The Scope and Direction of Health Informatics

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Abstract

Health Informatics (HI) is a dynamic discipline based upon the medical sciences, information sciences, and cognitive sciences. Its domain is can broadly be defined as medical information management. The purpose of this paper is to provide an overview of this domain, discuss the current "state of the art", and indicate the likely growth areas for health informatics. The sources of information utilized in this paper are selected publications from the literature of Health Informatics, HI 5300: Introduction to Health Informatics, which is a course from the Department of Health Informatics at the University of Texas Houston Health Sciences Center, and the author's personal experience in practicing telemedicine and implementing an electronic medical record at the NASA Johnson Space Center. The conclusion is that the direction of Health Informatics is in the direction of data management, transfer, and representation via electronic medical records and the Internet.

Key Words: electronic medical record, EMR, medical informatics, health informatics, telemedicine, eHealth

The Scope and Direction of Health Informatics

Introduction

What is Health Informatics? Health Informatics (HI) is a dynamic and nascent discipline with roots in the medical sciences, information sciences, and cognitive sciences. There are other, similar names for this concept, as well as the narrow aspects of this concept, i.e., medical informatics, nursing informatics, dental informatics, clinical informatics, clinical computing, etc.

Definitions

Academic definitions of the field will also put this into perspective. Greenes and Shortliffe defined Medical Informatics as "the field that concerns itself with the cognitive, information processing, and communication tasks of medical practice, education, and research, including the information science and the technology to support these tasks."(7). Alternatively, Health Informatics "is the study of how health data is collected, stored and communicated; how that data is processed into health information suitable for administrative and clinical decision making; and how computer and telecommunications technology can be applied to support those processes." (13).

The term "health informatics" is broad, inclusive, and thus far, malleable. The roots of the medical sciences are firm; the mechanisms for research and the means of providing health care are understood, practiced, and propagated in clinics, hospitals, and medical centers throughout the United States. The cognitive sciences, though established, are less well understood since it is difficult to measure and replicate the functions of the human mind. The information sciences provide the motive dynamic force for HI. This is due to the fact that information science and technology, and the market for information services are in the midst of tremendous growth and evolution-some would say revolution. These changes effect and include the means of delivering health care. Finally, though HI is broad, its common denominator today is the patient record.

Historical Scope

How broad is broad? The scope of HI begins and ends with patient health care data, but may subsume financial or administrative data. To date, computers and information systems have had the strongest impact on health care in regard to the latter two. An evaluation of many healthcare institutions before the 1990's would have revealed much automation, but such systems have been designed to support financial functions of the institutions. Cost reimbursement financial constraints meant that it was advantageous to accumulate charges. Sometimes ancillary functions were added such as patient order capabilities, but by and large, the computer systems were employed to optimize cost reimbursement. For example, Hospital Information Systems (HIS) matured during the 1980's to accomplish the following (1):

- Core administrative functions: registration, admission, discharge, and transfers.
- Core business functions: accounting, billing, and payroll.
- Core communications functions: orders and messages between departments.
- Departmental functions: internal business management.

Current Scope

With the advent of the 1990's, the Internet, and increasingly robust computers, the focus has returned to the patient. Thus, the current scope of HI includes:

1. Clinical data management. This includes acquisition, storage, re-presentation and representation of information. Order entry and results reporting are already automated to some degree. Currently, this refers to text and image files, but voice and video files will be incorporated as well.
2. Decision support systems. These allow the integration of pre-programmed or interactive knowledge bases such as medication formularies, allergy or drug interaction reminders, diagnostic software, and protocols.

   These two capabilities alone, when optimized, could positively impact the quality of health care. Two recent news items bear this out. Recently, a physician and a pharmacist were found liable for wrongful death, in a case where the pharmacist filled a prescription with the wrong medication. The physician's penmanship was deemed illegible. While physician handwriting is often the brunt of jokes, this is the first verdict related to poor penmanship. (11). Secondly, and related, the Institute of Medicine reported that up to 90,000 deaths occur per year due to preventable medical errors.
3. Technical and hardware issues: There are many devices for input/output. The main venue is the personal computer. But, PCs are rarely stand-alone, rather, they are networked workstations, where health care providers can access patient data, but also perform standard office tasks. Other devices such as scanners, sensors, personal digital assistants, and voice recognition system are, or can be networked.

4. Network technical issues: Internet, and intranets. PC's, workstations, etc., are typically linked through Local Area Networks or Wide Area Networks. Client-Server network architecture is utilized for several electronic medical records (EMR). It allows data to be shared between computers, such that tasks become more efficient. The client is typically a PC workstation, while the server is a mainframe, which contains more robust applications and databases or data repositories. Just as in industry, wireless radio frequency (RF) LANs are emerging within medical facilities, and the Internet has become a necessary link for data exchange.
5. Database structures and constraints. These are powerful tools for data storage, retrieval, manipulation and querying. The relational-database is widespread, familiar and state of the art. However, object-oriented-databases are also available, and these can perform more complex operations than relational databases
6. Development of autonomous, "smart" devices. An example would be automated patient monitors that communicate and interact with the EMR. For, instance, under the Sensors 2000 Program, NASA has utilized Teflon coated pellets, which, after ingestion, continually relay core body temperature to an external recipient device via RF.
7. Standards for the "languages" for communication between health care providers. Patients, doctors, nurses, etc., have different natural language vocabularies. Evans highlights the cruciality of this issue with an article entitled "The Canon Group Position Statement". (6). They posit this is the "central challenge in

medical informatics". There is not "a common, uniform, and comprehensive approach to representation of medical information". Furthermore, the standard methods for recording a controlled vocabulary will not lead to such a representation. The standard methods are: (a) the Systematized Nomenclature of Medicine or SNOMED, (b) the International Classification of Diseases, 9^{th} ed. or ICD-9, and (c) the Unified Medical Language System or UMLS. For example, in SNOMED, "acute appendicitis" can be represented in 10 legitimate ways.

8. Data exchange standards "language" for communications between health care devices. The call for such standards has moved to the forefront with the passage of the Health Insurance Portability and Accountability Act (HIPAA) in 1996. In that legislation, Congress indicated that standards would one day be legislated. However, market forces had long been tackling standards. From early efforts in laboratory messaging systems, SNOMED and Health Level 7 (HL7) emerged. HL7 is an example of the consortium of vendors, users, and researchers to create practical and ubiquitous standards. Administrative data has been standardized through the work of the Accredited Standards Committee X12N. Sometimes groups would become rivals as they proposed different standards. This was improved with Health Information Standards Planning Panel formed under the auspices of the American National Standards Institute in 1991. This panel dissolved in 1998 and the Health Information Standards Board (HISB) emerged as the major voice for standards creation. The HISB participates in the International Standards Organization's committee on Health Informatics (ISO TC 215). The major standards board in Europe is the European Committee for

Standardization, Technical Committee for Health Informatics (CEN TC 251). (3). The Computer-based Patient Record Institute (CPRI) was formed in response to recommendations from the Institute of Medicine in 1991, which set the priority goal to create a full EMR within a decade. Additional Standards Development Organizations (SDO) include the following (2):

- American Standards for Testing and Materials (ASTM): E1238 Clinical Data Interchange Standard.
- ASTM E1394: Clinical Laboratory Instruments to Computers.
- ASTM E1460: Standard Specification for Defining and Sharing Modular Health Knowledge Bases (The Arden Syntax).
- American College of Radiology/National Electrical Manufacturers Association Imaging Standards.
- National Council of Prescription Drug Programs (NCPDP): Telecommunications Standard Format for Transmission of Community Pharmacy Information.

Finally, in parallel to health related standards, are standards and architectures developed in relation to Internet communications such as hypertext transfer protocol (HTTP), hypertext mark-up language (HTML), eXtensible mark-up language (XML), object linking and embedding (OLE) and common object broker architecture (CORBA).

9. Legal and ethical considerations. As alluded to above, the information revolution is and will have indelible effects on the provision of health care. The Internet allows physicians and patients alike immediate and convenient access to a

cornucopia of medical information. A major concern is that individually attributable information is increasingly available in electronic format, thus presenting a threat to privacy and security. Privacy involves control of information and designation of who has access to information. Security involves accessibility of information via the physical protection of hardware, software, and networks. The overarching issues are not technical; rather they are ethical, social, and legal. According to Hodge the legal challenges fall into 3 interrelated domains: privacy of identifiable health information, reliability and quality of health data, and tort-based liability. (8). Upon an analysis of these domains, there are 7 recommendations. These are (a) recognizing identifiable health information as highly sensitive, (b) providing privacy safeguards based on fair information practices, (c) empowering patients with information and rights to consent to disclosure, (d) limiting disclosures of health data absent consent, (e) incorporating industry-wide security protections, (f) establishing a national data protection authority, and (g) providing a national minimal level of privacy protections.

10. Telemedicine. This is not a new concept, for "as far back as 1844, when the telegraph service was established, those involved in healthcare used innovations when they provided an improved solution". (14). Today, the practice of telemedicine is more often being mainstreamed into health care.
11. "Patient centered computing" and "enterprise wide computing" are concepts of the new paradigm in healthcare. As noted above, the Hospital Information Systems were designed to support the financial functions of the institution. The new patient centered systems will "integrate all information, from all services and

providers, and for all episodes of care around the patient, allowing providers to focus on patients, not on departments or venues of care. (9).

In summary, the scope of HI is broad, and it is in a growth phase in parallel to that of the computer, telecommunication and information industries.

Current Directions

Where is HI going? The most important avenue today is the transformation of the paper chart into an electronic medical record. Related, is the emergence of Internet based applications.

The Paper Chart

The inadequacies of the paper based medical record system nearly speak for themselves. The paper chart is a holdover from the 19th century, as physicians would record their observations in a lab book. That record has steadily grown to accommodate additional clinical and laboratory data. It has become the repository for notes from allied health professionals who render care for a particular patient. It has become a communications vehicle between various providers of care. (12).

As a medical document, it coordinates the efforts of all members of the healthcare team. Moreover, it is also a legal document, and it is a tool for monetary reimbursement. In order to fulfill these roles, the paper chart should be accurate, legible, thorough, authentic and secure. In addition, a large hospital may generate millions of pages of chart paper per year. These typically must be archived and stored for years, and be ready for expedient retrieval. While advances in the medical sciences have proceeded with a breath-taking pace this century, today's paper chart is nearly identical to its predecessor of 50 years ago—only thicker. (9).

Why is this? As stated above, by and large, the hospital information systems were employed toward cost reimbursement. The real patient information system stayed on the paper chart, as well as on clipboards, pocket notes and handbooks. Shortcomings to this are myriad:

- Disorganization: Data entries on paper charts reflect the view of each provider. Data are recorded in multiple spots within the chart. Some data are not included in the chart.
- Proliferation: In response to disorganization, increasing diagnostic and therapeutic modalities, and increasing members of the healthcare team, the number of specialized forms has increased.
- Significance: Large amounts of data can be accumulated on any one patient, and a large amount of this remains "within normal limits". A provider must spend time searching all data, and determining which is significant, since he saw that patient last.
- Co-location: The average outpatient has 2 or 3 doctors, while the average inpatient has primary doctor(s), several consultants, nurses, and ancillary personnel. Each must have access to the patient's chart at any given time.
- Analysis and Processing: The structure of paper records is not conducive to current and retrospective analysis, nor is that data readily extracted into population databases. Then, the data is virtually lost, as the chart eventually gets stored in a room or warehouse. (9).

Health care providers have long recognized such shortcomings.

<u>Electronic Charts</u>

Electronic Medical Records have been under development for decades, nearly since the start of the modern computer age. Pioneers in this field include Octo Barnett at the Massachusetts General Hospital and Morris Collen at Kaiser-Permanente in Oakland, California. Barnett developed an application for the ambulatory care environment call the COSTAR, which is an abbreviation for "computer-stored ambulatory record system". IBM marketed a Medical Information Systems Program until 1972. Lockheed Aircraft also developed an early EMR, and it is in use today. That program is now called Technicon Data System. (1). Another landmark EMR was the Regenstrief Medical Record, which began in 1972 at Wishard Memorial Hospital in Indianapolis, IN. This EMR began with 35 patients from the Diabetes Clinic. It has grown to contain information on over 1 million patients and over 70 million encounters, from 3 hospitals within the Indiana University and 30 clinics. (1). Similarly developed novel systems have emerged at Duke University (TMR System), and at the Latter Day Saints Hospital, Salt Lake City (HELP System).

In 1991, the Institute of Medicine (IOM) issued a report about improving patient records. This report recognized the numerous inadequacies with medical records, and recommended high-level strategies which would lead to the emplacement of Computer-based Patient Records (CPR) throughout the healthcare realm. (The terms EMR and CPR are nearly synonymous, but will be clarified in the next section.) The IOM drew three main conclusions:

1. Health care was in desperate need of a CPR.
2. Technology was not the limiting factor in CPR development.
3. A concerted effort would bring CPRs sooner rather than later.

Their ambitious recommendation was that CPRs could be employed throughout healthcare within a decade. Furthermore, the report presented a roadmap by which to proceed. (5). These strategic recommendations are as follows:

1. Health care professionals and organizations should adopt the CPR as the standard for medical and all other records related to patient care.
2. To accomplish the first Recommendation, the public and private sectors should join in establishing a CPR Institute (CPRI) to promote and facilitate development, implementation, and dissemination of the CPR.
3. Both public and private sectors should expand support for the CPR and CPR system implementation through research, development and demonstration projects.
4. The CPRI should promulgate uniform national standards for data and security to facilitate implementation of the CPR and its secondary databases.
5. The CPRI should review (laws and regulations) for the purpose of proposing (legislation to facilitate implementation) of the CPR.
6. The costs of the CPR should be shared by those who benefit from the value of the CPR.
7. Health care professional schools and organizations should enhance educational programs for students and practitioners in the use of the computer, CPRs, and CPR systems for patient care, education, and research. (1).

Terminology

What is the difference between an EMR and a CPR? EMR and CPR are nearly interchangeable. However, it is helpful to review Waegemann's article, "The Five Levels of the Ultimate Electronic Health Record", to discern specific nuances. Each level reflects technological advancement and standards acceptance. (15).

1. Level 1: Automated Medical Records. "This stage is still largely dependent on paper-based medical records, although as much as 50 percent of patient information is computer-generated and computer-stored..."
2. Level 2: Computerized Medical Record System. Here, the paper chart is essentially recreated in an electronic format by scanning. It is then stored as a scanned image.
3. Level 3: Electronic Medical Records (EMR). This record has the same information as the paper chart, but it is restructured for computer use. It is an interactive storage device. It can aid decisions via knowledge coupling with expert systems. It can seamlessly link to financial, administrative and other enterprise-wide applications. It uses a common workstation approach. It includes a security system—access control, electronic signatures, auditing. It has 24/7 availability to all users.
4. Level 4: Electronic or Computer-Based Patient Record Systems (CPR). This record subsumes a wider scope of information than today's standard medical record. It can cut across enterprises, and cut across geography. It is enabled to relate with other information systems such as for research, telemedicine, and public health.

5. Level 5: The Electronic Health Record. This record is the most comprehensive. It includes wellness information, non-traditional care, behavioral data, environmental data, and other data that the individual sees as appropriate.

According to Waegemann, Levels 1 and 2 are firmly in place. Level 3 is available today, "off the shelf", and would be considered as state-of-the-art. Shortliffe refers to the current state of the EMR as the "enterprise-wide intranet model". Physicians and other providers can access a wide variety of information, integrated through a workstation. (12).

Future Scope: Internet

Academicians, vendors and other entrepreneurs are rapidly creating new formats via the Internet, thereby making powerful new products for health care delivery. These would fall squarely into Waegemann's Level 4. What are the guideposts on the path to the future, and how might this future be manifest? Developments in 4 general areas will enhance informatics (10):

1. The mark-up languages will improve the process of and sharing of documents stored in archival databases.
2. JAVA and other languages will allow isolation and modularization of applications, thereby giving applications independence across heterogeneous platforms. This means that users can securely explore data on distributed systems, no matter where the users and data are located.
3. Using mark-up languages, digital libraries will see improvements in search capability from keyword searches to thematic searches.

4. Improved statistical inference capabilities will allow extraction of individually applicable data from group data.

Thus, with the Internet, we'll do old things in new ways, and new things in new ways. Cimino proposed several examples (4):

- Increasing access and use of on-line data sources.
- Increasing use of decision support systems and Medical Logic Modules.
- Increasing use of the web for interactive CME.
- Emergence of widespread electronic medical publications will succeed paper based journals.
- Emergence of Internet based consultation and telemedicine systems, as well as new collaborative care paradigms.
- Development of web based standard for EMR entries, such as a Data Entry and Report Markup Language.
- Internet access of the patient to his or her EMR.
- Exchange of secure email between health care providers and patients.

And Shortliffe outlines the vision (12):

> We can envision a world in which the enterprise *intranet*... is seamlessly connected to the full *Internet* beyond, with integrated access to a wide variety of information sources that are geographically distributed well beyond our local institutions. To the extent that an individual's medical records are maintained in a compatible electronic format at all the institutions where they have been seen, the Internet provides the potential of creating 'virtual medical records,' the

electronic compilation of a patients heath data from all the settings in which he or she has (been) seen.

Conclusion

In conclusion, while the scope of health informatics is broad, its focus today is the optimization of the electronic medical record. Its direction tomorrow is the realization of the computer based patient record, and the integration of Internet. Where will this vision lead? Cimino answers this best:

> By nature, it is impossible to predict what new tasks people will solve with the Internet. Some of the examples so far are tantalizing. The emergence of a true multimedia record seems likely. Perhaps clinicians will once again be able to look at all aspects of their patients, including patient's blood smears and x-rays. Perhaps they will be able to see patients for the first time and know what they looked like a year ago, or how they walked, or what their hearts sounded like. In this way, perhaps the computer, which is blamed for taking us away from our patients, can bring us closer. (4).

Disclaimer

The views, findings and opinions expressed herein are those of the author and may not represent those of NASA.

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