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Synopsis

The state of clinical information systems after four decades of effort

The outstanding papers which are included in this year's section on clinical information systems address issues that have been important since we began to build clinical information systems in the 60's. I would classify these long-standing issues under two headings: benefits (the papers by Walton et al. and Bates et al.) and barriers (the papers by Ammenwerth et al., Schoop and Wastell, and Goossen), We make progress by increasing or clearly documenting the benefits and/or by reducing or eliminating barriers. When the benefits outweigh the barriers to use, then clinical information systems will be implemented and used. In this introduction, I will review my thoughts and experience on each of these topics and offer my ruminations on prospects for the near future. Since these opinions are personal, I do not claim to have a comprehensive bibliography but only enough to give some support for my feelings.

Benefits

Benefits of computer-based patient record systems can be grouped under the following headings:

a. Convenient access (by legitimate stakeholders) to patient data. The ability to access patient information is the biggest selling point for clinical information systems investments. Because a piece of paper can only be in one place and needs to be manually managed, there are significant advantages for an electronic medical record that allows the patients' information to be made available whenever it is needed. In our experience health providers of any age [1] or professional role will gladly use such systems. The advent of Internet based access [2, 3, 4] has markedly expanded the ability to remotely access the data and has lowered the support costs [5]associated with providing access via a thick client which requires any degree of on-site maintenance.

b. Organized and legible information. If one vital piece of information (e.g. the notation of active tuberculosis) is written on one section of one page in a chart which consists of 200 pages, people will waste time searching for or overlook crucial information even though it was theoretically available. Graphing trends over time is far more informative than searching for cholesterol levels on different sheets of paper.

c. Links from displayed information to pertinent literature which are based upon the user's level of expertise. Howard Bleich [6] pioneered the ability to access literature from the same computer terminal used to access patient data. Covell, Uman and Manning [7] showed that physicians' information needs in an ambulatory setting were not met two-thirds of the time. Since then there have been numerous initiatives to lower the barriers to information access by linking the item being seen on the results review screen of the clinical information system to the "pertinent paragraph" of the library information system The continuing work of Cimino [8, 9] is an example of this effort. As a result of these integrated capabilities, I believe that Octo Barnett coined the phrase "just in time learning"

d. The automated generation of alerts, reminders and suggestions when standards of care are not being achieved. Much has been written on this subject and the references in the paper by Bates et al. to the work at Regenstrief Institute and LDS hospital corroborate his findings that behavior and outcomes are changed when decision support is available. The meta-analysis by Watson et al. covering 30 years worth of papers describing the positive impact of computer support for drug dosing is heartening in that there are 18 well-designed studies in just this limited aspect of decision support. We need the same meta-analysis for the other 40 some-odd areas where information systems can change behavior. However, it is my perception in general, that the work of an unbiased IOM committee on quality of medical care [10] has generated a universal

recognition that there is a need for decision support systems.

e. The ability to analyze the resulting population database for clinical research, epidemiology assessments, quality measures, and outcomes. As the use of clinical systems grows, the resultant databases will be increasingly used to measure quality and cost of care as well as to ascertain outcomes. This will replace laborious chart review efforts which currently occupies researchers and quality assurance directors alike.

There are pros and cons about using databases for post hoc analysis when they have been collected for another reason. For example, clinical researchers might not know which patients in a population are smokers, because that information was not explicitly asked for in every encounter. However, when one considers the use of such resources as the Medicare database or the hospital cost accounting systems, there is strong evidence of the value of these systems. In fact, at the current time in my institution, it is easier to find out which drugs an ambulatory patient is receiving by looking at the insurance claims system than it is to go to the clinical information system where only about 12% of the physicians are entering prescriptions into the clinical data repository.

f. Reduction in costs. Reductions can come because it pays to do things right the first time (less preventable adverse events). There is also the possibility of some side benefits as well; we no longer have the need for file clerks to retrieve medical records or for transcriptionists. Reductions can come because we prompt physicians to prescribe generic drugs or less expensive antibiotics which can provide the same coverage as the more expensive option for a particular patient.

g. Better service. By collecting information once and using it for multiple purposes, we spare the patient the perception that the left hand doesn't know what the right hand is doing by having multiple people re-ask the same question. The ability to see the surgery or radiology schedule allows us to conveniently arrange for the patient's use of our facilities. Having the insurance and guarantor information from the ambulatory visit saves the patient from repeating that information when they go to the hospital for an MRI examination. The paper by Schoop and Wastell presents a new way of looking at the interdisciplinary communication and the causes of breakdowns in communication that affect quality as well as service.

These beneficial capabilities impact the quality and cost of caring for our health in a positive way. However it is important to carefully quantify the degree to which these benefits change our behavior, outcomes and costs so that those who make investments will have some confidence that there will be a solid return. As with any intervention in patient care, it is important to have well designed experiments that clearly identify the efficacy of information systems. An early article by McDonald [11] and the recent study by the Institute of Medicine concluded that in medicine, as in aviation, good systems can compensate for the known tendencies of humans to err on occasion. However, my current leader (Carvel Whiting) reminds us regularly of the difference between efficacy and effectiveness. In his words: Effectiveness = efficacy (or quality of the product) x acceptance by users. Although I feel that the IOM report had a major impact on widespread acceptance, we need to mind our local users as well. When we build wonderful systems and don't implement them with good support from below and above, the best level of effectiveness may not be realized.

The benefits of an automated system do not apply to everyone equally. In a busy inner-city clinic that is staffed by rotating providers, it is almost impossible to deliver a paper record to the provider at the time the patient is present. I have seen major rejoicing, savings of time, improved care and improved patient satisfaction as well as the cost savings mentioned by Tierney et al. [12] when clinical information was made available in a timely manner. On the other hand, in a small practice where all charts are filed neatly on the wall, the benefits might not be perceived so readily, even though documents are occasionally misfiled or phone calls are received at home on the weekend.

Barriers

The state of clinical information systems in actual use is not as rosy as the list of potential benefits might warrant. As with any capability, there has to be sufficiently documented benefits to outweigh the costs of providing such benefits. In my mind these barriers are (in order of importance):

a. The marginal incremental time which current applications require for provider data entry at the point of care. Physician data entry has been the Holy Grail of clinical information systems since the beginning. If a busy physician has 12 minutes to visit with the patient and it takes 3 minutes to enter the data into the computer, it is understandable why there might not be a universal commitment to enter data. It is widely believed that wireless connected devices will exceed the hardwired Internet clients by the year 2002 [13]. The article by Ammenwerth et al. addresses the common hope that such portable devices will

substantially increase the ease of data input. In their opinion, the conveniences of mobility do not yet offset the need for real estate. It should be remembered however that the technology that they used beginning in 1997 is far different from that which is available today and projected to be available in the near future. One of their very interesting findings is that cellular phones do not need to be turned off in the hospital.

b. The need for capital investment in these systems. In the past, "hospital information systems" were the main focus of progress in clinical information systems. This is largely because hospitals had the capital to make investments; it is difficult to get a critical mass of ambulatory participants to justify the investment. As a result of the rising costs of medicine and reimbursement changes which were effected by the switch to Diagnostically Related Groups" instead of "fee for service" models, the pressure to trim HMO costs by contracting for fixed fee services, and the United States Balanced budget Act of 1997, nearly 35% of United States hospitals are currently operating in the red (The Medicare Payment Advisory Commission, or MedPAC). The other 2/3 are obviously slightly more successful because they carefully control costs. As a result, it is no longer easy to make investments in information systems. I have been told by financial officers in several different institutions that they do not believe the results of papers such as the ones presented here. I do feel that they would find it easier to believe these results if they had more access to capital.

The capital situation is even more difficult for private practice physicians in the ambulatory arena. I recently visited with the vendor of a very nice system for entering patient data to create an electronic medical record. They estimated the monthly fee for installing and maintaining such a system would be $850 per physician, but even at this cost, the system did not have all the advantages of interfaces to sources of information such as laboratory tests, radiology reports and discharge summaries. Other providers (Alina and Intermountain Health Care) have estimated the costs for one time investment in a paperless ambulatory process per physician at $14,000-18,000. They justify this investment primarily on the savings which result from reduced transcription costs which can run as high as $14,000 year.

c. The concern over privacy. I believe that there are sufficient technical means to ensure adequate privacy [14]. There need to be incentives to make the investments in those technological and policy approaches. To this date most investments have been made by groups wanting to foster availability (results review) with no countervailing forces to limit inappropriate access. Current laws in the European countries and the emerging HIPAA regulations in the US would appear to be sufficient to motivate implementation of currently available methods to appropriately limit access to personal data.

d. Lack of a uniform vocabulary and data models. This aspect is discussed in the paper by Goossen et.al. and is also a factor in the paper by Schoop and Wastell. We cannot interface disparate systems if the terminologies are not mapped to a common reference model. We cannot communicate and gather data once for a minimum data set if another discipline uses different terminology and wants different information sets. It is for this latter reason that I am somewhat apprehensive about concepts of minimum data sets. I am supportive of specific applications that appropriately try to narrow the scope of an application so that the task of data entry is practical. However, I feel that several of those kinds of applications will interface with a common, longitudinal clinical data repository where many users will benefit from tidbits of data gathered from users in other disciplines. The biggest systemic bottle-necks in the environments where I have worked have been the definition of data and the corresponding data models for efficient storage and retrieval.

e. The architecture and quality of vendor products. I have spent half of my career in an "integrated" environment and half in an "interfaced" environment. I strongly prefer the latter. Although I think interfacing is more difficult initially; I feel that over a 20-30 year horizon, there are payoffs for being able to acquire applications from more than one vendor. In fact, we all do that today to some extent- most people would not write a surgery scheduling/case cart manager application or a clinical laboratory system from scratch because they developed a new hand-held order entry system that physicians were anxious to use. As we searched for a vendor for several new applications, we were told that we could not buy just the piece we wanted because "there were no cleavage points." Either we bought their entire system or did without their version of the application we wanted. We understand the magnitude of the currently required work to map terms and build reliable interfaces and realize that not every 400-bed hospital or small practice group can afford to build the kind of infrastructure in which every application writes to a clinical data repository via an interface engine. However when the

vendors actively discourage such approaches, it forces potential users to make compromises when selecting software. If we buy system x, then the emergency department gets what they want, but the pharmacists and operating rooms are unhappy. If we make the nurses happy with vendor y, the physicians are stuck with an unappealing order entry system etc.. The ultimate single vendor choice may be such a compromise that no one got the best available functionality. Things are even more discouraging for the single system owner when they know that even before the system is installed, there will be some new application shown at the anesthesiology conference that people come home and demand.

f. Uptime, reliability, response time. These issues are mainly a question of attention, resources and technology. While they are very legitimate barriers to the acceptance half of the effectiveness equation, I do not think they have the same import as the other barriers we have listed. These are the solvable ones.

Prospects for the near future

While the documentation of benefits may become stronger, it is the challenge to lower barriers where we can have the most immediate impact. I think the future is very bright for several reasons:

a. Data entry. Natural language processing is being used routinely to parse and extract coded data from discharge summaries, radiology reports, and operative notes [15, 16]. The vast amount of information that gets captured as ASCII text is becoming accessible in coded form without requiring users to speak "drop down menus." Our experiments with voice recognition/natural language understanding are less satisfactory, but we have office practice physicians, anatomic pathologists, and radiologists who routinely use voice input.

b. I feel that standards-based message interface formats and vocabulary are on the verge of blossoming. The emergence of the web interoperability paradigm has spawned a growing dependence on XML communications capabilities. Such things as SOAP (simple object access protocol) may replace proprietary or platform dependent standards for interprocess communication. "SOAP is a lightweight protocol for exchange of information in a decentralized, distributed environment. It is an XML based protocol that consists of three parts: an envelope that defines a framework for describing what is in a message and how to process it, a set of encoding rules for expressing instances of application-defined datatypes, and a convention for representing remote procedure calls and responses." [17]

There are other instances where standards have migrated to the web paradigm as well. "A clinical desktop typically runs many different applications at one time. With the CCOW [Clinical Context Object Workgroup] standard in place, once a clinician selects a patient in one application, all other applications automatically tune-in and display their records pertaining to that patient. Likewise, the clinician no longer needs to repeatedly enter log-in names and passwords in specialized clinical applications that were independently authored" [18]. In other words one can (or will soon be able to) display information from several different web application servers using standards for seamless integration that occurs at the browser rather than the application level.

After decades of disparate standards setting activities, HL7 is gradually emerging as an empowered, vital standards setting group. There is a recent agreement with CEN TC251 to exchange intellectual content. The soon to be released HL7 Reference Information Model (RIM) encompasses the comprehensive scope of possible descriptors of health care and is beginning to show which vocabularies are best able to describe a particular aspect of health care (medications, lab results, signs and symptoms, etc.) The efforts of the United States National Library of Medicine to make SNOMED-ct more widely available will hasten the adoption of standardized vocabulary. In summary, although many vendors continue to resist interfaces, there is sufficient energy and momentum from many in the field to indicate that we are on the verge of having interface capabilities that were heretofore available only to larger organizations.

c. The case for increased investment in clinical information systems. It was pointed out above that those who must currently make the investments are not necessarily the ones who will reap the benefits or are capable of generating the capital to do so. In most countries outside of the United States, the governments are the ultimate payers and have not yet made substantial investments. In the United States, a new paradigm has emerged as a result of the IOM report on quality of care. "A leading group of Fortune 500 companies, and other large health care purchasers, founded *The Leapfrog Group* [19] by creating and committing to a common set of purchasing principles to drive leaps in patient safety. The Leapfrog Group's goal is to mobilize employer purchasing power to initiate breakthrough improvements in the safety and overall value of healthcare to American consumers". Leapfrog

purchasers will advance three initial methods to improve patient safety:

1. Computer physician order entry (CPOE);
2. Evidence-based hospital referral (EHR); and,
3. CU physician staffing (IPS).

"These methods are well suited to purchasing standards because:

1 There is scientific evidence that these standards would significantly reduce avoidable danger.
2 Their implementation by the health industry is feasible in the near term.
3. Consumers can readily appreciate their value.
4. Health plans, purchasers and consumers can easily ascertain their presence or absence in selecting among health care providers."

Purchasers who expect to gain direct economic benefit from improved quality of health care are ready to steer business to those who make investments in clinical information systems. As the results of this effort become well documented, the logical next step would be for governments to legislate the equivalent of the "Hill-Burton" act for information systems. This act was passed in the US in 1948 for the purpose of modernizing the bricks and mortar of the hospitals to reflect the medical advances of the previous decade. As we continue to improve our documentation of the benefits of information systems and to innovatively reduce the barriers to data entry, many cogent thinkers would argue that it is now equally as important to invest in information systems today as it was then to buy bricks and mortar. Spreading the cost across the society which benefits from less expensive and higher quality of care may be the best source of investment capital.

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