

Using Information Technology To Improve the Health Care of Older Adults

Michael Weiner, MD, MPH; Christopher M. Callahan, MD; William M. Tierney, MD; J. Marc Overhage, MD; Burke Mamlin, MD; Paul R. Dexter, MD; and Clement J. McDonald, MD

The high burden of illness and frailty common among our growing population of older adults often results in fragmentation of care across providers and health care systems, increasing the complexity and costs of caring for these patients. Information technology offers one way to meet this challenge. Scientists at the Regenstrief Institute have more than a quarter-century of experience in using medical informatics to support clinicians in the day-to-day care of older adults. Their research has progressed through several evolutionary cycles, beginning with the acquisition of relevant data and moving to studies of the most efficient and effective mechanisms that bring information to bear at the time of clinical decision making. Information technology designed

with the input of the end user has the greatest promise of changing provider behavior because it balances technological challenges with the cultural context of the practice environment. One topic of active research is information technology to support transitions of care among sites and providers. These transitions place older adults at increased risk for avoidable illness, death, and health care costs. Information systems that improve communication among providers during these transitions have the potential to improve safety and reduce costs.

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For author affiliations, see end of text.

To provide effective health care, providers must manage an ever-growing volume of medical information. Typically, this information is distributed across many isolated sources, including paper and electronic medical records belonging to different organizations, textbooks, and journals (1). Instead of enlightening its users, poorly organized or variably accessible information can obscure and confuse (2). The time needed to record, retrieve, and integrate clinical information accounts for more than one third of the physician's workday (3), and data management costs hospitals approximately one third of their budgets (4, 5). The Institute of Medicine (6) suggests that new investments in information systems are the best route to improved safety, quality, and efficiency of the health care system.

The ideal of a common mechanism for assessing and organizing all information required to care for one patient is thwarted by numerous organizational, procedural, and behavioral barriers (7). Furthermore, only a few health care systems in the United States provide one method with which to access disparate sources of information within the system (8). Even fewer have access to information systems that integrate patient-level data across multiple health care systems. Into this fragmented environment enters a growing population of older adults. Because of the burden of comorbidity and disability in this population, the care of this group is complex and expensive (9). Multidisciplinary collaboration and coordination of services (10) are essential, yet the very design of the current health care system fragments care for older adults across providers, sites, health systems, and third-party payers.

We describe the current limitations of and future prospects for using information technology to improve the care of older adults, with a particular focus on our experience with the Regenstrief Medical Record System (RMRS).

BACKGROUND

The computerized RMRS was created in the early 1970s, beginning with an attempt to create a computer-based medical record for 35 patients with diabetes mellitus. The goals were to make clinical data immediately available; to reduce the work associated with using paper-based records for clinical management; and to create a system that could enhance clinical care and research through strong capture, storage, and management of information. The system has been central to the clinical care of medical and geriatric patients at Wishard Health Services, where we have practiced for up to 25 years.

Nearly 30 years after its creation, the RMRS is now one of the oldest, largest, and most comprehensive computerized medical record systems in the world (11). It contains more than 400 million observations, 3.25 million narrative reports, and 15 million prescriptions, as well as 350 000 electrocardiograms and 35 million radiologic images for more than 2 million patients (11). These electronic records are accessed nearly 10 million times each year by more than 2500 health care providers. Since 1984, the system has allowed physician order entry and other direct interactions between computer and physician (12). It gives providers access to encyclopedic information (for example, about drug dosing and side effects) so that they can ask questions when they realize that they do not know all of the relevant facts, but it also allows the computer to push information to providers who do not know that they do not know. Furthermore, it can do this at the critical time of clinical decision making, while the physician is initiating an order or recording a diagnosis. Making it easy to do the right thing in a complex clinical environment is key to improving the care of older adults.

Components of this electronic medical record now serve nearly all of the major hospital systems in the India-

napolis, Indiana, metropolitan area; numerous practice sites for the primary care groups associated with some of the large hospitals; all of the systems caring for homeless persons in Indianapolis; and one large nursing home. The record does not capture home health care data, but integration of information databases among health care systems continues. Later in this paper, we focus on RMRS at Wishard Health Services, where the system originated. Other medical organizations (13), such as Columbia Presbyterian Medical Center (14), Partners Health Care (15–18), CareGroup Healthcare System (19–21), Intermountain HealthCare (22, 23), the University of Utah (24), and Vanderbilt University Medical Center (25), have built similar large-scale medical record systems, and the California HealthCare Foundation (26) has supported construction of a community-based information system (27) that links a major share of the physicians in Santa Barbara County, which has a large elderly population.

MANAGING COMPLEXITY IN THE CARE OF OLDER ADULTS

To provide health care for older adults, physicians must typically deliver longitudinal care for several chronic and acute conditions and track a wide variety of clinical measures and interventions. Physicians' poor adherence to protocols and guidelines is well documented, and the literature has moved beyond simple educational initiatives and admonitions to more sophisticated and potentially more effective approaches (28). In 1974, the RMRS began to deliver automatic reminders in the form of paper reports (29). The night before a patient's visit, the computer reviewed the patient's computer record against a set of predefined protocols and generated reminders about patient conditions that needed corrective action. These reminders were delivered to the responsible physician as a report placed on top of the patient's chart. The most common reminders were for preventive care, such as fecal occult blood testing, mammography, cervical cancer screening, and vaccinations, all of which are especially pertinent to the care of older adults.

Investigators at the Regenstrief Institute have conducted numerous randomized clinical trials to assess the effect of the paper-based reminders. The first of these studies involved nine physicians and 390 unique reminder rules. This was the first published study (28) to show that computer reminders could improve physician adherence to ideal practice standards. Indeed, physicians were more than twice as likely to adhere to recommended practice when reminders were given than when they were not. Over the next 8 years we did a series of reminder studies (30, 31), culminating in a 2-year randomized trial involving 130 providers, 12 467 patients, and 1491 reminder rules (32). This trial showed a strong persistence of the effect of computer reminders over several clinical conditions, including many relevant to older adults, such as cancer, osteoporosis, pneumonia, and influenza. Compared with physicians who

were not given reminders, physicians who received reminders ordered influenza vaccine for twice as many of their older adult patients (33). Patients eligible for influenza vaccine were less likely to be hospitalized or to visit an emergency department for respiratory disease if they were treated by physicians who received reminders than if they were treated by physicians who did not (33).

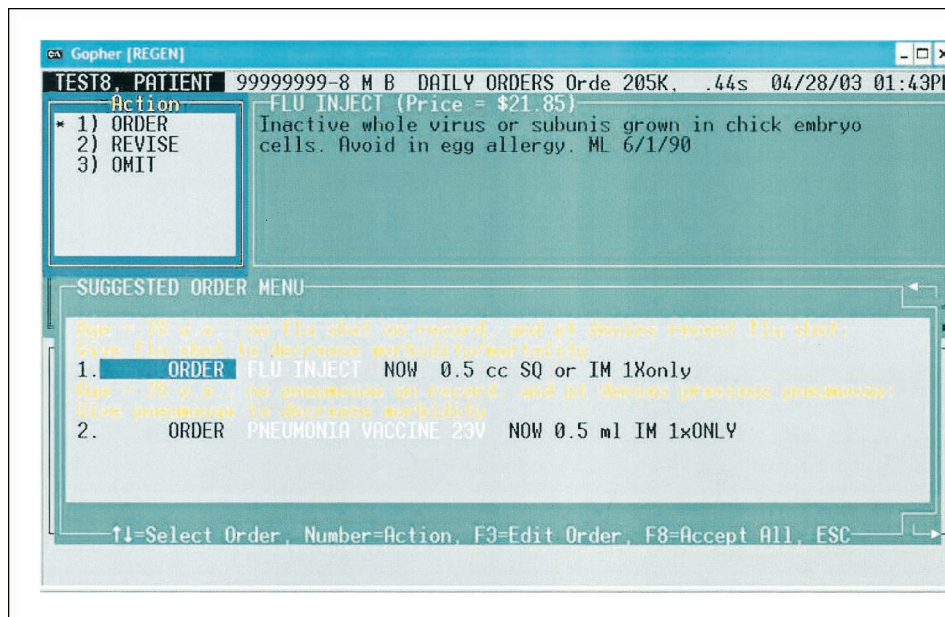
Further studies focused on the content and format of information that would be most useful in clinical decision making. For example, adding relevant citations from the medical literature to reminders had no significant effect on provider behaviors (31), and reminders delivered at the point of care had more effect than summary information about the physician's adherence to protocols reported later (34). Investigators from the University of Alabama (35), Massachusetts General Hospital (36), and the University of Utah (37) showed similar effects of computer-generated reminders on care processes.

We and other investigators (38) also showed the benefit of immediately available computer-generated reports. Stanford University showed the efficiency of a well-organized flow sheet in rheumatologic care. When this flow sheet was used, physicians' chart review time decreased from 7 minutes to 2 minutes per patient visit. When internists working in an emergency department received printed summaries of patients' medical records but no corresponding suggestions, they still ordered fewer tests and generated lower costs for the tests (39). Thus, merely presenting a patient's recent diagnostic evaluation could prevent redundant or possibly needless testing. Whiting-O'Keefe and colleagues (2) found that computer-generated patient summaries improved physician decision making.

During this first generation of reminder studies, we noted the importance of tailoring and prioritizing reminders for individual patients. In other words, presenting a "laundry list" of reminders—as had always been done in the printed reminders of the RMRS—may not be the ideal way to optimize adherence to a specific protocol. These findings parallel findings in the geriatric consultation literature, which was entering its infancy during the period when the first-generation reminder studies were being done. In the care of older adults, during any given outpatient or inpatient visit, there may be a litany of care suggestions. Whereas a younger adult might generate only one care recommendation, an older adult using several medications might easily generate a dozen recommendations. Numerous reminders might result in information overload that blunts the provider's response to any of them.

The introduction of the interactive Gopher system in 1984 provided a way to break up a long list of reminders. With this system, reminders or promptings could be offered stepwise during a physician's ordering session, precisely when the physician was addressing the relevant topic. Orders for suggested diagnostic testing would appear when the physician was ordering laboratory studies, for example, and recommendations for medications would appear only

Figure. Tailored reminder for influenza and pneumonia vaccinations.



When a physician records orders for a patient, the computer system prompts the physician to request vaccination on the basis of indications and the patient's history. The physician may accept the default orders, revise them, or omit them, as appropriate. IM = intramuscularly; SQ = subcutaneously.

when specific drugs were prescribed. Studies revealed that when physicians ordered one of a group of selected diagnostic tests, a computerized display of relevant past test results (40) or costs for the tests being ordered (41) decreased the ordering of those tests without a subsequent increase in care elsewhere. These studies further showed that recommendations requiring a complex action on the physician's part (for example, a recommendation for cervical cancer screening) were less likely to lead to action than were recommendations requiring a simple physician order (for example, a recommendation for mammography).

The new Gopher studies led to a series of studies of tailored, computer-based reminders, many of which focused on care for older adults. Reminders have had positive influences on physician behaviors with respect to ordering mammography and fecal occult blood testing (32, 42), managing diabetes mellitus (43), monitoring warfarin and digoxin use (43), preventing narcotic-induced constipation (43), discussing and completing advance directives (44), prophylactically prescribing heparin and aspirin in hospitalized patients, and administering pneumonia and influenza vaccinations (Figure) (45). Indeed, reminders about influenza and pneumonia vaccines increased orders for these two vaccines (45). The effects of reminders for mammography and fecal occult blood testing were greatest for patients older than 70 years of age, for whom physicians' baseline preventive screening had been lowest (42). Randomized trials (46–48) showed that physician order entry reduced inpatient and outpatient charges and length of stay and allowed more time for clinical care. The control condition for most of these studies included the traditional intensive educational intervention (49).

Many groups in many contexts have shown the power of computer reminders delivered interactively during care processes. A computerized "antibiotic assistant" greatly improved the costs, appropriateness, and outcomes of antibiotic prescribing (50). Computer reminders have also improved the timing of preoperative administration of prophylactic antibiotics (reducing the incidence of postoperative infection) (51), reduced inappropriate use of blood products (11, 52, 53), improved medical documentation (17), reduced unnecessary radiologic testing (22, 54), improved use of antiepilepsy medications (55), improved response times to critically abnormal test results (56), reduced unnecessary testing (57), and reduced overuse of vancomycin in a hospital setting (16, 58).

The past 10 years have seen new developments in applications of the RMRS for studying and improving care of older adults. The rich stores of clinical data in the RMRS can help physicians assess patterns of care and identify patients with particular risk factors and sequelae of adverse outcomes (59, 60). Studies have established rates of missed or unscheduled clinic visits (61), identified relationships between age and treatment or consultation (62), shown the effect of cognitive impairment on resource utilization and mortality (63), and shown associations between psychiatric and nonpsychiatric conditions in older adults (64).

Running queries on vast amounts of data in the computerized medical record system allow ready screening of numerous patients for identification of specific risk factors, including physiologic measures (65). The inclusion of pharmacy data has created possibilities for studying the appropriateness of supplies of medication and their association with health care use (66). Complex models that pre-

dict resource utilization (67, 68) and mortality (67, 69) have been developed. Fisch and colleagues (70) used RMRS data to identify patients with advanced cancer and the subset of those patients being treated for depression. We are working on mechanisms to link data from the RMRS Tumor Registries and the National Social Security Death Master File (71) to create a de-identified data set for cancer research. We have used clinical data from the RMRS with Medicare data (obtained in collaboration with Medicare's Quality Improvement Organization in Indiana) to understand 1) how patients obtain care across health care systems and 2) the problems caused by fragmentation of care. Medical record systems at other large academic institutions have been similarly useful (20, 72) and have even detected adverse events (73).

We recently expanded the RMRS to include data from all five major Indianapolis health systems, which together operate 11 hospitals to form the Indianapolis Network for Patient Care (74). At the time of a patient visit to the emergency department, for example, physicians can receive clinical information from the separate hospital systems as a single "virtual record." This expansion of access to regional health records has decreased charges for emergency care by up to \$26 per encounter (75). This reduction of fragmentation across health care systems has great potential to improve the care of patients with urgent, acute medical conditions.

For frail older adults who move frequently among care settings (for example, from skilled-nursing facilities or home health care settings to emergency departments or hospitals and back), the problem of fragmentation of care is especially severe. Information technology provides many ways to reduce this fragmentation (76), and telemedicine has broken into the geriatrics arena (77). Technology can be used to monitor drug use electronically in patients at home (78) and in nursing homes (79), and computer-based geriatric assessments have been used to facilitate geriatric care management (80, 81). With funding from the National Library of Medicine, several researchers at Regenstrief Institute helped develop a high-speed, full-motion videoconferencing system that links on-call geriatricians in their homes to patients in a 240-bed skilled-nursing facility (82). We are studying the effect of this system on patient and provider satisfaction and on health resource utilization (83). Others have studied teleconferencing with patients in community settings (84), retirement communities (85), and residential care homes (86, 87). Our own direct experience with videoconferencing illuminates the large and difficult technical and cultural barriers that must be overcome to improve coordination between skilled-nursing facilities and hospitals.

THE FUTURE

Information technology is the structural component of health care most likely to improve the process of health

care delivery (88), leading to improved health outcomes (6) and thereby increasing the functional independence of older adults. Information technology can help clinicians meet the challenges of complexity of care for older adults, but moving this science forward will require the development of gero-informatics units that include a cadre of geriatricians working with primary care physicians, informatics specialists, and health services researchers. Clearly, the problems we face are not amenable to purely technical solutions. Nearly all require multifactorial solutions involving changes in technology, workflow, and human behavior. Information technology, however, offers multiple levers for changing human behavior. Making systems work to improve aging for older adults will require that clinical elements with proven importance in geriatrics—such as pain, symptoms of depression, or measures of physical or cognitive function—be included systematically as data elements in the medical record. Equipped with clinical data about a particular patient, physicians can make decisions on the basis of general practice guidelines by merging patient-specific information with a guideline (89). Even when physicians completely accept a given practice guideline, however, they may not recognize that a particular patient is eligible for the actions suggested by that guideline. Fatigue, distractions, and oversights explain these failures in busy practice settings. Computer systems that scour the patient's electronic record for conditions that require action and remind the physician about these conditions can eliminate these failures. This is not "cookbook medicine" but smarter practice.

Community-based information systems can help solve the problems of fragmented care across the clinic, hospital, acute rehabilitation, and extended care settings so often visited by older adults. The success of these computer-based solutions, however, depends most strongly on the seamless movement of data from the legion data sources—the many pharmacies, hospitals, nursing homes, radiology departments, consultants' offices, primary care offices, and home health care systems where the patient has obtained care, medications, or diagnostic studies—to the central electronic medical record used by the clinician. Today, engineers can build computer systems with "slots" for storing every kind of clinical data. The difficult challenge is in building the plumbing, or infrastructure, that connects the sources of those data to the right slots in the central medical record system. For example, the result of a thyroid-stimulating hormone test done by a referral laboratory must get back to the appropriate section of the medical record system before the computer system can find it for intelligent display or decision support. At a minimum, this requires that the medical record's systems recognize the structures of the records sent to them, understand the codes that identify the test result as a thyroid-stimulating hormone measurement, and understand the unique patient-level identifier sent by the source system. This applies to every item of data produced by every source of data. The

solution is the adoption, among existing systems, of standardized electronic messages with codes that describe the orders, observations, and other parts of the medical record. The Centers for Medicare & Medicaid Services have taken a step in this direction by mandating use of Health Level Seven (HL7) (90, 91) and Digital Imaging and Communications in Medicine (92) standards for messages and the use of Logical Observation Identifiers Names and Codes (93, 94) for all laboratory test reporting in federal agencies. Building standards includes not only these vocabularies and message formats but also data models, such as the Clinical Document Architecture, which provides a standard for clinical documents that can be transmitted and exchanged (95). The National Committee on Vital and Health Statistics (96) has eloquently described the relevant issues and a solution, as part of the National Health Information Infrastructure (97).

Physicians can play a strong role in the evolution of better systems by demanding support for nationally accepted standards in all of the clinical computer systems they purchase for their offices, whether the product is an office management system, an electrocardiography station, a hand-held laboratory test instrument, or a laboratory referral service. Hospital leaders often know to demand support of the HL7 standard for larger systems but sometimes overlook the smaller clinical systems, such as those for electrocardiography or spirometry, with the result that these valuable components of the medical record are omitted from the hospital's central repository. Physicians should demand that hospitals adopt national standard codes so that their office systems can accept and understand hospitals' data messages as easily as they do those from the systems within their own offices. Physicians should also lobby for community-based information infrastructures that reduce the cost of clinical information management and provide clinical information needed for patient care, regardless of the source of the data.

From Indiana University Center for Aging Research, Regenstrief Institute, Indiana University, and Richard L. Roudebush Veterans Affairs Medical Center, Indianapolis, Indiana.

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Requests for Single Reprints: Michael Weiner, MD, MPH, Indiana University Center for Aging Research, Regenstrief Institute, 1050 Wishard Boulevard, 6th Floor, Indianapolis, IN 46202-2872; e-mail, mw@cogit.net.

Current author addresses are available at www.annals.org.

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Current Author Addresses: Drs. Weiner, Callahan, Overhage, Mamlin, Dexter, and McDonald: Regenstrief Institute, 1050 Wishard Boulevard, Indianapolis, IN 46202-2872.
Dr. Tierney: Indiana University, 1001 West 10th Street, OPW M200, Indianapolis, IN 46202.