CLINICAL INFORMATION SYSTEMS:

ACHIEVING THE VISION

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About the Kaiser Permanente Institute for Health Policy

Mission Statement
To advance understanding of key health policy issues and to advocate, in concert with others as appropriate, health policy that will improve health and the manner in which health care and financing systems serve Americans.

Goals
The Institute's Goals are to:
• Identify significant long-term health policy issues;
• Organize internal and external resources to analyze such policies;
• Improve understanding and recommend actions; and
• Build coalitions to shape and influence policy.

Emphasis is placed on developing political alternatives and exploring their implications, building on the experience of the largest privately organized health care delivery system in the United States.

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NOTICE

This document builds on the concepts prepared for and discussed at a meetings held in October 2001 in which many stakeholders expressed their own views and those of their organizations. The Kaiser Permanente Institute for Health Policy has studied the issues discussed at the meeting and has reviewed the relevant literature, and based on these considerations has developed the policy recommendations set forth in this paper. This paper is not meant to imply that there was consensus on any given issue. In fact, there was a wide range of opinions. The following report represents the views of the Kaiser Permanente Institute for Health Policy and does not necessarily present the views of individual participants nor the organizations that they represent.

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I. Executive Summary

Clinical information systems (CIS) and other information management tools hold the promise of improving the quality and safety of patient care and increasing the efficiency of health care personnel. However, the health care industry lags behind other sectors in information technology investment and, with few exceptions, has not fully benefited from the information revolution.

The practice of medicine, which largely uses paper-based records and is heavily dependent on unaided recall, is ripe for change. The limitations of the 20th century health care system are such that the old medical care paradigm is less viable and the emergence of a new way of practicing medicine is almost inevitable. Evidence-based medicine is the foundation for an emerging paradigm in medicine that calls for new tools to enable improved quality and outcomes. Furthermore, a variety of system enhancements can prevent many of the medical errors and adverse events that currently plague our health care delivery system. Clinical information systems can be a bridge to this new paradigm by providing the fastest route to evidence-based medical knowledge coupled with more complete and accurate patient data and diagnostic and treatment information.

The growing body of evidence of the value of CIS shows that clinical applications such as computerized reminders, automated order entry systems, and decision support tools can enable significant improvement in preventive health services, disease management, and patient safety. The evidence also suggests that clinical information systems provide practitioners with timely and comprehensive information, which leads to improved care. Health promotion and personalized care are also major tenets of the clinical information system value proposition.

A variety of barriers stand between health care providers and the implementation of clinical information systems. Among the most significant of these are the high capital and operating costs, competing priorities for limited resources, cultural issues, and the difficulty of defining and capturing a return on these investments. A select few larger, integrated delivery systems in the U.S. have uniquely positioned themselves to take advantage of CIS and have demonstrated the value of these systems in care delivery.

Progress toward broader use of clinical information technology in health care will not occur in the absence of sound public policy. To this end, the Kaiser Permanente Institute for Health Policy set forth the following policy recommendations:

Recommendation 1: The federal government should provide leadership to encourage development of a standard clinical vocabulary, standards for the exchange of clinical information, and other standards for interoperability as they emerge.

Recommendation 2: State and federal privacy policy should avoid establishing barriers to the legitimate development and use of clinical information technology.

Recommendation 3: The cost of health information technologies should be shared among those who benefit from them. Public investment is needed to encourage the adoption of these important technologies.

Recommendation 4: Research and development focused on implementation and effective use of health information technologies should be encouraged and supported.

II. Introduction

A review of the literature supports the conclusion that developments in Information Technology (IT) within the past forty years have enabled some organizations to integrate clinical information with medical care delivery in ways that can promote safer, more efficient, patient-centric health care. Clinical information technologies can support outcomes management, drug interaction checking, order entry, and electronic capture of vital signs and clinical notes. These advances in health care IT could pave the way
for early intervention in disease processes, improvement in quality, reduction of medical errors, improved care management, administrative efficiency, and increased patient satisfaction.

From the late 1950’s forward, health care visionaries have anticipated an information technology revolution within medical care delivery that would transform the health care industry in a manner similar to those seen in the finance and retail sectors. Pioneers of health informatics, such as Morris Collen, MD, Homer R. Warner, MD, PhD, Octo Barnett, MD, and Lawrence Weed, MD, among others, formulated the vision for reforming the chaos in modern medicine through the use of information technology.

In 1991, the Institute of Medicine’s Committee on Improving the Patient Record set a goal to make the computer-based patient record a standard technology in health care by 2001. Yet, to date the clinical IT revolution has eluded much of the U.S. health care system and the high expectations of the visionaries remain largely unfulfilled. Meanwhile, a variety of significant barriers still stand in the way of the overdue promise of clinical information technology. Although this concern has been discussed in a variety of forums over the past several years, neither straightforward solutions nor clear plans of action have emerged.

This document provides an overview of the issues surrounding the use of clinical information technology in the U.S. health care system and synthesizes the discussions at a meeting regarding “The Benefits of Clinical Information Systems,” sponsored by the Institute of Medicine and the Kaiser Permanente Institute for Health Policy on October 4 and 5, 2001. Participants in the meeting included representatives of some of the early adopters and pioneers of clinical information systems, including Beth Israel Deaconess Hospital, Brigham and Women’s Hospital, Kaiser Permanente, LDS Hospital, Mayo Clinic, Palo Alto Medical Foundation, Queen’s Medical Center, and the Veterans Administration. Other participating organizations included the Health Technology Center, the American Hospital Association, the Medical Records Institute, the Center for Health Care Quality at the University of Missouri, Cedars-Sinai Health System, and the U.S. Agency for Healthcare Research and Quality. (See Appendix A for a list of meeting participants.)

The meeting focused on contributing to the growing body of evidence regarding the benefits that can be achieved from clinical information systems, identifying the barriers and enablers related to implementation, and identifying the components of a policy agenda focused on encouraging investments by other health care organizations in clinical IT.

This paper begins by describing a paradigm shift toward the practice of evidence-based medicine and the movement away from the traditional paper-based system that relies heavily on the unaided mind. The symptoms that suggest that the traditional medical paradigm is not well suited for the 21st century are also explored. Next, clinical information systems are defined and the evidence of the value of these systems is summarized. The following section identifies the many obstacles to clinical information technology usage and benefit realization. The paper concludes with policy recommendations to expedite the expansion of clinical information systems in U.S. health care.

III. CIS: A Bridge to a New Health Care Paradigm

The practice of medicine, which combines a constantly evolving scientific knowledge base with clinical experience, human values, and human intuition, is undergoing fundamental changes. The cornerstone for what has been described as a paradigm shift in medicine is the widely held belief that the evidence-based practice of medicine can lead to improvement in patient outcomes. In addition, the demands on the health care system are shifting from acute to chronic care and consumers are beginning to play a much more active role in their health care. Over the past fifty years, evidence-based medicine has provided an explicit framework of scientifically
validated information for medical decision making. Evidence-based medicine supports the implementation of cutting-edge care management programs and can lead to improvements in patient outcomes and cost-effective care. Yet despite an exponential increase in the biomedical knowledge base and revolutionary advances in technology, the health care industry continues to rely on a framework for the distribution of new information regarding the practice of medicine that has changed little over the last century. Balas and Boren found that “an average of about 17 years is required for new knowledge generated in randomized, controlled clinical trials to be incorporated into practice, and even then its application is highly uneven.”

Whereas the traditional medical paradigm assumes that a physician’s initial medical school training and experiences provide a sufficient foundation for diagnosis and treatment, evaluation of new tests and procedures, and development of clinical practice guidelines, the new evidence-based paradigm comprises a different set of assumptions. For example, one of the main tenants of evidence-based medicine is that clinicians should use unbiased studies to increase their confidence in the usefulness of clinical therapies and diagnostic tests. Likewise, an evidence-based orientation is necessary to evaluate and apply the medical literature effectively.

The practice of medicine has grown almost unmanageably complex. The limitations of the 20th century health care system are such that the old medical care paradigm is less viable and the emergence of a new way of practicing medicine is almost inevitable. A variety of signs suggest that the traditional medical paradigm is not well suited for the 21st century:

- the paper-based system supporting clinical care is increasingly non-viable;
- human memory-based medicine is increasingly unreliable;
- clinical data capture has become a business imperative; and
- consumer expectations for improved care and service are rising.

A. The Paper-Based System Supporting Clinical Care Is Increasingly Non-Viable

Clinical decision making should be driven by point-of-care information accessed by providers in real-time. Traditional paper-based information systems are no longer an acceptable long-term option for the changing demands of health care delivery settings. Paper-based information storage and retrieval systems currently have high failure rates that can lead to duplication of service, delays in treatment, increased length of stay, and increased risk of medical errors caused by missing or inaccessible data and inefficient manual processes. The limitations of the paper-based system are numerous:

- Providers too frequently have access to only a portion of a patient’s information because medical histories are spread across multiple information silos (i.e., doctor’s offices, hospitals, pharmacies, health plans, and insurance companies).

Researchers have estimated that from 10 percent to 81 percent of the time, physicians do not find patient information that has been previously recorded and belongs in the medical record.

- In large institutions, the single copy of a patient’s paper-based record may not be available to others who need it while a clinician finishes documentation of an encounter.

- When a chart is not available, health professionals must provide medical care without the benefit of medical history. They document the encounter and hope that these notes eventually make it to the patient’s chart—an outcome that is not always the case, especially in large institutions.

- The structure of paper-based records makes it difficult to locate essential information within the chart. Paper-based systems allow free text documentation, often resulting in disorganized, non-integrated content that is not useful to others.
• Handwritten text entries are not always legible.

• After many years, a patient’s records can increase to multiple volumes, forcing a distinction between current and historic information and sending “old records” and source documents to long-term storage facilities.

A recommendation of the Institute of Medicine (IOM) for improving patient records dating back to 1991 called for the computer-based patient record to become the standard for patient medical records by 2001. The IOM recommendation has not been realized and the shortcomings of paper-based systems that it identified ten years ago persist and are escalating.

B. Human Memory-Based Medicine Is Increasingly Unreliable

The information-intensity of health care is increasing rapidly. New clinical practice guidelines, research findings, pharmaceuticals, and medical devices surface daily. Practitioners are bombarded with changing clinical decision factors and are challenged to stay abreast of an increasing knowledge base in their areas of expertise. So much information is now being published that a practitioner does not have the time to read the latest information. In 1966 just over 100 articles were published each year from randomized controlled trials; in 1995 nearly 10,000 articles were published annually. The current practice of medicine relies heavily on the unaided mind to recall a great amount of detailed knowledge, a process that has repeatedly been shown to be unreliable, to the detriment of all stakeholders nonetheless.

One physician described “voltage drops” in the transmission of medical knowledge as it is transferred from the source to the physician’s brain to its final application in patient care delivery. He observes:

• Only a portion of medical knowledge is ever loaded into the minds of professionals.

• Not all of the knowledge loaded in the minds of the professionals is retained.

• Much of the knowledge that professionals retain becomes obsolete, and there is no assurance that that they will learn new knowledge relevant to their patient's problems. In other words, they don't know when they will get their “upgrade”.

• Even with that reliable knowledge that it retains and the incredible integration prowess of the human mind, a doctor's unaided mind cannot reliably integrate all that knowledge with the infinite variety of patient data, to identify and systematically assess all diagnostic or treatment options within the soonest possible time.

• Faced with this clinical knowledge overload, doctors tend to fall back on clinical judgment and heuristics (global intuitive assessment), rather than organized investigation and correlation of patient findings with diagnostic and treatment options. Cognitive psychology has shown that experts' global judgments are inferior to judgments based on thorough analysis of data.

The advocates of clinical IT contend that automated information management tools are increasingly necessary as medical knowledge proliferates. Likewise, clinical IT is needed to lend cognitive aid to practitioners as they integrate the large body of general medical knowledge with the complex data on unique, individual patients.

C. Clinical Data Capture Has Become A Business Imperative

As the costs of health care continue to rise, purchasers are increasingly impatient with the health care industry’s inability to accurately account for its expenses. While other industries have developed extensive cost data and detailed accounting systems, the health care industry is finding it increasingly difficult to evade responsibility for the capture of clinically derived information that is necessary for a
As consumers learn more about clinical information technology they will appreciate that it can contribute to improvements in the safety and quality of their care, while increasing opportunities for them to partner with providers in their health. Like other advances in medical technology, clinical IT will raise consumer expectations of what is possible and what should be made available to them. Developments that are most likely to raise consumer expectations for the use of IT in the health care delivery system are personal experience, word of mouth, and exposure through the media. The omnipresent use of information systems that support service delivery in other sectors will also fuel these expectations.

There is a growing consensus that clinical information systems can be the bridge to a new health care paradigm. Clinical information systems offer new opportunities to further improve the quality and safety of care by ensuring that the most recent information is available for clinical decision making, improving evidence-based guideline compliance, and enhancing communication among providers. The information management tools within CIS can drive the changes toward an evidence-based framework for the evaluation and treatment of patients. Although clinical information systems are not an absolute requirement for quality health care delivery, it is difficult to envision addressing the limitations and challenges of the 21st century health care system without these information management tools.

IV. What is CIS?

"Clinical Information System" (CIS) is an umbrella term that has been applied to a broad range of clinical information technology. Several other terms are used to describe information systems that support the delivery of health care (e.g., electronic medical record system, health information system, and computer-based patient record system). For the purpose of this paper we use the term clinical information system to refer broadly to various configurations of clinical application components. In the past, these systems have typically been clinically oriented homegrown
applications on legacy platforms that were used primarily by larger hospitals and health care provider organizations and focused on the information needs of practitioners.

Because clinical information systems have taken different evolutionary paths in various organizations, a single definition of a clinical information system is elusive. Tang and McDonald offer useful definitions for the computer-based patient record, an essential element of many clinical information systems, and for the computer-based patient record system:

“A computer-based patient record (CPR) is a repository of electronically maintained information about an individual’s lifetime health status and health care, stored such that it can serve the multiple legitimate users of the record.”

“A computer-based patient record system adds information-management tools to provide clinical reminders and alerts, linkages with knowledge sources for health-care decision support, and analysis of aggregate data. A CPR system extends the usefulness of patient data by applying information management tools to the data.”

The Institute of Medicine (IOM) Committee on Improving the Patient Record used the following definition of a clinical information system during its work:

“A system dedicated to collecting, storing, manipulating and making available clinical information important to the delivery of patient care.”

The IOM Committee acknowledged that the central focus of a clinical information system is clinical data, rather than financial or billing information. Clinical information systems may be limited in their scope to a single area of clinical information (e.g., pharmacy data), or they may be comprehensive and cover virtually every aspect of patient care.

Clinical information systems typically include one or more of the system components identified below in Table 1. Within many organizations a clinical information system is a patchwork of clinical applications on disparate platforms that has evolved over time—not a single, seamless, integrated application. Organizations seeking flexibility and customization have combined application components incrementally over time.

Many of the rewards of clinical information technology can be harvested without a full-scale clinical information system that integrates multiple applications around an electronic medical record. For example, stand-alone applications such as results reporting or computerized physician order entry offer some of the same opportunities to improve care as the more sophisticated clinical information systems with electronic medical record functionality. Brigham and Women’s Hospital in Boston has a long history of CIS benefit realization in the area of medication prescribing with a system that does not feature a complete electronic medical record.

Nevertheless, a core source of automated clinical data, such as an electronic medical record, that feeds decision and communication support capabilities helps to maximize the benefits of other system tools. Furthermore, system components have a synergistic effect—the value of multiple integrated components is greater than the sum of the individual parts.

The use of IT applications in health care is rapidly evolving beyond what in the past has been considered a clinical information system. Health care IT now encompasses new tools and health services that are delivered or enhanced through the Internet and other advanced networking technologies, including telemedicine, wireless handheld applications, and home monitoring. Speech recognition tools hold the promise of reducing transcription costs. New patient-focused tools target the growing ranks of empowered health care consumers. These include patient self-management applications, interactive health promotion programs, on-line access to trusted medical knowledge, and personal health records that are owned by consumers. Many of the new products and services are component-based and off-the-shelf rather than home grown.
Table 1. Components that are often featured in Clinical Information Systems

<table>
<thead>
<tr>
<th>Application</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Practitioner Order Entry</td>
<td>A means to assist providers in completing clinical tasks such as ordering laboratory tests, prescription drugs, diagnostic imaging, or consult requests. Decision support and alerts are typically integrated into order entry capabilities.</td>
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<tr>
<td>- Laboratory Management System</td>
<td></td>
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<td>- Pharmacy Management System</td>
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<tr>
<td>- Diagnostic Image Management System</td>
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<tr>
<td>- Referral Management System</td>
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<tr>
<td>Integrated View of Patient Data</td>
<td>A repository of information about patients that presents an appropriate view of patient information to health care providers.</td>
</tr>
<tr>
<td>(e.g., Electronic Medical Record)</td>
<td></td>
</tr>
<tr>
<td>Documentation Management</td>
<td>A means, either using coded data entry or free-text input, to allow practitioners to record the actions they have taken in diagnosing, managing and treating the patient. Such an application could collect data such as nursing notes, physician progress notes, or even the medication administration record, for example.</td>
</tr>
<tr>
<td>Clinical Decision Support</td>
<td>Alerts based on current data from the electronic medical record, evidence-based practice guidelines, or more complex artificial intelligence engines for diagnostic support are provided at the time the clinician is formulating an assessment of the patient’s condition and making ordering decisions.</td>
</tr>
<tr>
<td>Administrative Data</td>
<td>Access to various types of administrative data such as admission, discharge and transfer records, surgery schedules, demographic data, room assignments, etc. These data are used to track patient movement and are often needed to allow the accurate generation and delivery of clinical alerts and reminders.</td>
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<tr>
<td>Integrated Communication Support</td>
<td>Tools that positively impact the effectiveness and efficiency of communication among team members to affect the continuity of patient care handoffs between multiple providers.</td>
</tr>
<tr>
<td>Access to Knowledge Resources</td>
<td>Online information such as reference materials or journal articles in the context of a specific patient at the time decisions or orders are being made.</td>
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This paper, however, takes a more narrow focus and examines the use of practitioner point-of-care tools that have supported the delivery of medical care within hospitals or outpatient settings. As the emerging IT applications take hold in the industry, the term clinical information system becomes an increasingly inadequate description of these technologies. A new term is likely to develop to reflect this evolution.

V. Evidence of Clinical Information System Value

Since the 1960’s, researchers from universities, health care providers and the federal government have attempted to demonstrate the value of clinical information systems. To gain a better understanding of the body of evidence about CIS, the Kaiser Permanente Institute for Health Policy reviewed many of the published studies regarding the use of information technology applications in the delivery of health care.

Following are the highlights from this review:

- A majority of the studies in circulation fall under the category of quality, health outcomes and safety.

- The research demonstrates repeatedly that reminder systems and order entry systems are extremely effective in improving preventive health and disease management guideline compliance, particularly in an outpatient setting.

- There is ample evidence that clinical information tools can improve prescription drug administration and patient safety through improved drug dosing.
reduction in adverse drug interactions, and more appropriate utilization.

- We confirmed what other reviews of literature have found—a number of articles demonstrate benefit related to specific aspects of clinical information systems, but very few provide compelling evidence.

- Very few studies contain substantial documentation of improvements in productivity, efficiency, service, or major cost savings in non-clinical areas. However, studies looking at adverse drug interactions and improved formulary usage have demonstrated cost savings.

Researchers continue to have difficulty finding evidence of benefits for a number of reasons:

- Process changes associated with IT implementation and human variability make it difficult to attribute positive outcomes solely to CIS. Likewise, decisions about patient care are ultimately made by physicians and the patients themselves.

- Much of the research in the area has been performed at individual sites on "home grown" systems, making it difficult to generalize the results.

- Most studies have focused on individual computerized processes in isolation; very few studies look at entire care delivery systems. It is likely that clinical and economic benefits will be more easily demonstrated after systems have been fully implemented and additional processes have been computerized.

The published evidence regarding CIS benefits fall into three broad categories:

- Improved quality, outcomes, and safety;

- Improved efficiency, productivity, and cost reduction; and

- Improved service and satisfaction.

The following is a sample of CIS benefits that have been documented in the literature as well as unpublished benefits reported by participants at the October 2001 meeting “The Benefits of Clinical Information Systems”, sponsored by the Institute of Medicine and the Kaiser Permanente Institute for Health Policy.

A. Improved Quality, Outcomes and Safety

Increase in Preventive Health Guideline Compliance

The positive effect of computerized reminder systems on preventive health guideline compliance is one of the most studied aspects of CIS. McDonald et al., found that physicians who were exposed to reminder messages were twice as likely to provide preventive care as those that were not. Reminder messages improve the likelihood physicians will act on their intentions. Following are some additional examples of how computerized reminders have demonstrated a positive impact on preventive health services:

Health Risk Assessment. Health screening guidelines are often overlooked in primary care settings. Computerized protocols encourage physician compliance with recommended guidelines. Physicians who utilized a computerized protocol increased the rate of recording blood pressure by 34%. In another study, a computer-based health maintenance tracking system significantly improved provider compliance with 8 of 11 recommended procedures at a cost of only 78 cents per patient per year.

Immunizations and Vaccinations. One in four toddlers remains underimmunized despite national campaigns to improve vaccination coverage such as Healthy People 2000. Computer-generated letters that identify children overdue for immunizations have proven effective especially among HMO enrolled populations. Fifty percent of parents who received a computer-generated reminder letter reported vaccinations for their children, whereas parents who did not receive a reminder letter reported no vaccinations. Other studies have found that patients...
of physicians who received computer-generated reminders were more likely to receive influenza vaccinations than patients of physicians who did not.43

Cancer Screening and Diagnosis. Cancer is the second leading cause of death in the U.S., accounting for approximately 23% of all deaths.44 Computerized reminders and prompts in an outpatient setting have been found to have a significant effect on cancer prevention activities such as the performance of stool occult-blood test, rectal examination, cervical cancer screening, pelvic examination, breast examination, smoking assessment, smoking cessation counseling, dietary assessment, and dietary counseling.45, 46, 47, 48, 49, 50, 51, 52

Improved Disease Management

Clinical information systems have been shown to have a positive impact on care management of the following diseases:

Diabetes. Diabetes, the 7th leading cause of death in the United States,53 requires a high degree of care management. Clinical information systems have been useful in improving care to diabetes patients by stratifying at-risk patients, improving physician compliance with guidelines and improving drug administration.54, 55 A study at Duke University documented a two-fold increase in clinician guideline compliance with a computerized decision support system.56 Kaiser Permanente in Ohio utilized an automated medical record and computer prompt system to stratify patients by risk group and apply preventive treatment to medium- and high-risk diabetic patients. The system was successful at increasing preventive care, reducing unnecessary visits for low-risk patients, and substantially reducing the number of amputations of high-risk patients.57

Hypertension. The prevalence of hypertension is high in the United States and the associated cost is a burden on the health care system. A computer-based medical record was used by Harvard Community Health Plan to significantly improve follow-up of newly discovered elevation in diastolic blood pressure. Follow-up was attempted or achieved in 84% of patients in the experimental group but in only 25% of patients in the control group.58

Asthma. Asthma is a common health problem that affects 14.5 million Americans, creating a minimum of 9.5 million office visits annually. A computerized questionnaire that indicates the likelihood and severity of asthma has been validated as a new approach to asthma diagnosis. The program holds the potential to ease the burden of information gathering and disease detection on general practitioners.59 In a separate study, a computer-generated reminder system was found to improve patient management of the disease, as well as reduce asthma related hospitalizations by 60% and emergency department visits by 50%.60

Unstable Angina. Partial thromboplastin time, or PTT, is a common screening test used to monitor heparin therapy. Common indicators for heparin are unstable angina and deep vein thrombosis. At Queen’s Medical Center in Honolulu an automated heparin protocol was used to reduce the average time to reach therapeutic PTT levels—96% within 24 hour with the automated protocol vs. 14% within 24 hours without the computer assisted protocol.61

Mental Health. Approximately 9.5% of the U.S. population or 44.3 million Americans suffer from a mental disorder in a given year.62 Computer administered screening instruments at primary care clinics were found to be useful for diagnosing mental health disorders, increasing the quality of patient care, and eliciting medical information from patients.63, 64, 65 In a separate study, a computer reminder system in an outpatient mental health clinic was shown to be superior to a paper system, improving adherence to clinical guidelines by 25%. The system also improved problem documentation by over 90%.66

Tuberculosis. The recent increase of tuberculosis in the United States makes appropriate preventive therapy a priority. A computer-based decision support system was found to be more effective and efficient than standard guideline tables for physicians in applying TB preventive therapy. Physicians who utilized the system applied the appropriate treatment 95% of the time, whereas physicians who used paper-
based resources applied the appropriate treatment only 56% of the time.69

HIV/AIDS. Advances in treatment are enabling persons living with HIV/AIDS to live longer, healthier lives. Getting current HIV treatment guidelines in the hands of practitioners is a major challenge considering the large amount of emerging information. Beth Israel Deaconess Medical Center in Boston saw a positive impact from computerized alerts and reminders on the dissemination and adoption of clinical practice guidelines in the area of HIV. Specifically, the median response time with the electronic alert system for a set of conditions was 11 days, as compared to 52 days without the alert system.70

Improved Drug Prescribing and Administration

Improved Antibiotic Usage. Studies show that up to 50% of antibiotic use may be inappropriate in a variety of clinical settings.71 A study at LDS Hospital in Salt Lake City found that an antibiotic information system that helped physicians select antibiotic regimens was more likely to address the pathogens causing a patient’s infection and offer the most cost-effective alternative. Additional use of this system in an intensive care setting at the same site resulted in fewer susceptibility mismatches and allergic reactions. Adverse drug reactions were reduced by over 70%, patients received excessive dosages for 2.9 fewer days, and the overall cost of antibiotic therapy was reduced.72, 73, 74

Increase of Appropriate Prescription Use and Refill Compliance. Patient noncompliance with medication use is a source of high medical costs associated with poor disease management. A study among outpatients demonstrated that only 22% of prescribed therapies were being taken properly.75 At a university health center a computer reminder system was found to be significantly more effective in increasing medication refill compliance in a controlled study.76

Improved Drug Dosing. Warfarin and other anticoagulant drugs are widely prescribed for a variety of clinical disorders that have high medical and administrative costs. Patients are found to be inadequately coagulated 35-50% of the time.77 Several studies have found that computer-assisted therapies and decision support systems can improve outpatient anticoagulant control in early and long-term treatment which may lead to a reduction in adverse events.78, 79, 80, 81, 82

Reduction in Medical Errors

Reduction in Adverse Drug Interactions. Adverse drug interactions are a major source of morbidity and mortality resulting in high costs in both inpatient and outpatient settings. An estimated 770,000 people are injured due to adverse drug events annually in the U.S.83, 84, 85 and up to 70% of these incidents may be avoidable.86, 87 A study at Brigham and Women’s hospital evaluated a physician order entry system that resulted in a 55% reduction in medical errors and a 17% decrease in the preventable adverse drug event rate with potential cost savings of at least $480,000 annually.88 Another study at the same institution documented that more than 80% of medication errors unrelated to missed dosage were eliminated by computerized physician order entry.89

Reduction in Errors of Omission. Errors of omission, such as failure to act on results or failure to carry out indicated tests, are a common problem in medicine. Computer generated reminders have been found to be effective in reducing errors of omission in both inpatient and outpatient settings.90, 91 A study at the Regenstrief Institute found that physicians who received a computer-generated reminder followed practice guidelines 25% more often in an inpatient setting.92

Improved Medical Data Capture and Display

A number of studies have found that computerized information systems enable more comprehensive and accurate documentation by physicians and nurses.93, 94 A more complete record is achieved with computer prompts that ask for missing information and can
improve the clinical decision process.\textsuperscript{95, 96, 97} One study found that charting errors occurred in 25% of handwritten flow sheets. An automated patient data management system eliminated these errors and increased the number of progress notes documented.\textsuperscript{98}

A study at Northwestern University documented increased completeness of progress notes in their electronic medical record compared to notes in paper records of a control group. A blinded expert panel scored completeness on a 0-2 scale—electronic medical records scored 1.8 vs. 0.9 for paper record users. The study also found that the clinical decisions of providers using the electronic medical records were deemed more appropriate compared with providers who used paper medical records.\textsuperscript{99}

Improved Access to Pertinent Literature and Clinical Information

Some clinical information systems make it possible for physicians to have access to knowledge bases and literature sources. This access may be useful at the diagnostic or treatment stage or in enhancing patient understanding of a clinical problem.\textsuperscript{100} A study at the University of Washington found that integrating the electronic health record with the Internet also led to efficiency gains.\textsuperscript{101}

B. Improved Efficiency, Productivity and Cost Effectiveness

More Appropriate Utilization of Services

Inpatient Utilization Reduction. Clinical information technology has been used to improve quality of care while reducing hospital utilization. A clinical laboratory alerting system used at LDS Hospital to increase the likelihood that patients in life-threatening situations receive appropriate care decreased length of stay by up to 6 days for some conditions.\textsuperscript{102} In a study conducted at the Regenstrief Institute, a physician order entry system in an inpatient setting was found to lower patient charges and hospital costs mainly by reducing length of stay by 10.5%, reducing test charges by 12.5%, and reducing drug costs by 15.3%. The total charges per admission were 12.7% less for teams that utilized the order entry system than those that did not.\textsuperscript{103}

Outpatient Utilization Reduction. Kaiser Permanente has evidence that the clinical information systems in its Colorado and Northwest regions helped reduce outpatient visits in the first two years after implementation. Total office visit rates decreased approximately 7% (on an age-adjusted basis) in both regions. The data indicate a reduction in the proportion of members with high visit frequency after the system implementation. While the visit rate has dropped, key measures of quality remain stable or improved.\textsuperscript{104}

Scheduling of Follow-up Appointment. Computerized support for the scheduling of follow-up appointments for anticoagulant treatment was found to be effective in providing more efficient care by having longer, more appropriate intervals between appointments, without compromising quality of care.\textsuperscript{105}

Reduction of Unnecessary Diagnostic Test. Unnecessary diagnostic tests are a financial burden on the health care industry and an imposition on patients. A Regenstrief Institute study found that computers can assist physicians in estimating the risk of disease, thereby reducing the ordering of unnecessary diagnostic tests in an outpatient setting. This was true particularly for the two most popularly ordered tests, electrolyte level tests and blood cell counts.\textsuperscript{106} In a separate study at the Regenstrief Institute, physicians ordered 14%-17% fewer diagnostic tests when they were given computerized information about the charges for tests. The resulting reduction in charges to the patient or insurer was almost $7 per patient visit.\textsuperscript{107} Patient inconvenience and risk were also reduced.

Better Use of Formulary and Generic Drugs

In 1998, pharmaceuticals were estimated at 8% of overall health care costs, which translates to approximately $90.6 billion.\textsuperscript{108} More recently, it has been estimated that pharmaceuticals have risen to 11% of overall health care costs.\textsuperscript{109} One strategy to reduce pharmaceutical costs is to use computer prompts and recommendations to encourage the use of generic and
formulary drugs. A study at Duke University found that providing physicians with monthly-computerized feedback of prescribing charges and patterns encouraged physicians to substitute generic alternatives for brand name prescriptions 30% more often. Another study in Scotland saw a reduction in prescription costs by more than 20% with the use of a computerized prescribing program and personalized formulary.

**Improved Workflow and Time Saving**

A study at Duke University found that the use of a computerized medical record system resulted in an overall time saving of 13% for physicians. The computerized medical record was also found to improve physicians’ response to information regarding diagnosis and treatment. In another study, physicians who utilized the computer-based medical record indicated that it contributed to time saving in follow-up phone conversations and office visits. Physicians found value in not needing to reenter patient and laboratory data.

**Savings Related to the Storage of Medical Records**

Electronic medical records can save a substantial amount of space required for paper storage. It has been estimated that an annual cost saving from storage due to a computerized medical record ranges from $4,000 at small centers to $100,000 at large centers. The Memorial Sloan Kettering Cancer Center estimates that they have realized space savings of 2,000 sq. feet with an electronic medical record, worth $100,000 annually. Kaiser Permanente’s Colorado and Northwest regions estimate annual savings of approximately $400,000 and $500,000, respectively, in avoided lease cost after implementation of an electronic medical record.

**Savings Related to Reduction in Chart Pulls**

The electronic medical record reduces the time necessary for clerical staff to locate, pull and deliver charts. Beth Israel Deaconess Medical Center uses a CIS to reduce the paper chart pulls for processing telephone messages. At $4 per chart pulled, the medical center estimates savings between $300,000-$500,000 per year. The Kaiser Permanente Colorado and Northwest regions have documented annual payroll cost savings of approximately $4 million and $5.7 million respectively. Both Kaiser Permanente regions enjoy nearly 100% chart availability with their CIS.

**Improved Charge Capture and Revenue**

Information systems have been historically successful in the area of charge capture. Both Beth Israel Deaconess Medical Center and Brigham and Women’s Hospital utilized an integrated hospital system and reduced the time to collect unpaid bills from 65 days to 39 days, and from 100 days to 59 days, respectively. At the latter hospital, outstanding debts in the outpatient clinics have been reduced by more than $6 million and revenues have increased by 45% over the three years since implementation. The systems at these hospitals enabled more than 90% of each patient’s charges to be captured as a byproduct of clinical computing.

**Elimination of Transcription Notes**

Medical transcription has grown to a $15 billion to $20 billion industry. Beth Israel Deaconess Medical Center has eliminated the use of transcription notes in the outpatient setting after the implementation of an electronic patient record system.

**C. Improved Service and Satisfaction**

**Improved Communication**

Communication and the sharing of information between providers are important for the delivery of quality care and prompt service to the patient. A study at Brigham and Women’s Hospital found that an outpatient clinical referral system decreased the amount of time needed to complete the referral process compared to the manual process. The time saving improved the quality of care, the communication between physicians and created cost savings. The Mayo Clinic’s clinical information
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system enables electronic submission of consult requests in the hospital with immediate appearance of the request on a provider's work list. Anecdotes have been collected at the Mayo Clinic of patients being discharged a full day earlier because of rapid notification.124

Improved Satisfaction

Physician and Health Care Worker Satisfaction
Since an estimated 20-30% of clinician time is spent searching for or organizing information125, access to a clinical information system is likely to improve provider satisfaction. For example, physicians at the Mayo Clinic have outpatient data available immediately when patients are admitted to the hospital. Prior to CIS implementation the charts might take several hours to arrive following patient admission to the hospital.126

Patient Satisfaction
Clinical information systems are likely to increase patient satisfaction with the care they receive. However, very few articles address the impact of these systems on the patient experience or on patients' level of satisfaction.127 A couple of studies have found improved patient satisfaction due to an automated nursing discharge summary128 and access to bedside technology.129

In a survey of 60 hospitalized patients and their families, the Mayo Clinic documented that 89% of patients' families had positive comments related to the use of bedside computers in patient care; 87% of patients felt that the computer increased the amount of time nurses spent with patient care; and 63% felt they had more involvement in their own plan of care.130 The Palo Alto Medical Foundation uses an online application that gives patients access to health care services and their medical record. Patients who use the Internet services feel that online communication with their physician and staff increases their satisfaction compared with telephone services and promotes the feeling of shared decision making.131

Conclusions about the Evidence
As evidenced above, the impact of clinical information systems on health care outcomes, safety, and service is growing. While only a limited number of the individual studies contain compelling evidence of benefit realization, when one looks at the studies collectively there is mounting and persuasive evidence of the positive impact of clinical information technology. Additional research in this area is imperative. Randomized controlled trials are recommended as they provide the most valid information about the efficacy of clinical information systems.132 Further evidence of improvements in productivity, service, and cost savings in non-clinical areas will also help to build the case for CIS.

VI. Roadblocks

Unlike other information-rich industries, health care, the largest service industry in the U.S. economy, has not fully benefited from the information revolution. The typical health care organization spends approximately two percent of its capital budget on information technology, as compared with an average of 10 percent in other industries.133 Why have health care providers failed to migrate to clinical information technologies?

A. Competing Priorities
Part of the answer lies in IT resource allocation decisions. In the 1970s, 1980s and 1990s the IT investments of health care organizations were focused primarily on financial and administrative systems.134 Patient registration and accounting applications were introduced to make workflow and billing processes more efficient. Avoiding the anticipated Y2K crisis occupied the health care IT agenda during 1998 and 1999. Most health care organizations froze new IT investments and focused their resources on remediation of projected Y2K problems in their financial and administrative applications.135 Today, a variety of IT solutions are competing with clinical information technology for the scare capital funds of health care organizations. These competing non-clinical technologies include practice management applications, supply chain automation, and web-based customer relations software.
B. Cost is a Significant Barrier

The high cost of the basic infrastructure of clinical information technology is a significant hurdle for many provider organizations, many of which are suffering from multiple years of margin deterioration from thinning Medicare or other reimbursement. Getting a clinical application up and running requires a minimum IT infrastructure (i.e., fiber-optic backbone network, staff training and development, clinical workstations, or high-speed internet access, T1 line etc.). For most hospitals, access to capital for new medical technology is extremely scarce. Likewise, small to mid-sized IPAs and independent physician offices, where the majority of physicians practice, are plagued with financial instability and cannot afford the infrastructure cost.

Many prospective purchasers decide not to make the investment in clinical systems after realizing that the cost of technology acquisition is beyond their means. Lack of adequate financial support for IT and difficulty proving quantifiable benefits/return on investment have been the top two IT implementation barriers cited in 2000 and 2001 by senior executives from health care provider and vendor organizations from across the U.S. in the Healthcare Information and Management Systems Society (HIMSS) Leadership Survey (see Chart 1).

C. The Elusive Business Case for Clinical IT

While quality and safety are important concerns, information technology investment decisions are often painstakingly evaluated by health care organizations based on measures such as cost-per-doctor-per-month, cost-per-member-per-month, and short-term return on investment. Tang and McDonald observed that part of the difficulty in understanding the relative costs and benefits of a computerized patient record is
the inability to accurately measure the actual costs of using paper-based records.\footnote{138} Return on investment for clinical information systems is not easy to measure nor is it necessarily the most appropriate indicator of CIS success. CIS benefits that have a significant impact on health care operations, such as provider convenience, patient satisfaction and service efficiency are not easily captured on the bottom line in terms of an increase in revenue, a decrease in expense, or an avoidance of expense. As a result many provider organizations have not been able to justify a significant resource investment in clinical information systems in the absence of a strong business case or market forces that dictate such an investment.

Prospective CIS purchasers are becoming increasingly aware that the true cost of a clinical information system is a lot higher than the price quoted. Further, it often takes much longer to implement a new system than is promised.\footnote{139} Savvy clinical IT investors also understand that the realization of CIS benefits is very dependent on how the business and practice of medicine is managed—the information technology only facilitates any gains. And capturing the gains requires focused management attention.

D. Other Barriers

Beyond resource constraints and the soft business case for CIS investment, there are a variety of other challenges and barriers to the widespread implementation of clinical information systems in the U.S. health care delivery system:

- **Data security and patient privacy**— Security and privacy of electronic medical records have been under intense scrutiny in recent years by both the U.S. government and the health care industry. A breach of patient data confidentiality leading to a crisis situation and media circus that threatens a hospital or health plan’s good name is a nightmare that no health care organization wants to envision.\footnote{140}

- **Integrating legacy systems** with new clinical information systems is a challenge to organizations that have large IT investments they don’t want to abandon.

- **Vendor selection** is an arduous process of sifting through a bewildering array of systems, RFPs, and prospective vendors. In a survey conducted by the Medical Records Institute in 2000, over one-third of companies indicated that the inability to find a vendor or technical solution that addresses their organization’s needs was a major barrier.\footnote{141}

- **Fragmented delivery system**— Most care in the U.S. is still highly fragmented, involving many unrelated providers who struggle to communicate with each other and provide continuity of care. This system leads to dysfunctional relationships between stakeholders and offers few incentives for collaboration to overcome the multiplicity of conflicting data standards that exist across the care continuum.

- **Provider resistance** can be an obstacle to clinical IT implementation, particularly if the system is counter-intuitive to physicians’ practice methodologies and preferences. Also, new processes can mean additional responsibilities for physicians and the need to change.

- **Lack of industry standards**— Interoperability refers to the ability of two or more systems to interact with one another and exchange data according to a prescribed method in order to achieve predictable results. Interoperability significantly impacts the accessibility of information across the continuum of care in multiple outpatient and inpatient facilities. Despite the substantial work toward health informatics standards, no standard for electronic health records allows true interoperability among various providers.\footnote{142}

- **Risk averse** health care organizations may be waiting to let others be the clinical IT pioneers. Numerous implementation efforts have been undertaken by organizations on the basis of vendor assurances, often at great expense, with an end result that is significantly less than promised. In an era of
shrinking margins, health care organizations are increasingly reluctant to “gamble” on a promised solution vs. one that has a tried and tested track record. Steady technical advances also complicate this—today’s system may be outmoded tomorrow. This is a particular concern with major IT projects that require more than a year to implement.

- **Lack of individuals trained in medical informatics with experience as leaders** - Most large-scale clinical information system implementation projects are still led by individuals who lack both formal training in the field of medical informatics and experience in the field of health care itself.

- **Time and cost required to choose, buy, and implement or build a clinical information system** - The time required to fully implement a robust, integrated clinical information system is on the same order of magnitude as that of other major construction projects within a medical center (e.g., building a replacement hospital). In addition to explicit costs such as training, there are hidden costs such as initial reduction in productivity.

- **Benefit realization is not easily transferable** — the benefits gained in a successful application implementation are not easily transferable to other organizations because of differences in care delivery models, leadership factors, and organizational culture.

### E. The Digital Divide

A small minority of care delivery systems has uniquely positioned themselves to overcome many of the barriers discussed above and has pioneered the use of clinical information technology in health care. For example, delivery systems such as LDS Hospital, the Mayo Clinic, Beth Israel Deaconess Medical Center, Brigham and Women’s Hospital, Kaiser Permanente, and the Veterans Health Administration have successful systems in place today that represent multi-million dollar investments that have evolved over many years—decades in some cases. In addition, clinical information systems have been successfully introduced into other health care organizations and interest is increasing in many more. In a recent survey of health care providers, 71% indicated that clinical information systems were a priority for them. However the vast majority of health care practitioners and institutions in the U.S. are not well positioned financially or organizationally to implement the IT infrastructure necessary to deploy clinical applications.

A recent California HealthCare Foundation report points out that only physicians who care for patients under a pre-paid reimbursement arrangement have financial incentives to use clinical information technology, whereas other providers are not financially rewarded for using information technology to achieve better outcomes. As the financial risk for population care management increases, the case for clinical IT investment is strengthened. Population-level financial incentives such as capitation reward health care providers that successfully manage populations, rather than units of service. However, physician group involvement in capitation has decreased in recent years rather than increase.

Our nation’s health care delivery system is in danger of becoming divided between the clinical information technology “haves” and “have-nots”. Widespread adoption of clinical IT in the near term is unlikely unless policy action is taken to address the significant challenges mentioned above.

### VII. Need for a National Health Care Information Infrastructure

As noted above, lack of standards has been a barrier to CIS implementation. Much has recently been written and discussed about the need for a national health care information infrastructure. This infrastructure has been described as “a set of technologies, standards, applications, systems, values, and laws that support all facets of individual health, health care, and public health.” It will be essential to facilitate communication and care among providers from different organizations. Four organizations have focused recent attention on the need for the U.S.
health care system to move toward a national health care information infrastructure and the need for broader adoption of clinical information technology.

The Institute of Medicine (IOM) in February 2001, published Crossing the Quality Chasm, a report that highlights six areas for focused improvement in U.S. health care: safety, effective, patient-centered, timely, efficient, and equitable. The report argues that information technology must play a central role in the redesign of the health care system and has enormous potential to improve the quality of care with regard to each of the six areas of focus listed above. The report calls for the establishment of a national health information infrastructure that will encourage public- and private-sector investments in information technology. This builds on the 1991 IOM report, The Computer-based Patient Record: An Essential Technology for Health Care in which the IOM recommends the promulgation of uniform national standards for data and security to facilitate implementation of clinical IT.

The National Committee on Vital and Health Statistics (NCVHS), the public advisory body for the Secretary of the U.S. Department of Health and Human Services on national health information policy articulated a vision of a National Health Information Infrastructure (NHII) in a report submitted to the Secretary in December 2001. Information for Health: A Strategy for Building the National Health Information Infrastructure builds on findings from public hearings and consultation with various health care stakeholders and outlines a vision and process for creating a NHII. The authors “…determined that the most important missing ingredient, which could accelerate and coordinate progress on the NHII, is leadership, specifically, Federal leadership.”

The President's Information Technology Advisory Committee's February 2001 report, Transforming Health Care Through Information Technology, delivers the message that advances in information technology can provide the foundation for important improvements in health care delivery. The report specifies six recommended actions for the federal government to advance the technological capability of U.S. health care.

The National Quality Forum, a not-for-profit organization created to develop and implement a national strategy for health care quality measurement and reporting, issued a resolution from its Board of Directors in March 2001 that addresses the need for a national health information infrastructure. The National Quality Forum is planning an IT Summit on this subject in March of 2002. Topics to be discussed at the IT Summit include architecture and infrastructure, funding and incentives, governance, and information standardization.

The recent attention on the national health care information infrastructure points to a growing awareness of the need for national standards for defining, collecting, communicating, storing, and protecting health care data. CIS and other information management tools are integral components of the larger vision for a national health care information infrastructure. This type of national strategy has a significant bearing on the advancement of CIS in the U.S. because it will enable provider organizations to overcome many of the implementation barriers that they currently encounter.

VIII. Policy Recommendations

Public policy that encourages and enables the health care industry to realize the potential of CIS outlined in this document is needed to promote broader use of clinical information technology. The following are recommendations to policymakers as they seek to advance the clinical IT revolution and as they consider the specific proposals for the development of a health information infrastructure in the United States:

Recommendation 1: The federal government should provide leadership to encourage development of a standard clinical vocabulary, standards for the exchange of clinical information, and other standards for interoperability as they emerge.

The fragmented nature of the U.S. health care system underscores the importance of standards to enable interoperability between various provider entities.
Without standards it is not practical for many health care organizations to adopt information technologies because of the numerous obstacles to sharing and maintaining digital clinical information. In addition, prospective investors risk that what they buy today will be obsolete tomorrow. Similar to the banking and airline industries, health care needs to create a level of standards that pertain to content, vocabulary and the format of data. Despite substantial work toward health information standards by a variety of private sector organizations, there is still no agreement on uniform standards.

The limited progress of the private sector in standards development is in part due to the fact that efforts have been fragmented among a large number of organizations. The leadership of the federal government is needed to encourage the development of standards in a coordinated and efficient manner. As a purchaser and provider of care and a user of clinical data, the federal government has a legitimate interest in expediting the development of health care data standards. The federal government needs to become more actively involved in the standards development process. Specifically the federal government should:

- Appoint a senior information technology leader to provide strategic leadership for the establishment of national standards for health information interoperability.
- Articulate a strategy for the establishment of national standards for health information interoperability.
- Convene an expert group (including key players in health care delivery, medical informatics, consumers, and researchers) to provide recommendations on a national mechanism to establish standards for use in health care settings and a process for the national maintenance of these standards and other mechanisms to facilitate interoperability.
- Additionally, the federal government should work to achieve consensus on standards for health care information across federal agencies. By doing so, the government can be a stimulus for the private sector to adopt the same or similar standards.

**Recommendation 2: State and federal privacy policy should avoid establishing barriers to the legitimate development and use of clinical information technology.**

Given the difficulty of implementing clinical information systems and their growing list of benefits, it is important that barriers to further implementation not be established by public policy. Public interest and attention regarding the confidentiality and privacy of personal health information have increased as information technology expands into health care. Opinion polls have found that the American public is skeptical of the data management practices of large health organizations. Public distrust of these practices should not be underestimated. Yet our review of the evidence demonstrates that significant benefit can be achieved with further implementation of CIS. A delicate balance needs to be found between the public’s right to privacy and a provider’s ability to coordinate quality medical care in a fragmented delivery system and perform medical research for the benefit of society. Reconciling consumers’ desire for the most advanced medical care that technology allows with privacy concerns remains a challenge for health care providers and policymakers.

HIPAA privacy regulations have established a national “floor” of privacy standards to protect the personal health information of Americans. Furthermore, two-thirds of states have enacted additional statutory protections in response to public concerns about privacy. State and federal policymakers should apply the adage “first do no harm” to the developing field of CIS as they consider additional legislation or regulation to protect against improper disclosure of personal health information. Privacy rules have the potential to create unintended but significant barriers to the delivery of health care services and medical research. It is entirely appropriate to impose security standards that assure that protected health information is not accessed improperly. It is not appropriate to preclude access to and use of essential medical information needed to provide medically needed care.
Policymakers should become better informed of the benefits of clinical information technologies and their growing impact on the quality and safety of health care. Knowledge that certain legislative proposals have the potential to restrict the legitimate and optimal use of clinical IT will help policymakers make informed decisions.

Recommendation 3: The cost of health information technologies should be shared among those who benefit from them. Public investment is needed to encourage the adoption of these important technologies.

The high capital and operating costs of information technology remain a significant barrier for many health care organizations. While the costs of CIS are borne by health care providers, the benefits accrue to patients and to society as a public good. This implies that purchasers, including the federal government, should be a more explicit part of the information technology reimbursement equation.

In 1991, the Institute of Medicine Committee on Improving the Patient Record issued a landmark report entitled The Computer-Based Patient Record: An Essential Technology for Health Care, which advocated the prompt development and implementation of computer-based patient records. One of the policy recommendations in the report suggested that the cost of implementing and operating clinical IT should be factored into reimbursement levels or payment schedules for both public and private sector third-party payers. In the revised 1997 edition of the report, the authors noted that no progress could be observed toward clinical IT cost-sharing. Lack of progress in this area can still be observed today.

- Following are some of the funding possibilities that have been discussed in various forums:

  - The IOM recommends that Congress establish a $1 billion "Health Care Quality Innovation Fund" to support the adoption of quality-improving innovations in medical practice and technology. The fund would be used in the next three to five years to help subsidize promising projects and communicate the need for these technologies in health care.

  - Legislation, modeled after the Hill-Burton Construction Act of 1946, to encourage the development of a national health information infrastructure should be explored. The Hill-Burton Construction Act encouraged the modernization of the nation’s decaying health care facility infrastructure by providing funds for its expansion and development. In return, facilities agreed to provide free or reduced charge medical services to persons unable to pay. Health care information infrastructure legislation modeled after the Hill-Burton Act would assist organizations with the high cost of capitalizing clinical IT. Linking funding to Medicaid and Medicare participation would ensure that these technologies are distributed equitably.

  - Appropriate reimbursement changes in the Medicare program and by other payers could go a long way toward promoting the development and use of health information technologies. Reimbursement legislation in fee-for-service Medicare could include changes such as reimbursement for remote visits that CIS can facilitate or bundled payments for chronic conditions. Organizations that receive Medicare capitation could receive a supplemental amount to cover system development.

Recommendation 4: Research and development focused on implementation and effective use of health information technologies should be encouraged and supported.

Research is an ongoing theme in the evolution of information technology in medicine. Much of the research that has been done to date on health information technologies has focused on clinical outcomes and cost savings. This work should continue. However, research also needs to be focused on the critical success factors for CIS implementation and benefit realization. Variation in CIS implementation strategies directly impacts the tangible benefits that are achieved and how quickly they are realized. Leadership factors, organizational factors, cultural factors, and lessons learned from past implementations have been understudied. Organizations with mature clinical information systems should be encouraged to continue their
development work and document their implementation experience.

Research to explore further innovation in technology development (e.g., new software and operating platforms) would also be beneficial. Along a similar vein, research in the development and standardization of health care applications and processes, including standards for authentication and electronic signatures that enable organizations to discontinue paper records is needed.

Finally some of the questions that need to be considered are:

- What are the lessons learned from the implementation of information systems as they pertain to people strategies, workflow patterns, physician and patient involvement, etc?

- What should be the role and responsibility of the patient in health care as information technologies are incorporated into the care delivery system?

- What is the optimal set of system applications and features that should be recommended to healthcare organizations to maximize benefit?

- What are the recommended implementation strategies for both large and small healthcare organizations?

- Given the profusion of medical evidence that exists, what are the best processes by which the validity of this information can be assessed?

In addition to implementation questions and in light of the many challenges to benefit documentation, more randomized controlled trials are recommended, as they provide the most valid information about the efficacy of information systems. Studies that focus on demonstrating improved health outcomes and cost savings should continue to be emphasized as well. Congress should provide the Agency for Healthcare Research and Quality specific authority and funds to support this work. Support is also needed to disseminate the growing body of knowledge regarding the benefit of these systems to further encourage their adoption.

IX. Conclusion

Despite the modest uptake of clinical information technology in the practice of medicine to date, evidence is growing that clinical information systems hold significant potential for positive benefit in the delivery of health care. It is increasingly evident that the electronic medical record and other emerging clinical information management tools are the enabling technologies that will lead to a new paradigm of evidence-based, patient-centric health care. A review of the literature and the experience of various organizations support the conclusion that CIS can improve provider performance, enhance clinical outcomes, and decrease medical errors. It is likely that many of these applications and the benefit they produce will become the “community standard of care” over the next decade, improving both patient care and satisfaction. Thus, there is an imperative to encourage broader implementation and use of clinical information systems with sound public policy focused on the identification of solutions to the barriers and disincentives to implementation that are experienced by healthcare organizations today.
Appendix  Meeting Participant List

A Meeting Sponsored by the Institute of Medicine and the Kaiser Permanente Institute for Health Policy

• E. Andrew Balas, MD, PhD, Director, Center for Health Care Quality, and Weil Distinguished Professor, University of Missouri

• David W. Bates, MD, MSc, Chief, Division of General Medicine, Brigham and Women's Hospital

• Homer L. Chin, MD, Medical Director for Clinical Information Systems, Kaiser Permanente—Northwest

• Gary A. Christopherson, Chief Information Officer, Veterans Health Administration, U.S. Department of Veterans Affairs

• Janet Corrigan (Meeting Co-Sponsor), Director, Board on Health Care Services, Institute of Medicine

• Molly Joel Coye, MD, MPH, MA, President and Chief Executive Officer, Health Technology Center

• Robert M. Crane (Meeting Co-Sponsor), Senior Vice President and Director, Kaiser Permanente Institute for Health Policy, Kaiser Foundation Health Plan, Inc.

• Daniel Davis, MD, Chief, Department of Internal Medicine, Queen's Medical Center

• Don E. Detmer, MD, Gillings Professor of Health Management, Judge Institute of Management, University of Cambridge

• Reed M. Gardner, PhD, Department of Medical Informatics, University of Utah

• William A. Gillespie, MD, Executive Vice President, Kaiser Foundation Health Plan, Inc.

• Elisabeth Hallman, MBA, RN, CAN, Director, Implementation, Cedars-Sinai Health System

• Andrew M. Lum, MD, Assistant Medical Director, Service Quality and Informatics, Kaiser Permanente—Colorado

• David Mohr, MD, Chair, Mayo Integrated Clinical Systems Committee, Mayo Clinic
• Donald M. Nielsen, MD, Senior Vice President for Quality Leadership, American Hospital Association

• Eduardo Ortiz, MD, MPH, Senior Service Fellow, Agency for Healthcare Research and Quality

• Daniel Z. Sands, MD, MPH, Clinical Director of EPR and Communication, Beth Israel Deaconess Medical Center, Center for Clinical Computing

• Dean F. Sittig, PhD, Senior Informatics Researcher, Kaiser Permanente

• Paul C. Tang, MD, Chief Medical Information Officer, Palo Alto Medical Foundation and Associate Clinical Professor, University of California, San Francisco

• Peter Waegemann, Chief Executive Officer, Medical Records Institute

• Andrew M. Wiesenthal, MD, Associate Executive Director, The Permanente Federation
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