner reminders and alerts, clinical decision support systems, links to bodies of medical knowledge, and other aids. This definition encompasses a broader view of the patient record than is current today, moving from the notion of a location or device for keeping track of patient care events to a resource with much enhanced utility in patient care (including the ability to provide an accurate longitudinal account of care), in management of the health care system, and in extension of knowledge.

In the past, a patient record has served the basic function of storing patient data for retrieval by users involved with providing patient care. Even this classic function must be broader in the future, however, especially with respect to the key feature of flexibility. Different health care professionals will require different modes of record information retrieval and display. Today, both paper and computer records are often cumbersome tools for these tasks. The record of the future must be far more flexible, allowing its users to design and utilize reporting formats tailored to their own special needs and to organize and display data in various ways.

The patient record system of the future must provide other capabilities as well, including links to administrative, bibliographic, clinical knowledge, and research databases. To meet the needs of clinicians, CPR systems must be linked to decision support systems; they must also support video or picture graphics and must provide electronic mail capability within and between provider settings.

Future CPR systems must offer enhanced communications capabilities to meet emerging user needs. The systems must be able to transmit detailed records reliably across substantial distances. Physician offices must be able to communicate with local hospitals and national bibliographic resources. In hospitals, all of the various departmental systems (e.g., finance, laboratory, nursing, radiology) must be able to communicate with the patient record system. In the larger health care environment, computer-based information management systems must be able to communicate with providers, third-party payers, and other health care entities, while at all times maintaining confidentiality of the information.

If users are to derive maximum benefits from future patient record systems, they must fulfill four conditions. First, users must have confidence in the data—which implies that the individual who collects data must be able to enter them directly into the system and that the system must be able to reliably integrate data from all sources and accurately retrieve them whenever necessary. Second, they must use the record actively in the clinical process. Third, they must understand that the record is a resource for use beyond direct patient care—for example, to study the effectiveness and efficiency of clinical processes, procedures, and technologies. Fourth, they must be proficient in the use of future computer-based record systems (i.e., the systems described in this report) and the tools that such systems provide (e.g., links to bibliographic databases or clinical decision support systems).

COMPUTER-BASED PATIENT RECORD TECHNOLOGIES

Over the past decades, progress has been steady toward developing complete CPR systems, and several powerful clinical information systems have become operational in recent years. Typically, development of these systems began at least a decade ago, and some have been under development for more than two decades. *No current system, however, is capable of supporting the complete CPR.*

Those clinical information systems that most closely approximate the CPR system envisioned by the committee share several common traits. First, they maintain a large data dictionary to define the contents of their internal CPRs. Second, all patient data recorded in the CPR are tagged with the time and date of the transaction, thus making the CPR a continuous chronological history of the patient's medical care. Third, the systems retrieve and report data in the CPR in a flexible manner. Finally, the systems offer a research tool for using the CPR data.

Most of the technological barriers that formerly impeded development of CPR systems have either disappeared already or are about to dissolve. Nevertheless, although no technological breakthroughs are needed to realize CPR systems, further maturation of a few emerging technologies, such as hand-held computers, voice-input or voice-recognition systems, and text-processing systems may be necessary to develop state-of-the-art CPR systems in the 1990s. In some cases, promising technologies must be tested further in "real-life" situations; in other cases, technologies that have proved beneficial in applications in other fields must be adopted for use in health care.

In addition to further development of necessary technologies, a variety of standards must be developed, tested, and implemented before the CPR can realize its full potential at both the macro (e.g., epidemiological) and micro (e.g., physician office) levels. Standards to facilitate the exchange of health care data are needed so that clinical data may be transmitted on networks or aggregated and analyzed to support improved decision making. Standards are also needed for the development of more secure CPR systems. This effort should focus on ensuring the integrity of the clinical data in the CPR and protecting its confidentiality. It is crucial that confidentiality be maintained in CPR systems not only for the patient but also for health care professionals.

NONTECHNOLOGICAL BARRIERS

In addition to technological advances, successful implementation of CPR systems requires elimination of the barriers to development (i.e., the production of new capabilities) and diffusion. It also requires that the concerns of many interested parties be addressed and that individuals and organizations with resources to support needed changes be engaged in the effort.

Many impediments to the CPR and to CPR systems arise from a lack of awareness and understanding of their capabilities and benefits. The intellectual understanding of what needs to be done, how to do it, and for whom to do it—that is, the demanding collection of insights required for design—is a continuing problem that must be addressed. (For example, when users are asked what capabilities they would like to have available to them, they may have difficulty imagining what CPR systems will be able to do in the future.) System purchasers and users often lack adequate information about the benefits and costs of the CPR. Developers and vendors require more specific information about what users want from systems and what price providers would be willing to pay for systems that meet their needs. Activities aimed at improving and disseminating available

information about CPR systems—for instance, through demonstration projects and education programs—constitute an important step toward CPR implementation.

Other impediments arise from the lack of an infrastructure to support CPR development and diffusion. Needed infrastructure components are standards for communication of data (i.e., vocabulary control and data format standards); laws and regulations that protect patient privacy but do not inhibit transfer of information to legitimate users of data outside the clinical setting; experts trained in the development and use of CPR systems; institutional, local, regional, and national networks for transmitting CPR data; reimbursement mechanisms that pay for the costs of producing improved patient care information; and a management structure (i.e., an organization) for setting priorities, garnering and allocating resources, and coordinating activities.

Consideration of the various barriers to CPR development, the interest and resources of individuals and organizations able to effect change, and the concerns of individuals who would be affected by implementation of CPRs prompted the committee to identify eight critical activities that will help advance CPR development: (1) identification and understanding of CPR design requirements; (2) development of standards; (3) CPR and CPR systems research and development; (4) demonstrations of effectiveness, costs, and benefits of CPR systems; (5) reduction of legal constraints for CPR uses as well as enhancement of legal protection for patients; (6) coordination of resources and support for CPR development and diffusion; (7) coordination of information and resources for secondary patient record databases; and (8) education and training of developers and users.

Accomplishing these activities will require adequate funding and effective organization. The committee reviewed organizational structures that could provide the necessary framework for coordinating CPR activities and concluded that no existing organization has the mandate and resources necessary to lead the CPR effort. Thus, for reasons set forth more fully in Chapter 4, the committee believes that a new organization is needed to support CPR development and implementation. The committee has proposed a framework for the establishment of such an organization, but it also emphasizes that achieving adequate resources for and engaging the appropriate parties in CPR development efforts are more important than the precise structure of the recommended organization.

**BOX 1 SUMMARY OF THE RECOMMENDATIONS OF THE
INSTITUTE OF MEDICINE COMMITTEE ON IMPROVING
THE PATIENT RECORD**

The committee recommends the following:

1. Health care professionals and organizations should adopt the computer-based patient record (CPR) as the standard for medical and all other records related to patient care.
2. To accomplish Recommendation No.1, the public and private sectors should join in establishing a Computer-based Patient Record Institute (CPRI) to promote and facilitate development, implementation, and dissemination of the CPR.
3. Both the public and private sectors should expand support for the CPR and CPR system implementation through research, development, and demonstration projects. Specifically, the committee recommends that Congress authorize and appropriate funds to implement the research and development agenda outlined herein. The committee further recommends that private foundations and vendors fund programs that support and facilitate this research and development agenda.
4. The CPRI should promulgate uniform national standards for data and security to facilitate implementation of the CPR and its secondary databases.
5. The CPRI should review federal and state laws and regulations for the purpose of proposing and promulgating model legislation and regulations to facilitate the implementation and dissemination of the CPR and its secondary databases and to streamline the CPR and CPR systems.
6. The costs of CPR systems be should shared by those who benefit from the value of the CPR. Specifically, the full costs of implementing and operating CPRs and CPR systems should be factored into reimbursement levels or payment schedules of both public and private sector third-party payers. In addition, users of secondary databases should support the costs of creating such databases.
7. Health care professional schools and organizations should enhance educational programs for students and practitioners in the use of computers, CPRs, and CPR systems for patient care, education, and research.

RECOMMENDATIONS

The committee believes its recommendations (see Box 1) effectively address the potential barriers to routine CPR use. The first recommendation defines CPRs and CPR systems as

the standard for future patient records; the second proposes an organizational framework within which barriers to CPR implementation can be systematically addressed and overcome. The remaining recommendations focus on specific impediments: needed research and development, promulgation of standards for CPR data and security, review of legal constraints and remedies, distribution of costs for CPR systems, and education of health care professionals.

The committee believes that the CPR can play an increasingly important role in the health care environment. This role begins in the care process as the CPR provides patient information when needed and supports clinical decision making. It extends to management of care through the establishment of a mechanism by which quality assurance procedures and clinical practice guidelines are accessible to health care professionals at the time and site of patient care. It also includes opportunities for reducing administrative costs and frustrations associated with health care financing and for capturing administrative data for internal and external review. Finally, the CPR's role extends to capturing relevant, accurate data necessary for provider and consumer education, technology assessment, health services research, and related work concerning the appropriateness, effectiveness, and outcomes of care.

The committee recognizes the considerable amount of work that remains to be done and the practical limitations that must be overcome before CPRs become the standard mode of documenting and communicating patient information and before they are perceived and used as a vital resource for improving patient care. The challenge of coordinating CPR development efforts in the pluralistic health care environment is great. Resources are limited and must be used wisely.

The committee is convinced that proper coordination and appropriate resources will lead to achievement of the goal of widespread CPR utilization within a decade. The desire to improve the quality of and access to patient data is shared by patients, practitioners, administrators, third-party payers, researchers, and policymakers throughout the nation. CPRs and CPR systems can respond to health care's need for a "central nervous system" to manage the complexities of modern medicine—from patient care to public health to health care policy. In short, the CPR is an essential technology for health care today and in the future.