Perspective

Evidence for Electronic Health Record Systems in Physical Therapy

With increasing pressures to better manage clinical information, we investigated the role of electronic health record (EHR) systems in physical therapist practice through a critical review of the literature. We reviewed studies that met our predefined criteria after independent review by 3 authors. The investigators in all of the reviewed studies reported benefits, including improved reporting, operational efficiency, interdepartmental communication, data accuracy, and capability for future research. In 7 studies, the investigators reported barriers, including challenges with behavior modification, equipment inadequacy, and training. The investigators in all studies reported key success factors, including end-user participation, adequate training, workflow analysis, and data standardization. This review suggests that EHRs have potential benefits for physical therapists. The authors formed the following recommendations based on the studies' themes: (1) incorporate workflow analysis into system design and implementation; (2) include end users, especially clinicians, in system development; (3) devote significant resources for training; (4) plan and test carefully to ensure adequate software and hardware performance; and (5) commit to data standards. [Vreeman DJ, Taggard SL, Rhine MD, Worrell TW. Evidence for electronic health record systems in physical therapy. *Phys Ther.* 2006;86:434–449.]

Key Words: *Computerized medical records systems, Medical informatics, Medical informatics applications, Physical therapy, Physical therapy department: hospital.*

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This review highlights the complex social-technical interactions of implementing electronic health record systems in physical therapy.

As physical therapists have expanded into more diverse and autonomous practice settings, they are required to make more effective and efficient clinical decisions. Making sound clinical decisions requires the right information at the right time and in the right format, but clinicians are often faced with a surplus of information that is ambiguous, incomplete, or poorly organized.[1,2] Humans are imperfect data processors,[3] and thus obscured or overwhelming information can hurt, rather than help, the decision-making process. Because clinicians process a vast amount of information while making decisions, they may be particularly susceptible to errors of omission. Computers, however, are tireless data processors. Supplementing the clinician's knowledge with computerized reminders informed by electronic data has been shown to improve care outcomes in many studies.[3–7] Physical therapists make decisions by considering a variety of patient and environmental factors[8]; therefore, it is likely that the quality and presentation of clinical information they use could influence the outcome.

Beyond its role in day-to-day clinical decision making, the legitimate uses and demands for health information also have expanded. For instance, the Joint Commission on Accreditation of Healthcare Organizations requires that accredited organizations collect data to support managerial operations, performance-improvement activities, and patient care.[9] At the same time, the Health Insurance Portability and Accountability Act of 1996 requires specific administrative procedures, physical safeguards, and technical mechanisms to ensure privacy and security of health information.[10,11] Increasingly empowered consumers also are creating a wave of information demands that are manifested in changing expectations. As consumers experience communication and e-commerce enabled by the Internet, they increasingly demand speed, convenience, and customized service throughout the marketplace, including health care.[12,13] New expectations will lead consumers to demand individualized tools for managing their health.[14,15] All of these forces emphasize the need to effectively manage health information, and they have exposed the clinical and economic inadequacy of our current paper-based health information system.[2]

There is now widespread recognition that information technology offers promise to greatly improve the health care delivery system. In 1991, the Institute of Medicine (IOM) organized a task force that examined the issues of the medical record system and concluded that the computer-based patient record was an "essential technology for health care."[16] A 1997 follow-up report of this committee found steady progress toward developing computerized health systems, but noted that no system at that time supported all of the features of a comprehensive system.[17] In July 2003, the Department of Health and Human Services (DHHS) began to promote widespread use of modern information technology in health care. The DHHS asked the IOM to identify the core care delivery–related functionalities of the electronic health record (EHR) and asked the health care standards organization Health Level 7 to develop an EHR func-

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All authors provided concept/idea/research design and consultation (including review of manuscript before submission). Dr Vreeman, Dr Taggard, and Dr Rhine provided writing, data collection and analysis, and project management. The authors acknowledge Clement McDonald, MD, Joyce Mac Kinnon, PT, EdD, and Elizabeth Domholdt, PT, EdD, FAPTA, for their valuable comments and review of the manuscript before submission.

Dr Vreeman's work as primary author was generously supported by a medical informatics research training grant from the National Library of Medicine (T15 LM-7117).

This work was presented, in part, at the Annual Conference & Exposition of the American Physical Therapy Association; June 8–11, 2005; Boston, Mass.

This article was received January 13, 2005, and was accepted September 1, 2005.

tional model that further specified these core functionalities.[18] In the 2004 State of the Union address, President Bush asserted that "by computerizing health records, we can avoid dangerous medical mistakes, reduce costs, and improve care."[19] President Bush has since made health information technology one of the nation's top priorities, calling for EHRs for most Americans in 10 years.[20] To achieve this ambitious goal, DHHS Secretary Tommy Thompson launched the "Decade of Health Information Technology,"[21] and DHHS is developing a plan to create an electronic national health information infrastructure. To lead this effort, President Bush created the Office of the National Health Information Technology Coordinator.[22]

These national initiatives have emerged out of the growing recognition of the importance of health information technology, a recognition also reflected in the more than 9,400 articles on EHRs indexed in PubMed. Building on the existing knowledge base, the near-term aims of initiatives like the DHHS's National Health Information Infrastructure[23] are to enable regional information sharing throughout the continuum of care by establishing health care policies and promoting effective use of data and vocabulary standards.[24] Operational examples of community-wide electronic information exchange, such as the Indiana Network for Patient Care,[25] already exist and are beginning to demonstrate the benefits of efficient access to clinical information.[26–28]

Despite the factors promoting information technology, adoption and penetration of EHRs in physical therapy have been limited. A 2004 online survey of health care providers indicated that, of those who had already implemented components of an EHR system, only 26.4% have physical therapy, occupational therapy, or respiratory therapy notes as a current function, and only another 25.6% plan to implement this in the future.[29] With burgeoning pressures to better manage clinical information through information technology, we sought to investigate the role of EHRs in physical therapist practice through a critical review of the literature. Specifically, the purpose of this review is to identify, review, and summarize the benefits, barriers, and key factors for success in implementing EHRs in physical therapist practice settings.

Method

EHR Definition

The field of *medical informatics*[30,31] is concerned with developing and evaluating information technology to advance health care. Although the EHR may be considered a fundamental application of medical informatics, there is currently no consensus definition of an EHR system among medical informatics experts. In light of this, we used the IOM's "core functionalities" of an EHR to guide our review.[18] The IOM has described an EHR as broadly including[18]:

(1) longitudinal collection of electronic health information for and about persons, where *health information* is defined as information pertaining to the health of an individual or health care provided to an individual;

(2) immediate electronic access to person- and population-level information by authorized, and only authorized, users;

(3) provision of knowledge and decision support that enhances the quality, safety, and efficiency of patient care; and

(4) support of efficient processes for health care delivery.

The IOM identified core functionalities of an EHR that fall into 8 categories: (1) health information and data, (2) results management, (3) order entry/management, (4) decision support, (5) electronic communication and connectivity, (6) patient support, (7) administrative processes, and (8) reporting and population health management. The IOM categorized uses of HER systems as either primary or secondary. *Primary* uses are associated with the provision of patient care; that is, with providing, consuming, managing, reviewing, supporting, charging, and reimbursing patient care services. *Secondary* uses are those not considered necessary for a particular encounter between a patient and a health care professional, but that still influence the environment in which patient care is provided. Education, research and development, regulation, and policy making are all considered secondary uses.[18]

Study Identification

We identified relevant articles by searching the electronic bibliographic databases of MEDLINE (1966 to week 4 of October 2004), the Cumulative Index to Nursing and Allied Health Literature (1982 to week 4 of October 2004), and Ovid's All Evidence-Based Medicine Reviews (Cochrane Database of Systematic Reviews, American College of Physicians Journal Club, Database of Abstracts of Reviews of Effects, and Cochrane Central Registrar of Controlled Trials; third quarter 2004). We also searched conference proceedings from the American Medical Informatics Association Annual Symposium (1998–2004). Studies were identified in the electronic bibliographic databases by combining medical informatics terms and physical therapy terms, but limited to articles that appeared in peer-reviewed journals published in English.

The MEDLINE search strategy included the medical informatics-related Medical Subject Heading (MeSH) terms "medical records systems, computerized," "information systems," "hospital information systems," "database management systems," "reminder systems," "automatic data processing," "medical informatics," and "decision making, computer-assisted." We combined these results with searches using MeSH terms pertaining to physical therapist practice: "physical therapy (specialty)," "physical therapy techniques," "rehabilitation," and "rehabilitation centers." Similar key terms were used to identify studies in the other databases. This initial search identified 2,002 articles. In order to identify studies not captured in our database search, we manually searched bibliographies from all retrieved articles and contacted authors of selected physical therapy–specific papers and medical informatics experts. Using these methods, we identified 8 additional studies, yielding a total of 2,010 studies that were considered for this review.

Study Selection

All titles, index terms, and abstracts (if available) of identified studies were screened by the first author (DJV) for potential inclusion in the review. Full-text articles were retrieved if the citation and abstract information left ambiguity about relevance of the article to the review.

We used the IOM's concept of an EHR[18] to guide our selection of studies. We recognized that an EHR may have primary and secondary uses, but were interested in studies that focused on primary uses. The IOM concept of a comprehensive EHR includes the integration of many disparate systems and components. However, even today, few organizations have implemented such all-inclusive systems,[18,29] so we did not want to limit our review to only studies of systems that had *all* attributes of a comprehensive EHR. Alternatively, we did not want to include studies of electronic devices (such as an electronic blood pressure cuff) that store and transmit medical information, but would not be considered a "true" medical record. Having multiple core functionalities beyond just containing or communicating health information indicates steps toward a fully integrated EHR, rather than an "island" or stand-alone system. Thus, in order to focus our review on computer systems that had established at least a minimum level of integration among components, we sought articles describing systems that contained health information (the first IOM core functionality) and 2 or more of the other IOM core functionalities.

Specifically, studies were included in this review if they met *all* of the following criteria: (1) an EHR was the intervention of interest in the study, (2) the EHR contained the IOM core functionality of health information and 2 or more of the other core functionalities, (3) the study described a primary use of the EHR, (4) physical therapists were study participants, and (5) the article reported outcomes that indicated benefits or barriers to system implementation. Studies were excluded from the review if they described only physiological monitoring systems, communication technology for telemedicine applications, or only secondary uses of an EHR.

Three authors (DJV, SLT, MDR) independently evaluated potentially relevant studies to determine eligibility for this review. The authors used the IOM's description of EHR core functionalities[18] and a structured form to judge whether each study met all inclusion criteria, ultimately labeling each article as "include" or "do not include." We used SAS software version 8.02* to calculate interrater reliability for inclusion eligibility. The percentage of agreement beyond chance on inclusion eligibility was 68% (κ=.68, 95% confidence interval=.51–.84), indicating a "substantial" strength of agreement according to the standards proposed by Landis and Koch.[32] All disagreements regarding eligibility were resolved by discussion. Studies excluded from the review included reports on stand-alone gait analysis systems, videoconferencing programs for telemedicine, and software reviews. Studies also were excluded when it was unclear whether the computer system was the intervention of focus or whether physical therapists were study participants. A total of 18 articles met the eligibility criteria and were selected for review.

Study Data Extraction and Analysis

For each of the articles selected for review, the 3 authors who evaluated the articles used a structured form to independently extract the study design, setting, system characteristics, measured outcomes, results (including key benefits, barriers, and strategies to maximize implementation success), and conclusions. The 3 authors periodically compared their extraction findings and reached consensus on differences through discussion.

For this review, formal meta-analytic methods were precluded because of the heterogeneity in study design, setting, system characteristics, outcomes measured, and results reported. In addition, we were unable to extract some factors that were potentially important in the overall success of the implementation because they were not reliably reported in the literature. These potentially important factors include system response time, user interface design, financial impact, and commitment from executive management. Furthermore, because none of the studies in this review evaluated EHRs with a

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design that formed comparison groups, formal appraisal of study rigor also was precluded. As a result, this review is a qualitative analysis of the relevant and representative literature. We synthesized the literature to answer our research questions and formed recommendations to address the underlying issues by identifying general themes in benefits, barriers, and success factors.

Results

Summary of Identified Studies

Eighteen articles met our eligibility criteria and were included in the review.[33–50] The authors of 6[33–36,38,39] of the 18 articles reported results for the study of an EHR at the Texas Institute for Rehabilitation and Research (TIRR), Houston, Tex. These authors reported on the initial implementation and ongoing analysis of the same EHR. Because our goal in this review was to synthesize evidence across studies, we felt that reporting these 6 articles individually would over-represent the characteristics of one institution and EHR. Thus, results from these articles were aggregated and analyzed as one unit. As a consequence, we present an analysis based on a total of 13 studies. The investigators in the remaining 12 studies reported on the initial development and implementation of other EHRs, with many studies containing naturalistic descriptions of the implementation process.

Table 1 provides the study setting, participants, and system characteristics for all 13 studies included in the review. All of the studies were conducted in the United States. The reports were published over a span of 5 decades, and describe EHRs that operated on all major historical classes of computers (mainframes, minicomputers, and microcomputers). The studies were implemented in a wide variety of practice settings: 3 studies were conducted in outpatient settings,[44,48,49] 4 in subacute rehabilitation hospitals[41–43] (including those at the TIRR[33–36,38,39]), 3 in acute care hospitals,[37,45,46] and 3 in health systems that span multiple practice settings,[40,47,50] including one study of an EHR used to document telerehabilitation encounters.[50] Although the researchers in only one study[45] reported the number of study participants, in 10 of 13 studies[33–36,38–43,46–50] the clinical participants were a multidisciplinary team, and, in 3 studies,[37,44,45] the clinical participants were all physical therapists. Characteristics of EHR systems varied widely among studies, as did the data elements they contained. Electronic health record systems were implemented on a wide array of hardware components, ranging from card-oriented mainframe computers to microcomputer networks with remote access. Twelve of 13 studies used software developed in-house, and only one study described an EHR based on commercially available software.[48]

Table 2 provides a summary of the benefits, barriers, and key factors for success in implementing EHRs. The investigators in all 13 studies reported benefits and key success factors of EHR implementation, whereas 7 of the 13 studies reported barriers to implementing an EHR. We present our synthesis of the findings reported in these studies below.

Benefits to Implementing an EHR

Improved reporting capabilities. The authors in 11[33,34,37,38,40–43,45–48,50] of the 13 studies reported that the EHR improved reporting capabilities. Investigators in 3 studies[43,47,48] cited the capability for more comprehensive reporting that integrated clinical and administrative data as a key benefit of EHR implementation. Authors in 2 studies[37,40] noted that the EHR's reporting capabilities provided a mechanism for analysis of physical therapy service outcomes. Shields et al[45] described the EHR at the University of Iowa Hospitals and Clinics as an improved mechanism for analyzing and reviewing patient outcomes among therapists because it standardized clinical assessments and enabled the routine calculation of common outcome measures.

Lehmann et al[41] noted that the EHR's reporting capabilities facilitated clinical decision making for individual patients. The authors also reported that the EHR enabled performance evaluation of rehabilitation services by reporting aggregate analyses of functional outcomes for each service component. They noted, for example, that these reports could be used to examine the effectiveness of physical therapists' interventions for improving ambulation. Crosswhite et al[46] described a series of automated reports that enabled an improved discharge summary process. With an EHR containing functional assessment and documentation, Brown and Gordon[42] reported the benefit of the EHR's flexible output formats that could be customized to meet the needs of patients, payers, referral sources, and other parties who use health information. Kaur et al[50] noted that EHR-generated reports enabled both clinicians and administrators to be aware of the current departmental workload, which helped provide the rationale for how patients and therapists were scheduled.

Improved operational efficiency. Investigators in 11[33–36,38–43,45–50] of the 13 studies reported that the EHR improved operational efficiency. The gains in efficiency were noted in a variety of areas across studies and were related to both the purpose for which the EHR was implemented and the stakeholder perspective taken. In general, the investigators in these studies noted that the EHRs had superior capabilities for storing, processing, and retrieving information compared with their previous methods. Shields et al[45] reported that computerized

Table 1.
Studies of Electronic Health Record Implementations in Physical Therapist Practice[a]

Study/Date	Study Setting (Location)	Participants	System Characteristics		
			Components	Data Content	Features
TIRR studies,[33–36,38,39] 1968–1974	Subacute university-affiliated rehabilitation hospital (Houston, Tex)	Rehabilitation team, administrative staff, and patients	IBM 360/50 time-shared mainframe computer with remote terminals	Treatment plan, physiological monitoring, laboratory, and hospital census data	Supports care planning, clinical decision making, scheduling, service management, quality assessment, accounting
Savander and Stutz,[37] 1973	Acute care hospital (Trenton, NJ)	Physical therapists	IBM 360-20 card-oriented computer	Demographic, treatment plan, visit data	Supports outcome and quality assessment
Savander,[40] 1977	Acute care hospitals (4) and outpatient clinics (Trenton, Atlantic City, and Red Bank, NJ)	Physical therapists, consultants, industrial engineer, and fiscal intermediary representative	IBM system 3 model 15 computer	Demographic, treatment plan, visit data	Supports peer review, audit, clinical research, utilization review
Lehmann et al,[41] 1984	Subacute rehabilitation hospital (Seattle, Wash)	Rehabilitation team and patients	Minicomputer with remote terminal via modem	ADL, AROM/PROM, strength, transfers, event count, standardized activities, and staff data	Supports patient and program performance monitoring, clinical decision making
Brown and Gordon,[42] 1986	Subacute university-affiliated rehabilitation hospital (New York, NY)	Rehabilitation team	Unspecified computer	Functional assessment data: skill, pattern, and status indicators	Supports clinical decision making and program evaluation
Sulton et al,[43] 1987	Subacute rehabilitation hospital (Wheaton, Ill)	Rehabilitation team, admissions, program evaluation, scheduling, and financial staff	Microcomputer	Demographic, functional status, treatment goals and status, unit charges, and administrative data	Supports utilization review, quality assurance, and program evaluation
Zimny and Tandy,[44] 1993	Outpatient physical therapy clinic (Burlington, Vt)	Physical therapists and patients	Microcomputer	Health history screening data	Supports clinical decision making via clinical knowledge library linking patient data to management options
Shields et al,[45] 1994	Acute care, university-affiliated hospital (Iowa City, Iowa)	Physical therapists	Mainframe computer with monthly download to microcomputer network	Demographic, problem list, and tests and measures data	Supports clinical care, outcomes research, and trend analysis
Crosswhite et al,[46] 1997	Acute care hospital (Tupelo, Miss)	Rehabilitation team, coding and marketing staff	Unspecified computer	Demographic, ADT, diagnosis, discharge instruction, medication, diet, activity, and follow-up data	Supports discharge summaries and instructions
Eiseman,[47] 1999	Health system rehabilitation hospital: inpatient, subacute, and outpatient rehabilitation (Harmarville, Pa)	Rehabilitation team	IBM 4381 model P2 mainframe with remote terminals linked to microcomputer network	Demographic, nutrition and diet, education, and case management data	Supports ADT, billing/accounting, scheduling, executive information, and medical records applications Abstracts data to functional outcomes and patient satisfaction databases
Mazzoni-Maddigan and Burchick,[48] 2000	Nonprofit rehabilitation agency: early intervention program (Allegheny, Pa)	Rehabilitation team, administrative, clerical, educational, vocational, social service, and production staff	Microcomputer network with remote access via modem	Demographic, diagnostic, and insurance data	Supports ADT, service reporting, and billing Extensive security provisions built into system
Swope,[49] 2000	Health system–based outpatient rehabilitation center	Rehabilitation team and patients	Microcomputer network with remote access via modem	Progress notes and certification forms	Supports identification of outstanding Medicare recertifications
Kaur et al,[50] 2004	Subacute rehabilitation hospital: telerehabilitation program (Oklahoma City, Okla)	Rehabilitation team, care coordinators, business analysts, administrative and technical staff	Microcomputer network with remote access via Internet	Demographic, registration, screening, clinical encounter data, including many standardized outcome measures	Supports clinical care, outcomes analysis, program evaluation, research hypothesis testing User role-based security and access logging

[a] TIRR=Texas Institute for Rehabilitation and Research, IBM=International Business Machines, ADL=activities of daily living, AROM/PROM=active range of motion/passive range of motion, ADT=admission, discharge, and transfer.

Table 2.
Studies Reporting Benefits Barriers, and Key Factors for Success in Implementing an Electronic Health Record[a]

Benefits	**n**
Improved reporting[33,34,37,38,40–43,45–48,50]	11
Improved operational efficiency[33–36,38–43,45–50]	11
Improved interdepartmental communication[33–36,38,39,41,42,46–48,50]	7
Improved data accuracy[45–50]	6
Provided data for future research[37,40,42,45,50]	5
Total	13
Barriers	**n**
Workflow or behavior modification[36,44,46,49,50]	5
Software or hardware inadequacy[33–35,48]	2
Staff training[46,48]	2
Total	7
Key Factors for Success	**n**
End user participation in the development process[37,40,41,45–48,50]	8
Data standardization[37,38,40,41,43,45,47,50]	6
Adequate staff training[40,41,46–48]	5
Incorporating workflow analysis into system design[35–37,43,47,50]	5
Total	13

[a] Studies conducted at Texas Institute for Rehabilitation and Research (TIRR) were counted as one unit.

documentation took 30% less time than the previous handwritten notes. Similarly, Kaur et al[50] included a description of a small pilot study in their article that showed that computerized data entry by a telerehabilitation coordinator was completed significantly faster than the previous paper-based entry (a mean of 6.97 minutes per computerized patient form versus a mean of 8.82 minutes per paper patient form, $P=.0005$). Mazzoni-Maddigan and Burchick[48] found that EHR implementation reduced the time to complete the billing error report from 5 to 7 hours to 1 to 2 hours.

Investigators at the TIRR reported a number of improvements that occurred after implementation of the EHR and its hospital-wide automated scheduling module. The time required to implement admission orders decreased from the previous average of about 2 hours to nearly immediate initiation.[35,38] The number of scheduled patient activities (eg, hygiene care, bathing, physical therapy sessions, recreational outings, scheduled turnings) increased 88%, whereas the number of scheduled activities actually performed increased 33%.[35] After system implementation, the mean length of stay decreased from 115 days to 99 days for patients with quadriplegia and decreased from 109 days to 79 days for patients with paraplegia.[38] Cost-effectiveness studies indicated that computerized care planning and scheduling at the TIRR cost 10% less than manual methods.[38]

Improved interdepartmental communication. Seven[33–36,38,39,41,42,46–48,50] of the 13 studies cited an improvement in interdepartmental communication with implementation of an EHR. The investigators at the TIRR,[33–36,38,39] Lehmann et al,[41] Brown and Gordon,[42] Crosswhite et al,[46] Eiseman,[47] Mazzoni-Maddigan and Burchick,[48] and Kaur et al[50] all reported an improvement in communication because patient records contained aggregated and legible information from multiple sources. Six of these 7 studies[33–36,38,39,41,42,47,48,50] also noted improved communication through records that were simultaneously accessible by multiple users. In a survey of multidisciplinary personnel at the TIRR, Beggs et al[35] reported that 88.4% of respondents believed that the computer system improved communication between other departments. Both Spencer et al[38] and Brown and Gordon[42] noted that the improved communication afforded clinical personnel a more comprehensive picture of patient's status, and it allowed them to devote more time to analyzing and planning appropriate plans of care. Kaur et al[50] reported that the process of designing and implementing an EHR stimulated a more integrated, interdisciplinary approach to patient management.

Improved data accuracy. Investigators in 6[45–50] of the 13 studies reported that implementation of an EHR led to improved data accuracy. The authors in 3[46,49,50] of these 6 studies reported that the EHR improved data accuracy because it reduced the need to capture duplicate data. In the EHR described by Eiseman,[47] the charge entry system was revised to include patient activity documentation, improving the correlation between charges and patient activity. The revised process also eliminated the error-prone practice in which other staff entered charges for the therapists from handwritten notes. Mazzoni-Maddigan and Burchick[48] described an EHR system that enabled a more accurate service authorization and billing process. They noted improvements from more accurate data entry, an automated process for finding and reporting errors, and an easier method for finding the information needed to correct errors. Following their EHR implementation, billing errors were reduced from approximately 100 per month to 20 per month.

In conjunction with implementing an EHR, Shields et al[45] described an extensive process of routine data quality assessments, including structured studies of the reliability, validity, and responsiveness of the clinical tests and measures, the values of which were stored in the database. The authors asserted that data quality monitoring was crucial for maintaining the credibility of the information in the EHR.

Data for future research. The benefit of an EHR providing data for future research was reported by the investigators in 5[37,40,42,45,50] of the 13 studies. Shields et al[45] reported a series of demonstration projects using the information in the computerized record to show that the

database could help generate clinical hypotheses, analyze outcome trends, and estimate patient variability. Savander and Stutz,[37] Savander,[40] Brown and Gordon,[42] and Kaur et al[50] all described the benefit of an infrastructure with aggregated data and advanced processing capabilities for supporting future clinical and health services research.

Barriers to Implementing an EHR

Workflow or behavior modification. Authors of 5[36,44,46,49,50] of the 7 studies reporting barriers to EHR implementation cited challenges in behavior or workflow modification. In 3 studies,[36,46,49] the authors reported that implementing an EHR altered the institution's workflow and workload in previously unanticipated ways, which required special efforts to accommodate. For example, Swope[49] described an EHR that was designed to improve compliance with Medicare regulations that required recertification for outpatient physical therapy plans of care at 30-day intervals. The automated process shifted much of the responsibility from the rehabilitation staff to the ordering physicians, creating workflow inefficiencies that required both special training efforts and system modifications to resolve.

Kaur et al[50] noted a challenge in changing the therapists' prior practice of documenting in unstructured narrative text. In order to support electronic data analysis, the system was designed with "drop-down" choices from menus. Finally, Zimny and Tandy[44] studied a computerized decision-support system and remarked that, before the system could be used in daily practice, physical therapists would have to change their traditional practice of memory-dependent decision making. The authors asserted that this behavior change would require recognition of the relative costs and benefits to using the less familiar method of computer-supported decision making.

Software or hardware inadequacy. In 2[33–35,48] studies, investigators cited the inadequacy of software or equipment as a barrier to implementing an EHR. Mazzoni-Maddigan and Burchick[48] noted initial problems with system performance because the EHR was largely built from donated equipment. Although some problems were resolved over time, system performance remained a problem that required users to stagger data entry to avoid causing the system to operate slowly. Investigators at the TIRR also reported ongoing problems with computer equipment and system performance. Because the EHR operated on a time-shared mainframe computer at the Baylor University College of Medicine, resources were shared and competed for with other departments of the College. Users often had to wait for others to finish their tasks.[33,35] Beggs et al[35] reported that the TIRR system had a 95% uptime, but that system failures frustrated health professional users and required overtime from clerical staff. Gotcher et al[34] also noted that system failure was detrimental because the computer system was used by all of the hospital departments.

Staff training. Investigators in 2 studies[46,48] reported that challenges in training staff presented a barrier to implementing an EHR. Mazzoni-Maddigan and Burchick[48] reported that the initial implementation required overtime on nights and weekends for staff to receive training. The training phase lasted approximately 4 months, but the investigators noted that ongoing training was needed. Crosswhite et al[46] also reported that extensive training programs were required during implementation of the automated discharge summary process. Much coordination and planning was required to train staff from many disciplines and departments across the hospital.

Key Factors for Success in Implementing an EHR

End-user participation in the development process. Investigators in 8 studies[37,40,41,45–48,50] reported that end-user participation in the development of the system was fundamental to the implementation's success. In these 8 studies, user participation took shape in many ways. The most common form of participation was a committee with stakeholder and user representatives that oversaw system implementation.[37,45,46] Lehmann et al[41] noted that clinical staff played an active role in the ongoing maintenance of the database, and Mazzoni-Maddigan and Burchick[48] reported ongoing dialogue with the system vendor to customize the application to the client's needs. Kaur et al[50] described an EHR designed at the request of the users and "championed" by the director of the Clinical Development Department. Eiseman[47] reported that *all* applications in the EHR at HealthSouth Harmarville were designed with the perspective of the clinician in mind, and their feedback was sought throughout the development process.

Data standardization. Investigators in 6 studies[37,38,40,41,43,45,47,50] described data standardization as a central component of success. Shields et al,[45] Eiseman,[47] and Kaur et al[50] noted the importance of structured data versus free text for standardizing the information stored in the EHR. Sulton et al[43] and Shields et al[45] described the importance of using quantifiable assessments for tracking concepts of interest. Authors in 3 studies[37,40,45] reported that agreement on operational definitions of data elements and a formal process for assessing data quality were both crucial factors in assuring the validity and usefulness of the EHR.

Adequate staff training. Investigators in 5 studies[40,41,46–48] reported that adequate staff training was key to successful EHR implementation. Savander[40] reported that comprehensive, on-site, team-led training oriented users to the system and their roles. The EHR described by Eiseman[47] used members of the design and development teams to train users in their own departments. Authors in 3 studies[41,46,48] noted the importance of addressing ongoing training needs beyond the initial orientation period.

Incorporating workflow analysis into system design. Investigators in 5 studies[35–37,43,47,50] asserted that incorporating workflow analysis into the process of system design was a key factor for success in implementing an EHR. Authors in 4 of these studies[37,43,47,50] noted the importance of identifying needed data elements, identifying how these data are collected, and determining whether additional elements are needed to support the desired functionality. Investigators at the TIRR[35,36] recommended careful study of the downstream effects of implementation on workflow; in particular, Beggs et al[35] noted that workflow shifts caused by the system could decrease clerical work while simultaneously increasing the responsibilities of higher-paid professional staff.

Discussion

Our review suggests that EHRs may have important benefits in physical therapy. The studies included in this review noted that an EHR may improve clinical and administrative reporting capabilities, operational efficiency, communication among departments, data accuracy, and the capacity to support clinical research. These benefits are well supported by studies from other disciplines, and we present a few examples here. The Regenstrief Medical Record System[51], one of the oldest, largest, and most studied EHRs in the world, has many sophisticated clinical applications and reporting capabilities. Even with well-designed electronic interfaces to access the data, the "pocket rounds" report for inpatient wards has long been one of the clinician's favorite outputs of the system. This paper report is produced from electronically stored data, and it provides a compact, yet comprehensive, overview of the patient's state in a format that, when folded in half, fits neatly into a lab coat pocket.

Gains in health care efficiency are a widely touted benefit of EHRs[2,11,18,21]; however, improved efficiency must be considered from a particular stakeholder perspective. To illustrate, we note the Medical Gopher,[52] a suite of programs that help fetch, organize, review, and record clinical data. A randomized controlled trial[53] of the Medical Gopher's computerized physician order entry component demonstrated significantly reduced patient charges and hospital costs, and it was reported to reduce the delay in executing admission orders 12-fold.[54] These benefits, however, came at the cost of requiring more physician time than the previous paper method did. Enhanced communication between physicians and nurses was noted by Ammenwerth et al[55] in a randomized evaluation of a computerized nursing documentation system. In this study, physicians reported that they read the new electronic nursing documentation more often than before.

Although direct comparisons of data accuracy in EHRs and paper-based records have not been reported, a review of data accuracy in EHRs[56] has noted that EHRs may improve data accuracy through support for structured data capture, automated data capture, monitoring and feedback of data quality to data entry personnel, and remote access to data. Moreover, the repositories of practice databases have well-documented uses in clinical research,[57] including support for clinical epidemiology, patient risk assessment, post-market drug surveillance, practice variation, resource consumption, quality assurance, and clinical decision making.

Similarly, the studies in this review identified barriers and key factors for success that echo those noted in the informatics literature from other disciplines. Berg[58] has noted that workflow and behavior modification are a core reason for implementation failure. He recommended that EHR implementation be thought of as "organizational development," to convey the idea that the information system is *intended* to affect the organization. Staff training, end-user participation in the development process, and maintaining (or improving) clinical productivity through maximal system performance have all been recognized as important contributors to implementation success in some of the most advanced clinical information systems in the United States.[59] Likewise, there is widespread recognition of the crucial role of data standards in health care,[2,24,60–62] and organizations with successful implementations have cited their commitment to data standards as paramount in achieving their aims.[51,63]

Although the studies in this review described benefits, barriers, and key factors for success that are supported by informatics literature from other disciplines, few provided any quantitative assessment of the effect of an EHR implementation and none used comparison groups. Many of the studies we reviewed contained qualitative descriptions of the initial development and implementations of an EHR. These reports can provide valuable insights into the complex and rarely predictable behaviors that emerge out of the social-technical interactions of integrating computer systems into the care environment.[64] Yet, a comprehensive evaluation of health care information technology includes both qual-

itative and quantitative assessment[65] and goes beyond the initial implementation period.

Although controlled trials of health care information technology are difficult to conduct,[66] they are still badly needed. As with any intervention, a controlled trial is the only way to convincingly demonstrate whether the new system improves, has no effect, or worsens the processes or outcomes of care delivery. Because computer systems have the potential to introduce errors and disrupt workflow as well as to improve care,[64] a controlled trial is necessary to determine which is occurring.[67] In other disciplines, many aspects of EHRs have been studied with controlled trials. Just a few examples from the medical literature include reports evaluating the effect of computerized reminders for preventive care,[5,7,68] computer-generated summaries of patient information[69] and computer predictions of abnormal test results[70] on physician test ordering, computerized physician order entry on time[71] and resource utilization,[53] and sharing electronic clinical information from another institution on emergency department outcomes.[27] These studies have demonstrated that information technology can affect care and be evaluated in live clinical settings.

The body of literature on EHRs from the broader field of medical informatics is vast and steadily expanding.[72] As indicated by the number of studies included in this review, physical therapy–specific literature makes up a relatively small percentage. Although we had expected to find an increased number of studies published on EHRs in recent years, we did not observe this trend. There is much to glean from the existing body of knowledge on EHRs from other disciplines, as many more benefits, barriers, and key factors for success have been reported but were not identified in the studies we reviewed. Notably absent from the themes that emerged in our review are the financial implications of implementing EHRs. In our conversations with clinicians and managers interested in EHRs, the financial incentives and disincentives to implementation are a major, if not the most important, concern. Similarly, security, privacy, and confidentiality were not prominent issues in the studies we reviewed. Addressing concerns for security, privacy, and establishing the case for financial and organizational value of health care information technology are all central themes in the current national initiatives.[2,21,62]

In considering the literature on EHRs from other disciplines, we note that various health care stakeholders may have different opinions about the barriers and benefits to implementing information technology.[73] Thus, it is important to investigate the unique perspective of the physical therapist. Physical therapists make diverse clinical decisions[74] and increasingly will need electronic systems customized to meet the information demands of autonomous practice environments. A remaining challenge for the profession of physical therapy is the small number of investigators who are trained as clinical informaticians and, therefore, capable of designing and evaluating such systems.

Recommendations

In an effort to synthesize the findings of this review and provide suggestions for practical application of the results, we have developed recommendations based on the underlying themes in the studies we reviewed. In no way are these recommendations presumed to be an all-inclusive "recipe" for success. Rather, we hoped to identify the insights that seemed to be essential conditions for successful implementation of EHRs.

(1) *Incorporate workflow analysis into the system design and implementation.*[35–37,43,47,50] A crucial part of system development is identifying the necessary data elements that exist and how they are currently collected, when and where they will be used, and whether new processes are needed to collect additional information. Effective system design requires an understanding of the information flow between data collection and use.

(2) *Include end users, especially clinicians, in the system development activities.*[40,41,45–48,50] Introduction of an EHR is inextricably linked to organizational change. Designing strategies to incorporate the perspectives of end users (with their existing and desired workflows in mind) helps identify data requirements and helps staff "buy" into the EHR implementation.

(3) *Devote significant resources for training.*[40,41,45–48] A large effort is required for training staff, and it is easily underestimated. Successful training is an ongoing process that involves more than just system navigation, and it includes training in new roles, workflows, and methods to ensure data integrity.

(4) *Plan and test carefully to ensure adequate software and hardware system performance.*[33–35,48] Clinical users can easily become frustrated with a poorly performing system. Electronic health record systems must meet or exceed user expectations, while also being capable of supporting future growth and functionality.

(5) *Pursue the efficient capture of coded data.*[45,47,50] Health information often is stored as free-text narratives with qualitative impressions, but coded observations and quantitative results are necessary for automating guidelines and driving decision-support systems and for many of the other higher level functions of an EHR.[75] Changing the clinical workflow to effi-

ciently produce reliable coded observations may require a comprehensive and strategic effort,[56] such as that described by Shields et al.[45]

(6) *Commit to data standards.*[37,40,43,45,47,50] Even coded observations for routine clinical assessments often lack precise definitions to guide their use, yet ensuring data quality is paramount to achieving the full functionality of an EHR. Furthermore, as already seen in medicine, the goal of meaningful and interoperable health information exchange can be impeded by the plethora of local conventions for identifying data in separate electronic systems.[75] Linking local clinical concepts with standardized terms from controlled vocabularies provides a bridge for aggregating data within and among sites.[25,28,51,75–77]

Implications

Electronic health records offer much promise to improve information management for physical therapists, but they are not a panacea. It is our hope that this review provides a useful foundation on which to better design, implement, and evaluate EHRs in physical therapist practice. Our recommendations summarize the reviewed literature into practical steps toward successful implementation. Further research is needed to better characterize the effect an EHR can have on the process and outcomes of care and to elucidate what "active ingredients" are necessary to achieve these benefits. Currently, many managers and clinicians view computerized systems as a one-time purchase. This review highlights the complex social-technical interactions of implementing EHRs that are perhaps better viewed as part of a broader, ongoing information management process that recognizes the workflow and practice demands of clinician users. As national initiatives are developing the foundation of a nationwide health information infrastructure, physical therapists must work to ensure that the existing standardized vocabularies recognized in this infrastructure adequately represent the clinical concepts forming our unique body of knowledge. Doing so will enable us to contribute our unique clinical perspective in this emerging electronic information exchange and simultaneously allow us to leverage the advanced EHR features (which require standardized and coded data) to advance clinical practice and research.

References

1 Tierney WM. Improving clinical decisions and outcomes with information: a review. *Int J Med Inform.* 2001;62:1–9.

2 Markle Foundation, Connecting For Health. *Achieving Electronic Connectivity in Healthcare: A Preliminary Roadmap From the Nation's Public and Private-Sector Healthcare Leaders.* New York, NY: Markle Foundation; July 2004. Available at: http://www.connectingforhealth.org/resources/cfh_aech_roadmap_072004.pdf. Accessed December 16, 2004.

3 McDonald CJ. Protocol-based computer reminders: the quality of care and the non-perfectability of man. *N Engl J Med* 1976;295:1351–1355.

4 McDonald CJ. Use of a computer to detect and respond to clinical events: its effect on clinician behavior. *Ann Intern Med.* 1976;84:162–167.

5 McDonald CJ, Hui SL, Smith DM, et al. Reminders to physicians from an introspective computer medical record: a two-year randomized trial. *Ann Intern Med.* 1984;100:130–138.

6 Overhage JM, Tierney WM, Zhou XH, McDonald CJ. A randomized trial of "corollary orders" to prevent errors of omission. *J Am Med Inform Assoc.* 1997;4:364–375.

7 Dexter PR, Perkins S, Overhage JM, et al. A computerized reminder system to increase the use of preventive care for hospitalized patients. *N Engl J Med.* 2001;345:965–970.

8 Jette DU, Grover L, Keck CP. A qualitative study of clinical decision making in recommending discharge placement from the acute care setting. *Phys Ther.* 2003;83:224–236.

9 Joint Commission on Accreditation of Healthcare Organizations Web site. Accredited organizations page. Available at: http://www.jcaho.org/accredited+organizations/index. Accessed December 16, 2004.

10 Brandt MD. Health informatics standards: a user's guide. *J AHIMA.* 2000;71:39–43.

11 Laing K. The benefits and challenges of the computerized electronic medical record. *Gastroenterol Nurs.* 2002;25:41–45.

12 Grantham C. The rise of the real-time consumer. *CIO Insight.* July 19, 2002. Available at: http://www.cioinsight.com/article2/0,3959,390459,00.asp. Accessed December 16, 2004.

13 Giga Information Group. GIGA taps key IT trends for 2003. *CIO Insight.* October 10, 2002. Available at: http://www.cioinsight.com/article2/0,3959,624894,00.asp. Accessed December 16, 2004.

14 Kaplan B, Brennan PF. Consumer informatics supporting patients as co-producers of quality. *J Am Med Inform Assoc.* 2001;8:309–316.

15 PricewaterhouseCoopers. *HealthCast 2010: Smaller World, Bigger Expectations.* Available at: http://www.pwchealth.com/healthcast2010.html. Accessed December 16, 2004.

16 Dick RS, Steen EB, eds. *The Computer-based Patient Record: An Essential Technology for Health Care.* Washington, DC: National Academy Press; 1991.

17 Dick RS, Steen EB, Detmer DE, eds. *The Computer-based Patient Record: An Essential Technology for Health Care.* Rev ed. Washington, DC: National Academy Press; 1997.

18 Institute of Medicine, Committee on Data Standards for Patient Safety, Board on Health Care Services. *Key Capabilities of an Electronic Health Record System.* Washington, DC: National Academy Press; 2003.

19 Bush GW. Health care excerpts from the 2004 State of the Union [press release]. January 20, 2004. Available at: http://www.whitehouse.gov/news/releases/2004/01/20040120–11.html. Accessed December 16, 2004.

20 Bush GW. *Transforming Health Care: The President's Health Information Technology Plan.* Available at: http://www.whitehouse.gov/infocus/technology/economic_policy200404/chap3.html. Accessed December 16, 2004.

21 Department of Health and Human Services. Thompson launches "Decade of Health Information Technology" [press release]. July 21, 2004. Available at: http://www.hhs.gov/news/press/2004pres/20040721a.html. Accessed December 16, 2004.

22 Executive Order 13335: Incentives for the Use of Health Information Technology and Establishing the Position of the National Health Information Technology Coordinator. 69 *Federal Register* 24059 (2004).

23 Assuring a health dimension for the National Information Infrastructure: a concept paper by the National Committee on Vital Health Statistics. Presented to the U.S. Department of Health and Human Services Data Council October 1998. Available at: http://www.ncvhs.hhs.gov/hii-nii.htm. Accessed April 19, 2005.

24 Stead WW, Kelly BJ, Kolodner RM. Achievable steps toward building a National Health Information infrastructure in the United States. *J Am Med Inform Assoc.* 2005;12:113–120.

25 Biondich PG, Grannis SJ. The Indiana network for patient care: an integrated clinical information system informed by over thirty years of experience. *J Public Health Manag Pract.* 2004;suppl:S81–S86.

26 Finnell JT, Overhage JM, Dexter PR, et al. Community clinical data exchange for emergency medicine patients. *AMIA Annu Symp Proc.* 2003:235–238.

27 Overhage JM, Dexter PR, Perkins SM, et al. A randomized, controlled trial of clinical information shared from another institution. *Ann Emerg Med.* 2002;39:14–23.

28 Overhage JM, Suico J, McDonald CJ. Electronic laboratory reporting: barriers, solutions and findings. *J Public Health Manag Pract.* 2001;7:60–66.

29 Medical Records Institute. *Sixth Annual Survey of Electronic Health Record Trends and Usage for 2004.* Available at: http://www.medrecinst.com/pages/latestNews.asp?id=115. Accessed December 16, 2004.

30 van Bemmel JH, Musen MA, Helder JC, eds. *Handbook of Medical Informatics.* Heidelberg, Germany: Springer Verlag; 1997.

31 Greenes RA, Shortliffe EH. Medical informatics: an emerging academic discipline and institutional priority. *JAMA.* 1990;263:1114–1120.

32 Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics.* 1977;33:159–174.

33 Vallbona C, Spencer WA, Levy AH, et al. An on-line computer system for a rehabilitation hospital. *Methods Inf Med.* 1968;7:31–39.

34 Gotcher SB, Carrick J, Vallbona C, et al. Daily treatment planning with an on-line shared computer system. *Methods Inf Med.* 1969;8:200–205.

35 Beggs S, Vallbona C, Spencer WA, et al. Evaluation of a system for on-line computer scheduling of patient care activities. *Comput Biomed Res.* 1971;4:634–654.

36 Carter RE, Jackson CC. Patient planning in a spinal cord centre using a computer. *Paraplegia.* 1972;10:11–18.

37 Savander GR, Stutz RN. Electronic data processing of physical therapy services. *Phys Ther.* 1973;53:1046–1054.

38 Spencer WA, Moffet CL, Baker RL. An application of information science and technology to provision of rehabilitation services. *Rehabil Rec.* 1973;14:12–16.

39 Sterling T, Pollack S, Spencer W. The use of an information system to "humanize" procedures in a rehabilitation hospital. *Int J Biomed Comput.* 1974;5:51–57.

40 Savander GR. Development of an outcome assessment and informational system for physical therapy: a multi-institutional project. *Phys Ther.* 1977;57:891–896.

41 Lehmann JF, Warren CG, Smith W, Larson J. Computerized data management as an aid to clinical decision making in rehabilitation medicine. *Arch Phys Med Rehabil.* 1984;65:260–262.

42 Brown M, Gordon WA. Rehabilitation indicators: a complement to traditional approaches to patient assessment. *Cent Nerv Syst Trauma.* 1986;3:25–35.

43 Sulton LD, Hardisty B, Bisterfeldt J, Harvey RF. Computerized data bases: an integrated approach to monitoring quality of patient care. *Arch Phys Med Rehabil.* 1987;68:850–853.

44 Zimny NJ, Tandy CJ. Development of a computer-assisted method for the collection, organization, and use of patient health history information in physical therapy. *J Orthop Sports Phys Ther.* 1993;17:84–89.

45 Shields RK, Leo KC, Miller B, et al. An acute care physical therapy clinical practice database for outcomes research. *Phys Ther.* 1994;74:463–470.

46 Crosswhite R, Beckham SH, Gray P, et al. Using a multidisciplinary automated discharge summary process to improve information management across the system. *Am J Manag Care.* 1997;3:473–479.

47 Eiseman CA. Information systems in the rehabilitation setting: the multidisciplinary approach. *Top Health Inf Manage.* 1999;19:1–9.

48 Mazzoni-Maddigan J, Burchick G. Health information management in the rehabilitation environment: the Easter Seal Society of Western Pennsylvania. *Top Health Inf Manage.* 2000;21:70–78.

49 Swope S. Compliance efforts lead to process improvements. *J AHIMA.* 2000;71:37–40.

50 Kaur K, Forducey PG, Glueckauf RL. Prototype database for telerehabilitation. *Telemed J E Health.* 2004;10:213–222.

51 McDonald CJ, Overhage JM, Tierney WM, et al. The Regenstrief Medical Record System: a quarter century experience. *Int J Med Inform.* 1999;54:225–253.

52 McDonald CJ, Tierney WM. The Medical Gopher: a microcomputer system to help find, organize and decide about patient data. *West J Med.* 1986;145:823–829.

53 Tierney WM, Miller ME, Overhage JM, McDonald CJ. Physician inpatient order writing on microcomputer workstations: effects on resource utilization. *JAMA.* 1993;269:379–383.

54 McDonald CJ, Overhage JM, Mamlin BW, et al. Physicians, information technology, and health care systems: a journey, not a destination. *J Am Med Inform Assoc.* 2004;11:121–124.

55 Ammenwerth E, Eichstadter R, Haux R, et al. A randomized evaluation of a computer-based nursing documentation system. *Methods Inf Med.* 2001;40:61–68.

56 Hogan WR, Wagner MM. Accuracy of data in computer-based patient records. *J Am Med Inform Assoc.* 1997;4:342–355.

57 Tierney WM, McDonald CJ. Practice databases and their uses in clinical research. *Stat Med.* 1991;10:541–557.

58 Berg M. Implementing information systems in health care organizations: myths and challenges. *Int J Med Inform.* 2001;64:143–156.

59 Doolan DF, Bates DW, James BC. The use of computers for clinical care: a case series of advanced U.S. sites. *J Am Med Inform Assoc.* 2003;10:94–107.

60 Barthell EN, Coonan K, Finnell J, et al. Disparate systems, disparate data: integration, interfaces, and standards in emergency medicine information technology. *Acad Emerg Med.* 2004;11:1142–1148.

61 McDonald CJ, Schadow G, Suico J, Overhage JM. Data standards in health care. *Ann Emerg Med.* 2001;38:303–311.

62 Middleton B, Hammond WE, Brennan PF, Cooper GF. Accelerating U.S. EHR adoption: how to get there from here, recommendations based on the 2004 ACMI retreat. *J Am Med Inform Assoc.* 2005;12:13–19.

63 Lincoln MJ, Brown SH, Nguyen V, et al. U.S. Department of Veterans Affairs enterprise reference terminology strategic overview. *Medinfo.* 2004;11:391–395.

64 Ash JS, Berg M, Coiera E. Some unintended consequences of information technology in health care: the nature of patient care information system-related errors. *J Am Med Inform Assoc.* 2004;11: 104–112

65 Heathfield M, Pitty D, Hanka R. Evaluating information technology in health care: barriers and challenges. *BMJ.* 1998;316:1959–1961.

66 Tierney WM, Overhage JM, McDonald CJ. A plea for controlled trials in medical informatics. *J Am Med Inform Assoc.* 1994;1:353–355.

67 Berger RG, Kichak JP. Computerized physician order entry: helpful or harmful? *J Am Med Inform Assoc.* 2004;11:100–103.

68 Dexter PR, Perkins SM, Maharry KS, et al. Inpatient computer-based standing orders vs physician reminders to increase influenza and pneumococcal vaccination rates: a randomized trial. *JAMA.* 2004;292: 2366–2371.

69 Wilson GA, McDonald CJ, McCabe GP Jr. The effect of immediate access to a computerized medical record on physician test ordering: a controlled clinical trial in the emergency room. *Am J Public Health.* 1982;72:698–702.

70 Tierney WM, McDonald CJ, Hui SL, Martin DK. Computer predictions of abnormal test results: effects on outpatient testing. *JAMA.* 1988;259:1194–1198.

71 Overhage JM, Perkins S, Tierney WM, McDonald CJ. Controlled trial of direct physician order entry: effects on physicians' time utilization in ambulatory primary care internal medicine practices. *J Am Med Inform Assoc.* 2001;8:361–371.

72 Moorman PW, van der Lei J. An inventory of publications on computer-based medical records: an update. *Methods Inf Med.* 2003;42: 199–202.

73 Lyons SS, Tripp-Reimer T, Sorofman BA, et al. VA QUERI informatics paper: information technology for clinical guideline implementation: perceptions of multidisciplinary stakeholders. *J Am Med Inform Assoc.* 2005;12:64–71.

74 Magistro CM. Clinical decision making in physical therapy: a practitioner's perspective. *Phys Ther.* 1989;69:525–534.

75 McDonald CJ. The barriers to electronic medical record systems and how to overcome them. *J Am Med Inform Assoc.* 1997;4:213–221.

76 Elkin PL, Brown SH, Carter J, et al. Guideline and quality indicators for development, purchase and use of controlled health vocabularies. *Int J Med Inform.* 2002;68:175–186.

77 Kannry JL, Wright L, Shifman M, et al. Portability issues for a structured clinical vocabulary: mapping from Yale to the Columbia medical entities dictionary. *J Am Med Inform Assoc.* 1996;3:66–78.

● Invited Commentary

As Vreeman and colleagues point out, health care professions in general and physical therapy in particular have lagged well behind other information-based professions in embracing the computer as a tool for information management. At the bank, we would likely be astounded if the teller had to find or write paper copies of our transactions; hand calculate the necessary sums for our accounts, mortgages, and investments; or rely exclusively on memory to find solutions or options related to our financial issues. In fact, with the advent of ATMs and online banking, even the use of a human teller seems antiquated! And yet, when we visit our physician or physical therapist, we would likely still be surprised if he or she turned immediately to a computer for assistance to collect, organize, or interpret the myriad of details involved in making a clinical decision about our health problem.

The authors correctly point out, however, that there is a growing awareness of the need and outright pressure for better methods of information management in health care using information technology (IT). The president of the United States expects that most Americans will have electronic health records (EHRs) within the next 10 years.[1] In October 2005, the Commission on Systemic Interoperability released a final report that recommended actions to be taken to achieve this goal.[2] Among the imperatives are: to help clinicians and consumers embrace IT, to promote the interchange and ease of information sharing among different electronic systems, to ensure access and confidentiality to consumers, and to provide suitability for data aggregation that allows tracking of public health issues for population-based management and research.

Some of these initiatives may be more easily accomplished than others. Indeed, IT seems exceptionally well suited to many of the "administrative-like" tasks. Systems that improve the ease, accuracy, and efficiency of scheduling, billing, health check reminders, and even record keeping of specific clinical data over time no longer seem particularly novel and are therefore likely to be progressively instituted as they become commercially available. Perhaps this is, at least in part, because these uses are most akin to what we already experience daily as manipulation and transmission of information in business and educational environments. Similarity to existing systems and behaviors has been noted as one mechanism that makes acceptance of a novel idea more likely, at least in the short term.[3]

The stated focus of this article, however, is on the EHR and, according to the authors, its ability to provide "the right information at the right time and in the right format" so that clinical decisions in physical therapy can be more "effective and efficient." It is interesting that the authors do not, therefore, include improved clinical decision making in the potential benefits of the EHR.