Biomedical and Health Informatics

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Chapter 1

Health Information Technology

Health information technology (HIT) provides the umbrella framework to describe the comprehensive management of health information across computerized systems and its secure exchange between consumers, providers, government and quality entities, and insurers. Health information technology (HIT) is in general increasingly viewed as the most promising tool for improving the overall quality, safety and efficiency of the health delivery system. Broad and consistent utilization of HIT will:

- Improve health care quality;
- Prevent medical errors;
- Reduce health care costs;
- Increase administrative efficiencies
- Decrease paperwork; and
- Expand access to affordable care.

Interoperable HIT will improve individual patient care, but it will also bring many public health benefits including:

- Early detection of infectious disease outbreaks around the country;
- Improved tracking of chronic disease management; and
- Evaluation of health care based on value enabled by the collection of de-identified price and quality information that can be compared.

Concepts and Definitions

Health information technology (HIT) is “the application of information processing involving both computer hardware and software that deals with the storage, retrieval, sharing, and use of health care information, data, and knowledge for communication and decision making” (Brailer, & Thompson, 2004). Technology is a broad concept that deals with a species' usage and knowledge of tools and crafts, and how it affects a species' ability to control and adapt to its environment. However, a strict definition is elusive; "technology" can refer to material objects of use to humanity, such as machines, hardware or utensils, but can also encompass broader themes, including systems, methods of organization, and techniques. For HIT, technology represents computers and communications attributes that can be networked to build systems for moving health information. Informatics is yet another integral aspect of HIT.

Informatics refers to the science of information, the practice of information processing, and the engineering of information systems. Informatics underlies the academic investigation and practitioner application of computing and communications technology to healthcare, health education, and biomedical research. Health informatics refers to the intersection of information science, computer science, and health care. Health informatics describes the use and sharing of information within the healthcare industry with contributions from computer science, mathematics, and psychology. It deals with the resources, devices, and methods required for optimizing the acquisition, storage, retrieval, and use of information in health and biomedicine. Health informatics tools include not only computers but also clinical guidelines, formal medical terminologies, and information and communication systems. Medical informatics, nursing informatics, public health informatics, and pharmacy informatics are subdisciplines that inform health informatics from different disciplinary perspectives. The processes and people of concern or study are the main variables.

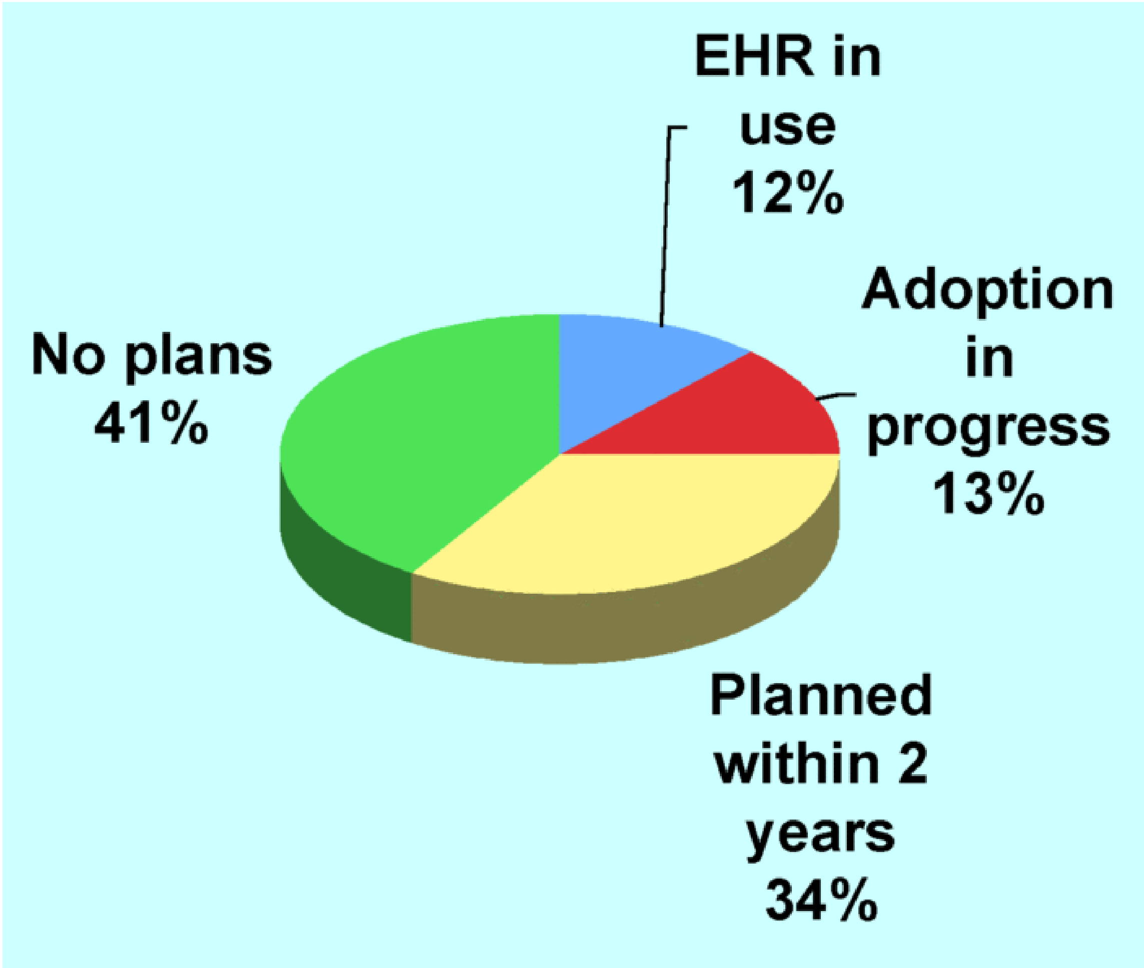
Implementation of HIT

The Institute of Medicine's (2001) call for the use of electronic prescribing systems in all healthcare organizations by 2010 heightened the urgency to accelerate United States hospitals' adoption of CPOE systems. In 2004, President Bush signed an Executive Order titled the President's Health Information Technology Plan, established a ten-year plan as this technology is essential to put the needs and the values of the patients first and gives patients information they need to make clinical and economic decisions. According to a study by RAND Health, the US healthcare system could save more than $81 billion annually, reduce adverse healthcare events and improve the quality of care if it were to widely adopt health information technology. The most immediate barrier to widespread adoption of technology is cost: patients benefit from better health, and payers benefit from lower costs; however, hospitals pay in both higher costs for implementation and lower revenues due to reduced patient length of stay.

Types of technology

In a recent study about the adoption of technology in the United States, Furukawa, and colleagues (2008) classified applications for prescribing to include electronic medical records (EMR), clinical decision support (CDS), and computerized physician order entry (CPOE). They further defined applications for dispensing to include bar-coding at medication dispensing (BarD), robot for medication dispensing (ROBOT), and automated dispensing machines (ADM). And, they defined applications for administration to include electronic medication administration records (EMAR) and bar-coding at medication administration (BarA).

Electronic Health Record (EHR)



US medical groups' adoption of EHR (2005)

Although frequently cited in the literature the **Electronic health record** (EHR), previously known as the Electronic medical record (EMR), there is no consensus about the definition (Jha et al., 2008). However, there is consensus that EMRs can reduce several types of errors, including those related to prescription drugs, to preventive care, and to tests and procedures. Recurring alerts remind clinicians of intervals for preventive care and track referrals and test results. Clinical guidelines for disease management have a demonstrated benefit when accessible within the electronic record during the process of treating the patient. Advances in health informatics and widespread adoption of interoperable electronic health records promise access to a patient's records at any health care site. A 2005 report noted that medical practices in the United States are encountering barriers to adopting an EHR system, such as training, costs and complexity, but the adoption rate continues to rise. Since 2002, the National Health Service of the United Kingdom has placed emphasis on introducing computers into healthcare. As of 2005, one of the largest projects for a national EHR is by the National Health Service (NHS) in the United Kingdom. The goal of the NHS is to have 60,000,000 patients with a centralized electronic health record by 2010. The plan involves a gradual roll-out commencing May

2006, providing general practices in England access to the National Programme for IT (NPfIT), the NHS component of which is known as the "Connecting for Health Programme". However, recent surveys have shown physicians' deficiencies in understanding the patient safety features of the NPfIT-approved software.

Clinical point of care technology

Computerized Provider (Physician) Order Entry (CPOE)

Prescribing errors are the largest identified source of preventable errors in hospitals. A 2006 report by the Institute of Medicine estimated that a hospitalized patient is exposed to a medication error each day of his or her stay. Computerized provider order entry (CPOE), formerly called **Computer physician order entry**, can reduce total medication error rates by 80%, and adverse (serious with harm to patient) errors by 55%. A 2004 survey by Leapfrog found that 16% of US clinics, hospitals and medical practices are expected to be utilizing CPOE within 2 years. In addition to electronic prescribing, a standardized bar code system for dispensing drugs could prevent a quarter of drug errors. Consumer information about the risks of the drugs and improved drug packaging (clear labels, avoiding similar drug names and dosage reminders) are other error-proofing measures. Despite ample evidence of the potential to reduce medication errors, competing systems of barcoding and electronic prescribing have slowed adoption of this technology by doctors and hospitals in the United States, due to concern with interoperability and compliance with future national standards. Such concerns are not inconsequential; standards for electronic prescribing for Medicare Part D conflict with regulations in many US states.

Technological Innovations, Opportunities, and Challenges

Handwritten reports or notes, manual order entry, non-standard abbreviations and poor legibility lead to substantial errors and injuries, according to the Institute of Medicine (2000) report. The follow-up IOM (2004) report, Crossing the quality chasm: A new health system for the 21st century, advised rapid adoption of electronic patient records, electronic medication ordering, with computer- and internet-based information systems to support clinical decisions. However, many system implementations have experienced costly failures (Ammenwerth et al., 2006). Furthermore, there is evidence that CPOE may actually contribute to some types of adverse events and other medical errors.(Campbell et al., 2007) For example, the period immediately following CPOE implementation resulted in significant increases in reported adverse drug events in at least one study (Bradley, Steltenkamp, & Hite, 2006) and evidence of other errors have been reported.(Bates, 2005a; Bates, Leape, Cullen, & Laird, 1998; Bates; 2005b) Collectively, these reported adverse events describe phenomena related to the disruption of the complex adaptive system resulting from poorly implemented or inadequately planned technological innovation.

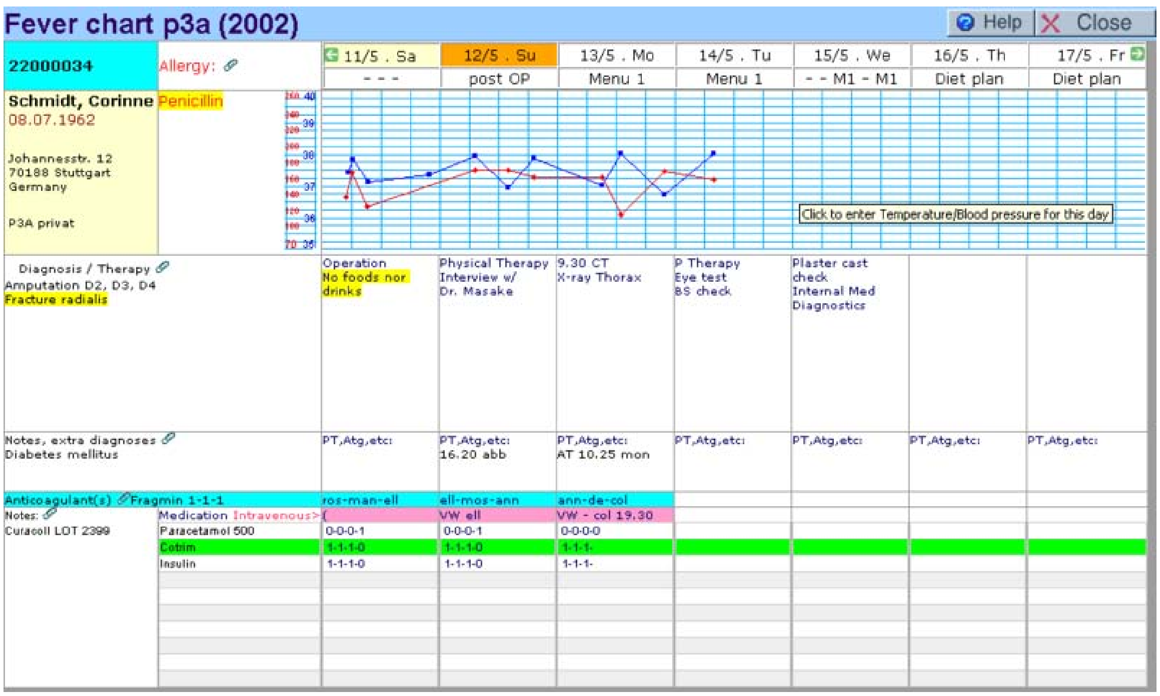
Technological Iatrogenesis

Technology may introduce new sources of error Technologically induced errors are significant and increasingly more evident in care delivery systems. Terms to describe this new area of error production include the label technological iatrogenesis for the process and e-iatrogenic for the individual error. The sources for these errors include:

- Prescriber and staff inexperience may lead to a false sense of security; that when technology suggests a course of action, errors are avoided.
- Shortcut or default selections can override non-standard medication regimens for elderly or underweight patients, resulting in toxic doses.
- CPOE and automated drug dispensing was identified as a cause of error by 84% of over 500 health care facilities participating in a surveillance system by the United States Pharmacopoeia.
- Irrelevant or frequent warnings can interrupt work flow.

Chapter 2

Health Informatics



Electronic patient chart from a health information system

Health informatics (also called **health care informatics**, **healthcare informatics**, **medical informatics**, **nursing informatics**, or **biomedical informatics**) is a discipline at the intersection of information science, computer science, and health care. It deals with the resources, devices, and methods required to optimize the acquisition, storage, retrieval, and use of information in health and biomedicine. Health informatics tools include not only computers but also clinical guidelines, formal medical terminologies, and information and communication systems. It is applied to the areas of nursing, clinical care, dentistry, pharmacy, public health, occupational therapy, and (bio)medical research.

Aspects of the field

- architectures for electronic medical records and other health information systems used for billing, scheduling, and research

- decision support systems in healthcare, including clinical decision support systems and information workflows
- standards (e.g. DICOM, HL7) and integration profiles (e.g. Integrating the Healthcare Enterprise) to facilitate the exchange of information between healthcare information systems—these specifically define the *means* to exchange data, not the content
- controlled medical vocabularies (CMVs) such as the Systematized Nomenclature of Medicine, Clinical Terms (SNOMED CT), MEDCIN, Logical Observation Identifiers Names and Codes (LOINC), OpenGALEN Common Reference Model or the highly complex UMLS—used to allow a standard, accurate exchange of data content between systems and providers
- use of hand-held or portable devices to assist providers with data entry/retrieval or medical decision-making, sometimes called mHealth.
- The international standards on the subject are covered by ICS 35.240.80 in which ISO 27799:2008 is one of the core components.
- Molecular bioinformatics and clinical informatics have converged into the field of translational bioinformatics.

History

Informatics were a central part of the Nazi health care system, which included Nazi eugenics as one of it's fundamental principles. New systems and technology, like electronic punch card tabulating and sorting machines, and the science of medical statistics, were used to gather, sort, and analyze personal information on a vast scale unseen before in human history. The information was used to help find and eliminate the 'genetically inferior' through sterilization or wholesale murder. Many of the architects of these systems would go on to play a role in the post-war medical informatics field.

World wide use of technology in medicine began in the early 1950s with the rise of the computers. In 1949, Gustav Wager established the first professional organization for informatics in Germany. The prehistory, history, and future of medical information and health information technology are discussed in reference. Specialized university departments and Informatics training programs began during the 1960s in France, Germany, Belgium and The Netherlands. Medical informatics research units began to appear during the 1970s in Poland and in the U.S. Since then the development of high-quality health informatics research, education and infrastructure has been the goal of the U.S. and the European Union.

Early names for health informatics included medical computing, medical computer science, computer medicine, medical electronic data processing, medical automatic data processing, medical information processing, medical information science, medical software engineering, and medical computer technology.

The health informatics community is still growing, it is by no means a mature profession, but work in the UK by the voluntary registration body, the UK Council of Health Informatics Professions has suggested eight key constituencies within the domain -

information management, knowledge management, portfolio/programme/project management, ICT, education and research, clinical informatics, health records(service and business-related), health informatics service management. These constituencies accommodate professionals in and for the NHS, in academia and commercial service and solution providers.

Since the 1970s the most prominent international coordinating body has been the International Medical Informatics Association (IMIA).

Medical informatics in the United States

Even though the idea of using computers in medicine sprouted as technology advanced in the early twentieth century, it was not until the 1950s that informatics made a realistic impact in the United States.

The earliest use of computation for medicine was for dental projects in the 1950s at the United States National Bureau of Standards by Robert Ledley.

The next step in the mid 1950s were the development of expert systems such as MYCIN and Internist-I. In 1965, the National Library of Medicine started to use MEDLINE and MEDLARS. At this time, Neil Pappalardo, Curtis Marble, and Robert Greenes developed MUMPS (Massachusetts General Hospital Utility Multi-Programming System) in Octo Barnett's Laboratory of Computer Science at Massachusetts General Hospital in Boston. In the 1970s and 1980s it was the most commonly used programming language for clinical applications. The MUMPS operating system was used to support MUMPS language specifications. As of 2004, a descendent of this system is being used in the United States Veterans Affairs hospital system. The VA has the largest enterprise-wide health information system that includes an electronic medical record, known as the Veterans Health Information Systems and Technology Architecture (VistA). A graphical user interface known as the Computerized Patient Record System (CPRS) allows health care providers to review and update a patient's electronic medical record at any of the VA's over 1,000 health care facilities.

In the 1970s a growing number of commercial vendors began to market practice management and electronic medical records systems. Although many products exist, only a small number of health practitioners use fully featured electronic health care records systems.

Homer R. Warner, one of the fathers of medical informatics, founded the Department of Medical Informatics at the University of Utah in 1968. The American Medical Informatics Association (AMIA) has an award named after him on application of informatics to medicine.

Current state of health informatics and policy initiatives

Argentina

Since 1997, the Buenos Aires Biomedical Informatics Group, a nonprofit group, represents the interests of a broad range of clinical and non-clinical professionals working within the Health Informatics sphere. Its purposes are:

- Promote the implementation of the computer tool in the healthcare activity, scientific research, health administration and in all areas related to health sciences and biomedical research.
- Support, promote and disseminate content related activities with the management of health information and tools they used to do under the name of Biomedical informatics.
- Promote cooperation and exchange of actions generated in the field of biomedical informatics, both in the public and private, national and international level.
- Interact with all scientists, recognized academic stimulating the creation of new instances that have the same goal and be inspired by the same purpose.
- To promote, organize, sponsor and participate in events and activities for training in computer and information and disseminating developments in this area that might be useful for team members and health related activities.

The Argentinian health system is very heterogeneous, because of that the informatics developments shows an heterogeneous stage. Lot of private Health Care center has develop system, as the German Hospital of Buenos Aires who was one of the first in develop the electronic health records system.

Brazil

The first applications of computers to medicine and healthcare in Brazil started around 1968, with the installation of the first mainframes in public university hospitals, and the use of programmable calculators in scientific research applications. Minicomputers, such as the IBM 1130 were installed in several universities, and the first applications were developed for them, such as the hospital census in the School of Medicine of Ribeirão Preto and patient master files, in the Hospital das Clínicas da Universidade de São Paulo, respectively at the cities of Ribeirão Preto and São Paulo campi of the University of São Paulo. In the 1970s, several Digital Corporation and Hewlett Packard minicomputers were acquired for public and Armed Forces hospitals, and more intensively used for intensive-care unit, cardiology diagnostics, patient monitoring amd other applications. In the early 1980s, with the arrival of cheaper microcomputers, a great upsurge of computer applications in health ensued, and in 1986 the Brazilian Society of Health Informatics was founded, the first Brazilian Congress of Health Informatics was held, and the first *Brazilian Journal of Health Informatics* was published.

Canada

Health Informatics projects in Canada are implemented provincially, with different provinces creating different systems. A national, federally-funded, not-for-profit organization called Canada Health Infoway was created in 2001 to foster the development and adoption of electronic health records across Canada. As of December 31, 2008 there were 276 EHR projects under way in Canadian hospitals, other health-care facilities, pharmacies and laboratories, with an investment value of $1.5-billion from Canada Health Infoway.

Provincial and territorial programmes include the following:

- **eHealth Ontario** was created as an Ontario provincial government agency in September 2008. It has been plagued by delays and its CEO was fired over a multimillion-dollar contracts scandal in 2009.
- **Alberta Netcare** was created in 2003 by the Government of Alberta. Today the netCARE portal is used daily by thousands of clinicians. It provides access to demographic data, prescribed/dispensed drugs, known allergies/intolerances, immunizations, laboratory test results, diagnostic imaging reports, the diabetes registry and other medical reports. netCARE interface capabilities are being included in electronic medical record products which are being funded by the provincial government.

United States

In 2004 the U.S. Department of Health and Human Services (HHS) formed the Office of the National Coordinator for Health Information Technology (ONCHIT). The mission of this office is widespread adoption of interoperable electronic health records (EHRs) in the US within 10 years.

The Certification Commission for Healthcare Information Technology (CCHIT), a private nonprofit group, was funded in 2005 by the U.S. Department of Health and Human Services to develop a set of standards for electronic health records (EHR) and supporting networks, and certify vendors who meet them. In July, 2006 CCHIT released its first list of 22 certified ambulatory EHR products, in two different announcements.

Europe

The European Union's Member States are committed to sharing their best practices and experiences to create a European eHealth Area, thereby improving access to and quality health care at the same time as stimulating growth in a promising new industrial sector. The European eHealth Action Plan plays a fundamental role in the European Union's strategy. Work on this initiative involves a collaborative approach among several parts of the Commission services. The European Institute for Health Records is involved in the promotion of high quality electronic health record systems in the European Union.

The NHS in England has contracted out to several vendors for a national health informatics system 'NPFIT' that originally divided the country into five regions and is to be united by a central electronic medical record system nicknamed "the spine". The project, in 2010, is seriously behind schedule and its scope and design are being revised in real time. In 2010 a wide consultation was launched as part of a wider ‘Liberating the NHS’ plan. Many organisations and bodies (look on their own websites, as most have made their responses public in detail for information) responded to the consultation and a new strategy is expected in the second quarter of 2011. The degree of computerisation in NHS secondary care was quite high before NPfIT and that programme has had the unfortunate effect of largely stalling further development of the installed base. Almost all general practices in England and Wales are computerised and patients have relatively extensive computerised primary care clinical records. Computerisation is the responsibility of individual practices and there is no single, standardised GP system. Interoperation between primary and secondary care systems is rather primitive. A focus on interworking (for interfacing and integration) standards is hoped will stimulate synergy between primary and secondary care in sharing necessary information to support the care of individuals. Scotland has an approach to central connection under way which is more advanced than the English one in some ways. Scotland has the GPASS system whose source code is owned by the State, and controlled and developed by NHS Scotland. GPASS was accepted in 1984. It has been provided free to all GPs in Scotland but has developed poorly. Discussion of open sourcing it as a remedy is occurring. The broad history of health informatics has been captured in the book UK Health Computing : Recollections and reflections, Hayes G, Barnett D (Eds.), BCS (May 2008) by those active in the field, predominantly members of BCS Health and its constituent groups. The book describes the path taken as ‘early development of health informatics was unorganized and idiosyncratic’. In the early -1950s it was prompted by those involved in NHS finance and only in the early 1960s did solutions including those in pathology (1960), radiotherapy (1962), immunization ((1963), and primary care (1968) emerge. Many of these solutions, even in the early 1970s were developed in-house by pioneers in the field to meet their own requirements. In part this was due to some areas of health services (for example the immunization and vaccination of children) still being provided by Local Authorities. Interesting, this is a situation which the coalition government propose broadly to return to in the 2010 strategy Equity and Excellence: Liberating the NHS (July 2010); stating:

"We will put patients at the heart of the NHS, through an information revolution and greater choice and control’ with shared decision-making becoming the norm: ‘no decision about me without me’ and patients having access to the information they want, to make choices about their care. They will have increased control over their own care records."

These types of statements present a significant opportunity for health informaticians to come out of the back-office and take up a front-line role supporting clinical practice, and the business of care delivery. The UK health informatics community has long played a key role in international activity, joining TC4 of the International Federation of Information Processing (1969) which became IMIA (1979). Under the aegis of BCS

Health, Cambridge was the host for the first EFMI Medical Informatics Europe (1974) conference and London was the location for IMIA's tenth global congress (MEDINFO2001). In 2002, the idea of a profession of health informatics across the UK was first mooted and by 2004 a voluntary open register was established. The UK Council for Health Informatics Professions (UKCHIP) now has a formal Code of Professional Conduct, standards for expressing competences which are used for entry, confirmation of fitness to practice, re-grading and personal development. Consistent standards express competences of health informatics professionals in both domain-specific and generic informatics professional areas. The consistency is intended to apply in operational care delivery organizations, academia and the commercial service and solution providers. In 2011, self-assessment tools were introduced for use by any interested party. In addition, the principles and UKCHIP model are being considered internationally (as at 2011). UKCHIP certification is being considered for regulatory purposes. In conjunction with workforce development tools such as the NHS HI Career Framework it is possible for individuals to compare their skills against typical job roles, determine their professional level, and for employers to carry out detailed workforce analysis to meet the emerging requirements of the informatics strategies of all the home countries.

The European Commission's preference, as exemplified in the 5th Framework as well as currently pursued pilot projects, is for Free/Libre and Open Source Software (FLOSS) for healthcare.

Asia and Oceania

In Asia and Australia-New Zealand, the regional group called the Asia Pacific Association for Medical Informatics (APAMI) was established in 1994 and now consists of more than 15 member regions in the Asia Pacific Region.

Australia

The Australasian College of Health Informatics (ACHI) is the professional association for health informatics in the Asia-Pacific region. It represents the interests of a broad range of clinical and non-clinical professionals working within the health informatics sphere through a commitment to quality, standards and ethical practice. Founded in 2002, ACHI is increasingly valued for its thought leadership, its trusted advisors and national and international experts in Health Informatics. ACHI is an academic institutional member of the International Medical Informatics Association (IMIA) and a full member of the Australian Council of Professions. ACHI is a sponsor of the "e-Journal for Health Informatics", an indexed and peer-reviewed professional journal. ACHI has also supported the "Australian Health Informatics Education Council" (AHIEC) since its founding in 2009.

Although there are a number of health informatics organisations in Australia, the Health Informatics Society of Australia (HISA) is regarded as the major umbrella group and is a member of the International Medical Informatics Association (IMIA). Nursing informaticians were the driving force behind the formation of HISA, which is now a company limited by guarantee of the members. The membership comes from across the informatics spectrum that is from students to corporate affiliates. HISA has a number of branches (Queensland, New South Wales, Victoria and Western Australia) as well as special interest groups such as nursing (NIA), pathology, aged and community care, industry and medical imaging (Conrick, 2006).

Hong Kong

In Hong Kong a computerized patient record system called the Clinical Management System (CMS) has been developed by the Hospital Authority since 1994. This system has been deployed at all the sites of the Authority (40 hospitals and 120 clinics), and is used by all 30,000 clinical staff on a daily basis, with a daily transaction of up to 2 millions. The comprehensive records of 7 million patients are available on-line in the Electronic Patient Record (ePR), with data integrated from all sites. Since 2004 radiology image viewing has been added to the ePR, with radiography images from any HA site being available as part of the ePR.

The Hong Kong Hospital Authority placed particular attention to the governance of clinical systems development, with input from hundreds of clinicians being incorporated through a structured process. The Health Informatics Section in Hong Kong Hospital Authority has close relationship with Information Technology Department and clinicians to develop healthcare systems for the organization to support the service to all public hospitals and clinics in the region.

The Hong Kong Society of Medical Informatics (HKSMI) was established in 1987 to promote the use of information technology in healthcare. The eHealth Consortium has been formed to bring together clinicians from both the private and public sectors, medical informatics professionals and the IT industry to further promote IT in healthcare in Hong Kong.

India

Religare Technova IT solutions is attempting a new service to improve the healthcare information system in India

New Zealand

Health Informatics is taught at five New Zealand universities. The most mature and established is the Otago programme which has been offered for over a decade. Health Informatics New Zealand (HINZ) is the national organisation that advocates for Health Informatics.

Saudi Arabia

The Saudi Association for Health Information (SAHI) was established in 2006 to work under direct supervision of King Saud University for Health Sciences to practice public activities, develop theoretical and applicable knowledge, and provide scientific and applicable studies.

Health informatics law

Health informatics law deals with evolving and sometimes complex legal principles as they apply to information technology in health-related fields. It addresses the privacy, ethical and operational issues that invariably arise when electronic tools, information and media are used in health care delivery. Health Informatics Law also applies to all matters that involve information technology, health care and the interaction of information. It deals with the circumstances under which data and records are shared with other fields or areas that support and enhance patient care.

Clinical Informatics

Clinical Informatics is concerned with use information in health care by clinicians.

Clinical informaticians transform health care by analyzing, designing, implementing, and evaluating information and communication systems that enhance individual and population health outcomes, improve [patient] care, and strengthen the clinician-patient relationship. Clinical informaticians use their knowledge of patient care combined with their understanding of informatics concepts, methods, and health informatics tools to:

- assess information and knowledge needs of health care professionals and patients,
- characterize, evaluate, and refine clinical processes,
- develop, implement, and refine clinical decision support systems, and
- lead or participate in the procurement, customization, development, implementation, management, evaluation, and continuous improvement of clinical information systems.

Clinicians collaborate with other health care and information technology professionals to develop health informatics tools which promote patient care that is safe, efficient, effective, timely, patient-centered, and equitable.

Translational bioinformatics

With the completion of the human genome and the recent advent of high throughput sequencing and genome-wise association studies of single nucleotide polymorphisms, the fields of molecular bioinformatics, biostatistiques, statistical genetics and clinical informatics are converging into the emerging field of translational bioinformatics.

Chapter 3

Health information Exchange & Health Administration Informatics

Health information Exchange

Health information exchange (HIE) is defined as the mobilization of healthcare information electronically across organizations within a region, community or hospital system.

HIE provides the capability to electronically move clinical information among disparate health care information systems while maintaining the meaning of the information being exchanged. The goal of HIE is to facilitate access to and retrieval of clinical data to provide safer, more timely, efficient, effective, equitable, patient-centered care. HIE is also useful to Public Health authorities to assist in analyses of the health of the population.

HIE systems facilitate physicians and clinicians meeting high standards of patient care through electronic participation in a patient's continuity of care with multiple providers. Secondary health care provider benefits include reduced expenses associated with: duplicate tests, time involved in recovering missing patient information, paper, ink and associated office machinery, manual printing, scanning and faxing of documents, the physical mailing of entire patient charts, and manual phone communication to verify delivery of traditional communications, referrals and test results. According to an internal study at Sushoo Health Information Exchange, a single-clinician practice spends $17,160/year associated with the current method of exchanging patients' health information.

Formal organizations are now emerging to provide both form and function for health information exchange efforts, both on independent and governmental/regional levels. These organizations are, in many cases, enabled and supported financially by statewide health information exchange grants from the Office of the National Coordinator for Health Information Technology. These grants were legislated into the HITECH components of the American Reinvestment and Recovery Act in 2009. The latter organizations (often called Regional Health Information Organizations, or RHIOs) are ordinarily geographically-defined entities which develop and manage a set of contractual conventions and terms, arrange for the means of electronic exchange of information, and develop and maintain HIE standards.

In the United States, federal and state regulations regarding HIEs and HIT (health information technology) are still being defined. Federal regulations such as "Meaningful Use" legislation as well as the implementation of some state governments of state-sponsored HIEs (such as the North Carolina HIE) in addition to fluctuating health care regulations among the states are rapidly changing the face of this relatively new industry. HIEs and RHIOs continue to struggle to achieve self-sustainability and the vast majority remain tied to Federal, State, or Independent grant funding in order to remain operational; with some exceptions such as the Indiana HIE.

Established HIE Communities

- Chesapeake Regional Information System for our Patients (CRISP):

Chesapeake Regional Information System for our Patients (CRISP) is a non-profit corporation that is implementing health information exchange in the state of Maryland. The organization also serves as the Health IT Extention Center for Maryland. CRISP was created by Johns Hopkins Medicine, MedStar Health, the University of Maryland Medical System and Erickson Retirement Communities. Audacious Inquiry serves as program director and technical architect for the health information exchange under CRISP.

- Northern Virginia Regional Health Information Organization (NoVA RHIO):

NoVA RHIO serves as the health information exchange organization for northern Virginia. The NOVA RHIO organization recently began a pilot to ensure that electonic copies of patient medication histories are available from Pharmacies in the region's emergency departments.

- e-Health Network of Long Island (EHNLI):

e-Health Network of Long Island is a non-profit RHIO servicing eastern Nassau county and all of Suffolk County in Long Island, New York. Members of the EHNLI include Stony Brook University Medical Center, Winthrop-University Hospital, Southampton Hospital, and other various hospitals, adult long-term care facilities, and community physicians. HealthUnity is the primary technology provider. EHNLI's headquarters are located in Stony Brook, NY.

- Southern Tier HealthLink NY (STHL):

STHL is a non-profit New York RHIO designed as a partnership which brings together health care providers and consumers in Central New York with technology that will improve health care quality, access, and safety while reducing costs.

- Sushoo Health Information Exchange:

Sushoo is an independent HIE operating on the community level in multiple states.

- OpenHRE Community:

The OpenHRE Community is a consortium of communities and organizations throughout the United States that are working together to achieve secure and sustainable health information exchange via utilization of the OpenHRE Toolkit, an open source software suite originally developed by Browsersoft, Inc. OpenHRE was used to deploy the Nation's first Multiple Health Market Health Information Exchange between Indianapolis, Boston and Mendocino CA.

- Health Monitoring Systems:

Health Monitoring Systems is a private firm that connects hundreds of hospitals to public health departments throughout the United States primarily for the sake of syndromic surveillance. Public health and hospital users are able to see regional emergency department activity.

- LIPIX - Long Island Patient Information Exchange:

An independent, not-for-profit corporation established to develop a Regional Health Information Organization (RHIO) for Nassau county in Long Island, NY. Headquartered in Manhasset, NY.

- Healthcare Access San Antonio (HASA):

A health care consortium and OpenHRE Community Contributor serving the medically uninsured in Bexar County, TX. HASA participants include the seven major safety net hospitals, City of San Antonio Metropolitan Health District (Immunization Data) and a network of community FQHCs serving the uninsured of San Antonio. The SecureShare centralized community repository contains demographic and clinical records for over 500,000 uninsured patients.

- CareSpark:

CareSpark is an innovative effort underway in the central Appalachian region that is working to improve health through the collaborative use of health information. The CareSpark region includes 17 counties in the Tri-Cities Tennessee and Virginia area with approximately 750,000 residents, 21 hospitals, and 1,200 physicians.

- Eastern Kern County Information Technology Association (EKCITA):

A rural community based 501.c3 not-for-profit corporation and OpenHRE Contributor in Southern California. EKCITA has enabled sharing of electronic health files and clinical data for public health, patient care, and research purposes. The EKCITA deployment provides community caregivers access to over 32,000 local patient health profiles.

- Bayou Teche Community Health Network (ByNet, Franklin LA.):

A non-profit, rural health network and OpenHRE Contributor comprising community health centers, local and regional hospitals and FQHCs, a social service agency, a tribal health clinic, a regional State of Louisiana Office of Public Health, and a coalition of over seventy St. Mary Parish organizations. The ByNet centralized repository contains demographic and clinical records that will exceed 100,000 patients.

- Medical Information Network - North Sound: The Medical Information Network - North Sound is a Washington state-based HIE consisting of three members: Skagit Valley Hospital, Island Hospital, and United General Hospital.

- Kansas Health and Environment (KDHE) Diabetes Quality of Care Project:

The Kansas Diabetes Quality of Care Project involves over 68 funded organizations at 90 provider sites across the State of Kansas. This effort has electronically connected many of these sites to allow the collection and analysis of patient diabetes data by KDHE personnel for improving quality of care. Over 350 health professionals participate in this program with representation from over 50% of Kansas' counties. KDHE is an OpenHRE Contributor.

- Big Bend RHIO:

The BBRHIO is a 501.c3 not for profit Florida Corporation that aims to deliver an enhanced level of patient centered care. Headquartered in Tallahassee, Florida.

- HealthBridge:

Southwest Ohio, North Central Kentucky and South Eastern Indiana Regions.

- Indiana Health Information Exchange:

The Indiana Health Information Exchange (IHIE) provides several health information exchange services throughout the state of Indiana. IHIE provides a clinical messaging result delivery service and a clinical quality improvement services called Quality Health First(tm)

- MA-SHARE:

Massachusetts SHARE (Simplifying Healthcare Among Regional Entities) is a regional collaborative initiative operated by the Massachusetts Health Data Consortium. In June, 2009, MA-SHARE merged with the New England Healthcare Exchange Network.

- New England Healthcare Exchange Network (NEHEN):

NEHEN, headquartered in Waltham, MA is a 501.c3 organization with more than thirty five member organizations and founded in 1998. Initially focused on payor/provider information exchange, after the merger with MA-SHARE, NEHEN now offers electronic prescribing support and clinical information exchange to its members as well as healthcare administrative transaction support.

- Redwood MedNet HIE:

Redwood MedNet, located in Mendocino County, California, is a community based nonprofit 501(c)(3) organization operating a clinical results delivery service in a thinly populated 5,000-square-mile (13,000 km^2) rural region on the north Pacific coast.

- The MidSouth eHealth Alliance:

The MidSouth eHealth Alliance is a community wide information system that helps health care providers in the treatment of patients. Providers are as doctors, nurses, healthcare workers, hospitals, and clinics. The MidSouth eHealth Alliance is based in Memphis, TN.

- Michiana Health Information Network:

The Michiana Health Information Network is a health information exchange that support institutions and health care providers and clinicians in northern Indiana and southwestern Michigan.

- University of Pittsburgh Medical Center:

UPMC is an integrated healthcare delivery network that provides healthcare services to a large portion of the population in Western Pennsylvania. Incorporating an HIE solution has enabled the integration of patient data across the enterprise in addition to the flexibility of the creation and rapid deployment of enterprise wide applications that leverage integrated patient data.

- Clalit Health Services / Rambam Medical Center / Sheba Medical Center:

Covering more than half of Israel’s population, this HIE has been operational since 2001. The HIE includes 16 hospitals (8100+ beds), 1300 primary and specialized clinics and 400 pharmacies, and collectively provides health services to close to over 5 million patients.

- Wisconsin Health Information Exchange
- WHIN - Western Health Information Network:

WHIN - Western Health Information Network (formerly Long Beach Network for Health) Is an independent, community based not-for-profit corporation operating a regional Health Information Exchange for Southern California. Headquartered in Long Beach, CA.

- MedVirginia:

MedVirginia Solution® is an HIE serving central Virginia.

- US Government Agencies - VA and DoD:

The U.S. Department of Veteran's Affairs and the Department of Defense have several very large health information exchange projects including FHIE, BHIE, CHDR, and VLER.

Health Administration Informatics

The emerging field of **Health administration informatics** is concerned with the evaluation, acquisition, implementation and day to day operation of information technology systems in support of all administration and clinical functions within the health care industry. The closely-related field of biomedical informatics is primarily focused on the use of information systems for acquisition and application of patients' medical data, whereas nursing informatics deals with the delivery, administration and evaluation of patient care and disease prevention. What remains unclear, however, is how this emerging discipline should relate to the myriad of previously existing sub specializations within the broad umbrella of health informatics - including clinical informatics (which itself includes sub areas such as oncology informatics), bioinformatics and healthcare management informatics - particularly in light of the proposed "fundamental theorem" of biomedical informatics posed by Friedman in early 2009.

The field of health administration informatics is emerging as attention continues to focus on the costly mistakes made by some health care organizations whilst implementing electronic medical records.

Relevance within the health care industry

In a recent survey of health care CIOs and Information System (IS) directors, increasing patient safety and reducing medical errors was reported as among the top business issues. Two other key findings were that:

- two-thirds of respondents indicated that the number of FTEs in their IT department will increase in the next 12 months;

- and three-quarters of respondents indicated that their IT budgets would be increasing.

The most likely staffing needs reported by the health care executives are network and architecture support (HIMMS, 2005).

“The government and private insurers are beginning to pay hospitals more for higher quality care–and the only way to measure quality, and then improve it, is with more information technology. Hospital spending on such gear is expected to climb to $30.5 billion next year, from $25.8 billion in 2004, according to researcher Dorenfest Group” (Mullaney and Weintraub, 2005).

This fundamental change in health care (pay for performance) means that hospitals and other health care providers will need to develop, adapt and maintain all of the technology necessary to measure and improve on quality. Physicians have traditionally lagged behind in their use of technology (i.e., electronic patient records). Only 7% of physicians work for hospitals, and so the task of “wooing them is an extremely delicate task” (Mullaney and Weintraub, 2005).

Careers

The market demand for a specialized advanced degree that integrates Health Care Administration and Informatics is growing as the concept has gained support from the academic and professional communities. Recent articles in Health Management Technology cite the importance of integrating information technology with health care administration to meet the unique needs of the health care industry. The health care industry has been estimated to be around 10 years behind other industries in the application of technology and at least 10 to 15 years behind in leadership capability from the technology and perhaps the business perspective (Seliger, 2005; Thibault, 2005). This means there is quantifiable demand in the work force for health care administrators who are also prepared to lead in the field of health care administration informatics.

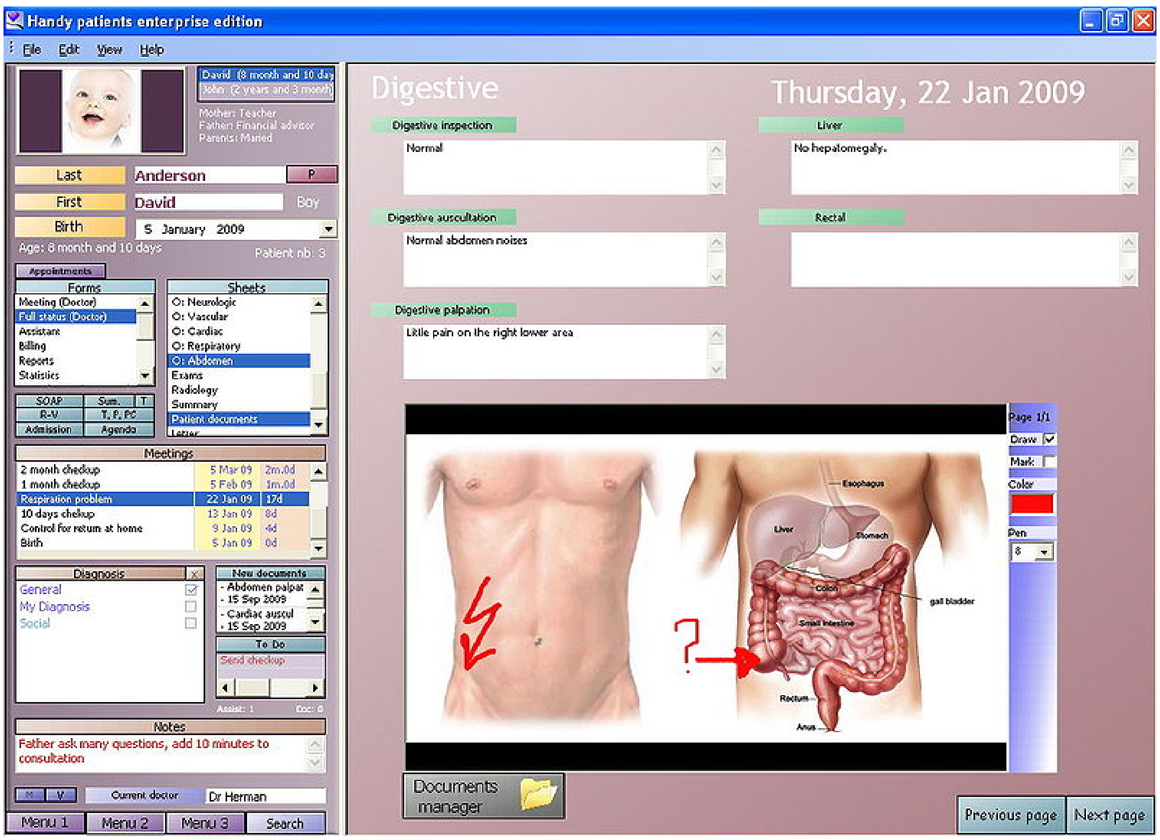
In addition, the increasing costs and difficulties involved in evaluating the projected benefits from IT investments are requiring health care administrators to learn more about IT and how it affects business processes. The health care Chief Information Officer (CIO) must be able to build enterprise wide systems that will help reduce the administrative cost and streamline the automation of administrative processes and patient record keeping. Increasingly, the CIO is relied upon for specialized analytical and collaborative skills that will enable him/her to build systems that health care clinicians will use. A recent well-publicized debacle (shelving of a $34 million computer system after three months) at a top U. S. hospital underlines the need for leaders who understand the health care industry information technology requirements (Connolly, 2005).

Several professional organizations have also addressed the need for academic preparation that integrates the two specializations addressed by UMUC’s MSHCAI degree. In the collaborative response to the Office of the National Coordinator for Health Information

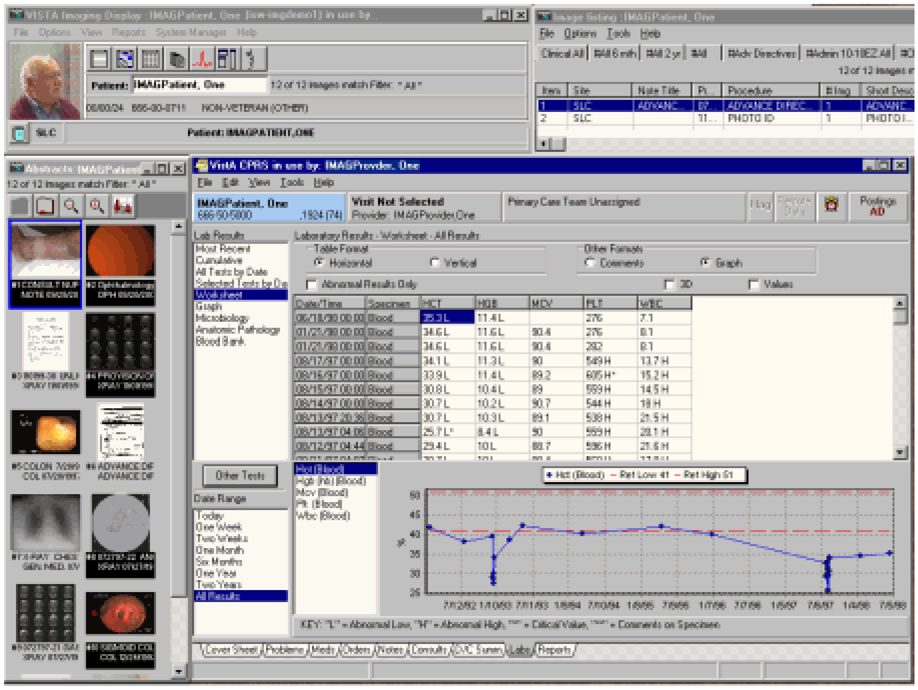
Technology (ONCHIT) request for information regarding future IT needs, thirteen major health and technology organizations endorsed a “Common Framework” to support health information exchange in the United States, while protecting patient privacy. The response cited the need for continuing education of health information management professionals as a significant barrier to implementation of a National Health Information Network (NHIN) (The Collaborative Response, 2005).

Chapter 4

Electronic Health Record



Sample view of an electronic health record



Sample view of an electronic health record based on images

An **electronic health record (EHR)** (also **electronic patient record** (EPR) or **computerised patient record**) is an evolving concept defined as a systematic collection of electronic health information about individual patients or populations. It is a record in digital format that is capable of being shared across different health care settings, by being embedded in network-connected enterprise-wide information systems. Such records may include a whole range of data in comprehensive or summary form, including demographics, medical history, medication and allergies, immunization status, laboratory test results, radiology images, vital signs, personal stats like age and weight, and billing information.

Its purpose can be understood as a complete record of patient encounters that allows the automation and streamlining of the workflow in health care settings and increases safety through evidence-based decision support, quality management, and outcomes reporting.

Terminology

The terms EHR, EPR and EMR (electronic medical record) are often used interchangeably, although a difference between them can be defined. The EMR can be defined as the legal patient record created in hospitals and ambulatory environments that is the data source for the EHR. It is important to note that an EHR is generated and maintained within an institution, such as a hospital, integrated delivery network, clinic, or physician office, to give patients, physicians and other health care providers, employers, and payers or insurers access to a patient's medical records across facilities.

A personal health record is, in modern parlance, generally defined as an EHR that the individual patient controls.

Philosophical views of the EHR

Within a meta-narrative systematic review of research in the field, Prof. Trish Greenhalgh and colleagues defined a number of different philosophical approaches to the EHR. The health information systems literature has seen the EHR as a container holding information about the patient, and a tool for aggregating clinical data for secondary uses (billing, audit *etc.*). However, other research traditions seen the EHR as a contextualised artefact within a socio-technical system. For example, actor-network theory would see the EHR as an actant in a network (*e.g.*), while research in computer supported cooperative work (CSCW) sees the EHR as a tool supporting particular work. Prof. Barry Robson and OK Baek also reviewed these aspects and see the EHR as pivotal in human history.

History

Although many think the creation and use of Medical record is very modern and associated early use of computer, some sources indicate that medical record was first developed by Hippocrates, in the fifth century B.C. for two goals: to accurately reflect the course of disease and indicate the probable cause of disease. These goals are still appropriate, but electronic health records systems can also provide additional functionality, such as interactive alerts to clinicians, interactive flow sheets, and tailored order sets, all of which can not be done with paper-based systems. Because of these advantages starting late 1960s many universities in the United States started developing different software to help capturing and maintaining EHR. For example, in the 1960s, Dr. Lawrence Weed proposed a type of electronic medical record system that he called a problem-oriented medical record. His idea was to integrate the medical information of patients from different physicians to be able to provide better health care. In the mid 1980s, IOM initiated a study to be conducted to improve the healthcare delivery because of the unhappiness with the paper medical record. In 1991 this study titled "The computer-based Patient Record: An essential Technology for Health Care." was released. This study has a landmark effect on the advancement of EHR. This study alone did not play much role in the advancement of electronic health record as expected so the IOM conducted more studies to come up with more recommendations and find out what the obstacle were. In 1999, a landmark work called To Err is Human that was a wake-up call was released. This study highlighted 44,000-98.000 people die in the United States because of medical errors. Some of these death happened because of unreadable physician handwriting that could be easily prevented by using EHR.

Advantages

Several possible advantages to EHRs over paper records have been proposed, but there is debate about the degree to which these are achieved in practice (*e.g.*).

Reduction of cost

In the U.S. a vast amount of funds are allocated towards the health care industry—more than $1.7 trillion per year. If savings are allocated using the current level of spending from the National Health Accounts, Medicare would receive about $23 billion of the potential savings per year, and private payers would receive $31 billion per year.

Improve quality of care

The implementation of electronic health records (EHR) can help lessen patient sufferance due to medical errors and the inability of analysts to assess quality. Information Technology is being used today to automate day-to-day processes, thus helping to reduce administration costs which then in turn can free up time and money for patient care.

EHR systems can help reduce medical errors by providing healthcare workers with decision support. Fast access to medical literature and current best practices in medicine are hypothesised to enable proliferation of ongoing improvements in healthcare efficacy.Improved usage of EHR is achieved if the presentation on screen or on paper is not just longitudinal, but hierarchically ordered and layered. During compilation while hospitalisation or ambulant serving of the patient, easing to get access on details is improved with browser capabilities applied to screen presentations also cross referring to the respective coding concepts ICD, DRG and medical procedures information.

Computerized Physician Order Entry (CPOE)—one component of EHR—increases patient safety by listing instructions for physicians to follow when they prescribe drugs to patients. Naturally, CPOE can tremendously decrease medical errors: CPOE could eliminate 200,000 adverse drug events and save about $1 billion per year if installed in all hospitals.

Promote evidence-based medicine

EHRs provide access to unprecedented amounts of clinical data for research that can accelerate the level of knowledge of effective medical practices.

Realistically, these benefits may only be realized if the EHR systems are interoperable and wide spread (for example, national or regional level) so that various systems can easily share information. Also, to avoid failures that can cause injury to the patient and violations to privacy, the best practices in software engineering and medical informatics must be deployed.

Record keeping and mobility

EHR systems have the advantages of being able to connect to many electronic medical record systems. In the current global medical environment, patients are shopping for their procedures. Many international patients travel to US cities with academic research centers for specialty treatment or to participate in Clinical Trials. Coordinating these appointments via paper records is a time-consuming procedure.It is also easier to check in their records whether a patient as been admitted to such a medical centre or if they have any allergies since they have been admitted **before**.

Disadvantages

Critics point out that while EHRs may save the "health system" money, physicians, those who buy the systems, may not benefit financially. EHR price tags range widely, depending on what's included, how robust the system is, and how many providers use it. Asked what they paid in an online survey, about a third of respondents paid between $500 and $3,000 per physician. A third paid between $3,001 and $6,000, and 33 percent paid more than $6,000 per physician for their EHR. Physicians do tend to see at least short-term decreases in productivity as they implement an EHR. They spend more time entering data into an empty EHR than they used to spend updating a paper chart with a simple dictation. Such hurdles can be overcome once the software has some data, as physicians learn to use templates for data entry, and as workflow in the practice changes, but not every practice gets that far.

Studies also call into question whether, in real life, EHRs improve quality. 2009 produced several articles raising doubts about EHR benefits.

Costs

The steep price of EHR and provider uncertainty regarding the value they will derive from adoption in the form of return on investment has a significant influence on EHR adoption. In a project initiated by the Office of the National Coordinator for Health Information (ONC), surveyors found that hospital administrators and physicians who had adopted EHR noted that any gains in efficiency were offset by reduced productivity as the technology was implemented, as well as the need to increase information technology staff to maintain the system.

The U.S. Congressional Budget Office concluded that the cost savings may occur only in large integrated institutions like Kaiser Permanente, and not in small physician offices. They challenged the Rand Corp. estimates of savings. "Office-based physicians in particular may see no benefit if they purchase such a product—and may even suffer financial harm. Even though the use of health IT could generate cost savings for the health system at large that might offset the EHR's cost, many physicians might not be able to reduce their office expenses or increase their revenue sufficiently to pay for it. For example. the use of health IT could reduce the number of duplicated diagnostic tests. However, that improvement in efficiency would be unlikely to increase the income of many physicians." If a physician performs tests in the office, it might reduce his or her income. "Given the ease at which information can be exchanged between health IT systems, patients whose physicians use them may feel that their privacy is more at risk than if paper records were used."

Time

Often, doctors do not want to spend the time to learn a new system. Some doctors believe that adopting a system with EHRs could reduce clinical productivity.

Governance, privacy and legal issues

Privacy Concerns

In the United States, Great Britain, and Germany, the concept of a national centralized server model of healthcare data has been poorly received. Issues of privacy and security in such a model have been of concern.

Privacy concerns in healthcare apply to both paper and electronic records. According to the *Los Angeles Times*, roughly 150 people (from doctors and nurses to technicians and billing clerks) have access to at least part of a patient's records during a hospitalization, and 600,000 payers, providers and other entities that handle providers' billing data have some access also. Recent revelations of "secure" data breaches at centralized data repositories, in banking and other financial institutions, in the retail industry, and from government databases, have caused concern about storing electronic medical records in a central location. Records that are exchanged over the Internet are subject to the same security concerns as any other type of data transaction over the Internet.

The Health Insurance Portability and Accountability Act (HIPAA) was passed in the US in 1996 to establish rules for access, authentications, storage and auditing, and transmittal of electronic medical records. This standard made restrictions for electronic records more stringent than those for paper records. However, there are concerns as to the adequacy of these standards.

In the European Union (EU), several Directives of the European Parliament and of the Council protect the processing and free movement of personal data, including for purposes of health care.

Personal Information Protection and Electronic Documents Act (PIPEDA) was given Royal Assent in Canada on April 13, 2000 to establish rules on the use, disclosure and collection of personal information. The personal information includes both non-digital and electronic form. In 2002, PIPEDA extended to the health sector in Stage 2 of the law's implementation. There are four provinces where this law does not apply because its privacy law was considered similar to PIPEDA: Alberta, British Columbia, Ontario and Quebec.

One major issue that has risen on the privacy of the U.S. network for electronic health records is the strategy to secure the privacy of patients. Former US president Bush called for the creation of networks, but federal investigators report that there is no clear strategy to protect the privacy of patients as the promotions of the electronic medical records expands throughout the United States. In 2007, the Government Accountability Office reports that there is a “jumble of studies and vague policy statements but no overall strategy to ensure that privacy protections would be built into computer networks linking insurers, doctors, hospitals and other health care providers.”

The privacy threat posed by the interoperability of a national network is a key concern. One of the most vocal critics of EMRs, New York University Professor Jacob M. Appel, has claimed that the number of people who will need to have access to such a truly interoperable national system, which he estimates to be 12 million, will inevitable lead to breaches of privacy on a massive scale. Appel has written that while "hospitals keep careful tabs on who accesses the charts of VIP patients," they are powerless to act against "a meddlesome pharmacist in Alaska" who "looks up the urine toxicology on his daughter's fiance in Florida, to check if the fellow has a cocaine habit." This is a significant barrier for the adoption of an EHR. Accountability among all the parties that are involved in the processing of electronic transactions including the patient, physician office staff, and insurance companies, is the key to successful advancement of the EHR in the U.S. Supporters of EHRs have argued that there needs to be a fundamental shift in “attitudes, awareness, habits, and capabilities in the areas of privacy and security” of individual’s health records if adoption of an EHR is to occur.

According to the *Wall Street Journal*, the DHHS takes no action on complaints under HIPAA, and medical records are disclosed under court orders in legal actions such as claims arising from automobile accidents. HIPAA has special restrictions on psychotherapy records, but psychotherapy records can also be disclosed without the client's knowledge or permission, according to the *Journal*. For example, Patricia Galvin, a lawyer in San Francisco, saw a psychologist at Stanford Hospital & Clinics after her fiance committed suicide. Her therapist had assured her that her records would be confidential. But after she applied for disability benefits, Stanford gave the insurer her therapy notes, and the insurer denied her benefits based on what Galvin claims was a misinterpretation of the notes. Stanford had merged her notes with her general medical record, and the general medical record wasn't covered by HIPAA restrictions.

Within the private sector, many companies are moving forward in the development, establishment and implementation of medical record banks and health information exchange. By law, companies are required to follow all HIPAA standards and adopt the same information-handling practices that have been in effect for the federal government for years. This includes two ideas, standardized formatting of data electronically exchanged and federalization of security and privacy practices among the private sector. Private companies have promised to have “stringent privacy policies and procedures.” If protection and security are not part of the systems developed, people will not trust the technology nor will they participate in it. So, the private sector know the importance of privacy and the security of the systems and continue to advance well ahead of the federal government with electronic health records.

Legal issues

Liability

Legal liability in all aspects of healthcare was an increasing problem in the 1990s and 2000s. The surge in the per capita number of attorneys and changes in the tort system caused an increase in the cost of every aspect of healthcare, and healthcare technology was no exception.

Failure or damages caused during installation or utilization of an EHR system has been feared as a threat in lawsuits.. Similarly, it's important to recognize that the implementation of electronic health records carries with it significant legal risks.

This liability concern was of special concern for small EHR system makers. Some smaller companies may be forced to abandon markets based on the regional liability climate. Larger EHR providers (or government-sponsored providers of EHRs) are better able to withstand legal assaults.

In some communities, hospitals attempt to standardize EHR systems by providing discounted versions of the hospital's software to local healthcare providers. A challenge to this practice has been raised as being a violation of Stark rules that prohibit hospitals from preferentially assisting community healthcare providers. In 2006, however, exceptions to the Stark rule were enacted to allow hospitals to furnish software and training to community providers, mostly removing this legal obstacle.

Legal Interoperability

In cross-border use cases of EHR implementations, the additional issue of legal interoperability arises. Different countries may have diverging legal requirements for the content or usage of electronic health records, which can require radical changes of the technical makeup of the EHR implementation in question. (especially when fundamental legal incompatibilities are involved) Exploring these issues is therefore often necessary when implementing cross-border EHR solutions.

Regulatory compliance

- Consumer Credit Act 2006
- HIPAA
- Health Level 7

Technical issues

Standards

- ANSI X12 (EDI) - transaction protocols used for transmitting patient data. Popular in the United States for transmission of billing data.

- CEN's TC/251 provides EHR standards in Europe including:
  - EN 13606, communication standards for EHR information
  - CONTSYS (EN 13940), supports continuity of care record standardization.
  - HISA (EN 12967), a services standard for inter-system communication in a clinical information environment.
- Continuity of Care Record - ASTM International Continuity of Care Record standard
- DICOM - an international communications protocol standard for representing and transmitting radiology (and other) image-based data, sponsored by NEMA (National Electrical Manufacturers Association)
- HL7 - a standardized messaging and text communications protocol between hospital and physician record systems, and between practice management systems
- ISO - ISO TC 215 provides international technical specifications for EHRs. ISO 18308 describes EHR architectures

The U.S. federal government has issued new rules of electronic health records.

Open Specifications

- openEHR: an open community developed specification for a shared health record with web-based content developed online by experts. Strong multilingual capability.
- SMArt Platforms: an open platform specification to provide a standard base for healthcare applications.

Customization

Each healthcare environment functions differently, often in significant ways. It is difficult to create a "one-size-fits-all" EHR system.

An ideal EHR system will have record standardization but interfaces that can be customized to each provider environment. Modularity in an EHR system facilitates this. Many EHR companies employ vendors to provide customization.

This customization can often be done so that a physician's input interface closely mimics previously utilized paper forms.

At the same time they reported negative effects in communication, increased overtime, and missing records when a non-customized EMR system was utilized. Customizing the software when it is released yields the highest benefits because it is adapted for the users and tailored to workflows specific to the institution.

Customization can have its disadvantages. There is, of course, higher costs involved to implementation of a customized system initially. More time must be spent by both the implementation team and the healthcare provider to understand the workflow needs.

Development and maintenance of these interfaces and customizations can also lead to higher software implementation and maintenance costs.

Long-term preservation and storage of records

An important consideration in the process of developing electronic health records is to plan for the long-term preservation and storage of these records. The field will need to come to consensus on the length of time to store EHRs, methods to ensure the future accessibility and compatibility of archived data with yet-to-be developed retrieval systems, and how to ensure the physical and virtual security of the archives.

Additionally, considerations about long-term storage of electronic health records are complicated by the possibility that the records might one day be used longitudinally and integrated across sites of care. Records have the potential to be created, used, edited, and viewed by multiple independent entities. These entities include, but are not limited to, primary care physicians, hospitals, insurance companies, and patients. Mandl et al. have noted that “choices about the structure and ownership of these records will have profound impact on the accessibility and privacy of patient information.”

The required length of storage of an individual electronic health record will depend on national and state regulations, which are subject to change over time. Ruotsalainen and Manning have found that the typical preservation time of patient data varies between 20 and 100 years. In one example of how an EHR archive might function, their research "describes a co-operative trusted notary archive (TNA) which receives health data from different EHR-systems, stores data together with associated meta-information for long periods and distributes EHR-data objects. TNA can store objects in XML-format and prove the integrity of stored data with the help of event records, timestamps and archive e-signatures."

In addition to the TNA archive described by Ruotsalainen and Manning, other combinations of EHR systems and archive systems are possible. Again, overall requirements for the design and security of the system and its archive will vary and must function under ethical and legal principles specific to the time and place.

While it is currently unknown precisely how long EHRs will be preserved, it is certain that length of time will exceed the average shelf-life of paper records. The evolution of technology is such that the programs and systems used to input information will likely not be available to a user who desires to examine archived data. One proposed solution to the challenge of long-term accessibility and usability of data by future systems is to standardize information fields in a time-invariant way, such as with XML language. Olhede and Peterson report that “the basic XML-format has undergone preliminary testing in Europe by a Spri project and been found suitable for EU purposes. Spri has advised the Swedish National Board of Health and Welfare and the Swedish National Archive to issue directives concerning the use of XML as the archive-format for EHCR (Electronic Health Care Record) information."

Synchronization of records

When care is provided at two different facilities, it may be difficult to update records at both locations in a co-ordinated fashion.

Two models have been used to satisfy this problem: a centralized data server solution, and a peer-to-peer file synchronization program (as has been developed for other peer-to-peer networks).

Synchronization programs for distributed storage models, however, are only useful once record standardization has occurred.

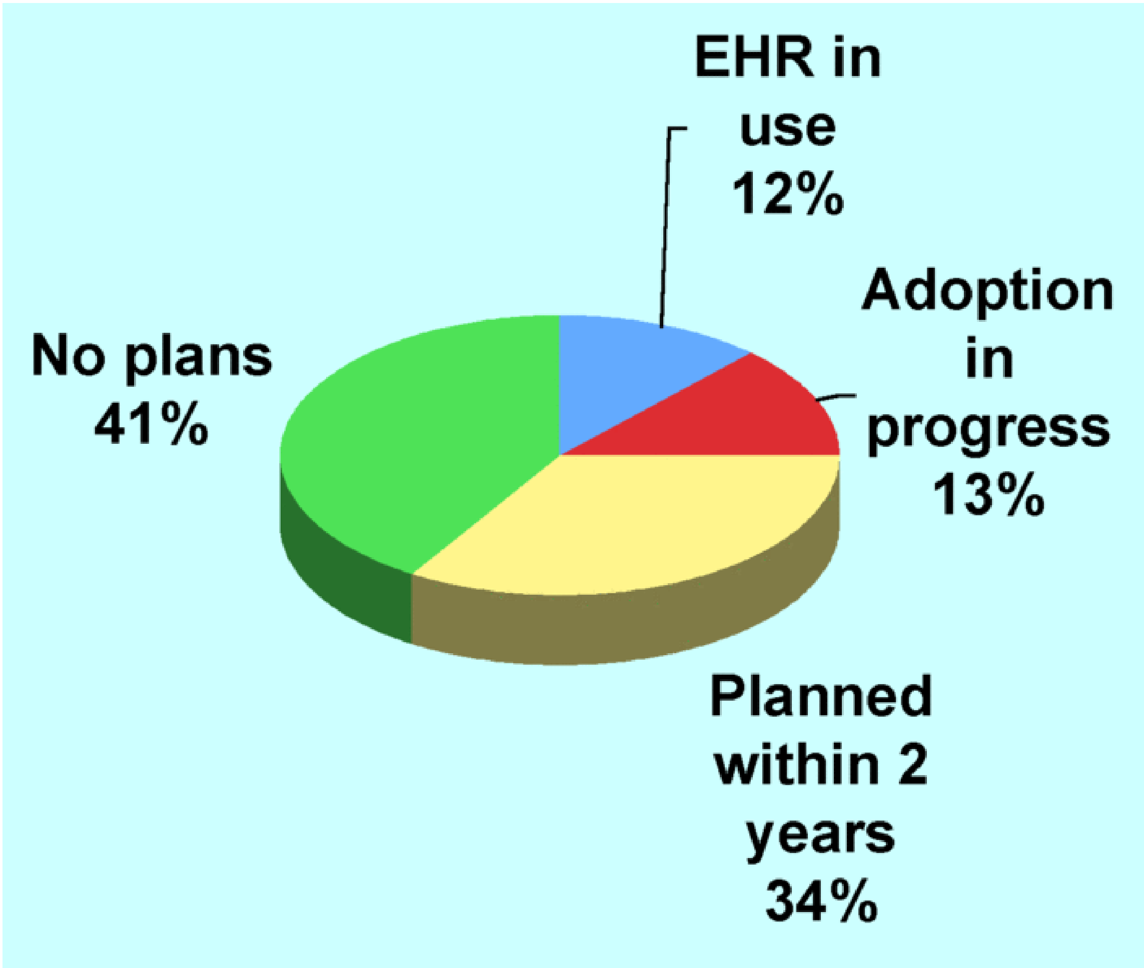
Merging of already existing public healthcare databases is a common software challenge. The ability of electronic health record systems to provide this function is a key benefit and can improve healthcare delivery.

eHealth and teleradiology

The sharing of patient information between health care organizations and IT systems is changing from a "point to point" model to a "many to many" one. The European Commission is supporting moves to facilitate cross-border interoperability of e-health systems and to remove potential legal hurdles, as in the project. To allow for global shared workflow, studies will be locked when they are being read and then unlocked and updated once reading is complete. Radiologists will be able to serve multiple health care facilities and read and report across large geographical areas, thus balancing workloads. The biggest challenges will relate to interoperability and legal clarity. In some countries it is almost forbidden to practice teleradiology. The variety of languages spoken is a problem and multilingual reporting templates for all anatomical regions are not yet available. However, the market for e-health and teleradiology is evolving more rapidly than any laws or regulations.

National contexts

United States



US medical groups' adoption of EHR (2005)

As of 2000, adoption of EHRs and other health information technology (HITs) (such as computer physician order entry (CPOE)) was minimal in the United States (outside of the VA system). Fewer than 10% of American hospitals had implemented HIT, while a mere 16% of primary care physicians used EHRs. In 2001-2004 only 18% of ambulatory care encounters utilized an EHR system. In 2005, 25% of office-based physicians reported using fully or partially electronic medical record systems (EMR), an almost one-third increase from the 18.2% reported in 2001. However, less than one-tenth of these physicians actually had a "complete EMR system" (with computerized orders for prescriptions, computerized orders for tests, reporting of test results, and physician notes).

The healthcare industry spends only 2% of gross revenues on HIT, which is low compared to other information intensive industries such as finance, which spend upwards of 10%.

Incentives and Penalties

Until recently, with the American Recovery and Reinvestment Act of 2009, (ARRA) providers were expected to take the full risk of investing in healthcare IT. Notably, healthcare payers, such as the government through Medicare, also have potential for significant cost savings if providers adopt EHR systems.

The HITECH Act, part of the 2009 economic stimulus package (ARRA) passed by the US Congress, aims at inducing more physicians to adopt EHR. Title IV of the act promises maximum incentive payments for Medicaid to those who adopt and use "certified EHRs" of $63,750 over 6 years beginning in 2011. Eligible professionals must begin receiving payments by 2016 to qualify for the program. For Medicare the maximum payments are $44,000 over 5 years. Doctors who do not adopt an EHR by 2015 will be penalized 1% of Medicare payments, increasing to 3% over 3 years. In order to receive the EHR stimulus money, the HITECH act (ARRA) requires doctors to show "meaningful use" of an EHR system. As of June 2010, there are no penalty provisions for Medicaid.

Health information exchange (HIE) has emerged as a core capability for hospitals and physicians to achieve "meaningful use" and receive stimulus funding. Healthcare vendors are pushing HIE as a way to allow EHR systems to pull disparate data and function on a more interoperable level.

Starting in 2015, hospitals and doctors will be subject to financial penalties under Medicare if they are not using electronic health records.

Meaningful Use

The meaningful use of EHRs intended by the US government incentives is categorized as follows:

- Improve care coordination
- Reduce healthcare disparities
- Engage patients and their families
- Improve population and public health
- Ensure adequate privacy and security

The Obama Administration’s Health IT program intends to use federal investments to stimulate the market of electronic health records:

- Incentives: to providers who use IT
- Strict and open standards: To ensure users and sellers of EHRs work towards the same goal
- Certification of software: To provide assurance that the EHRs meet basic quality, safety, and efficiency standards

The detailed definition of “meaningful use” is to be rolled out in 3 stages over a period of time until 2015. Details of each stage are hotly debated by various groups. Only stage 1 has been defined while the remaining stages will evolve over time.

Start-up costs

In a 2006 survey, lack of adequate funding was cited by 729 health care providers as the most significant barrier to adopting electronic records. At the American Health Information Management Association conference in October 2006, panelists estimated that purchasing and installing EHR will cost over $32,000 per physician, and maintenance about $1,200 per month (including the amortization of startup investment). Vendor costs account for 60-80% of these costs. There are exceptions. A November 2006 survey of a widely available open source EHR reported startup costs of only $1083 – $7500/provider and $67 – $750/month per provider.

Some proponents of EHR systems suggest that startup costs will be recouped within 3 years. A study of the effects of EHRs in primary care settings published in the American Journal of Medicine estimated net benefits from EHR use of over $86,000 per provider over a five-year period.

Some physicians are skeptical of such published cost-savings claims, however. They believe the data is skewed by vendors and by others who have a stake in the success of EHR implementation. Many are resistant to invest in a system which they are not confident will provide them with a return on their investment.

Brigham and Women’s Hospital in Boston, Massachusetts, estimated it achieved net savings of $5 million to $10 million per year following installation of a computerized physician order entry system that reduced serious medication errors by 55 percent. Another large hospital generated about $8.6 million in annual savings by replacing paper medical charts with EHRs for outpatients and about $2.8 million annually by establishing electronic access to laboratory results and reports.

Software maintenance costs

Furthermore, software technology advances at a rapid pace. Most software systems require frequent updates, often at a significant ongoing cost. Some types of software and operating systems require full-scale re-implementation periodically, which disrupts not only the budget but also workflow. Costs for upgrades and associated regression testing can be particularly high where the applications are governed by FDA regulations (e.g. Clinical Laboratory systems). Physicians desire modular upgrades and ability to continually customize, without large-scale reimplementation.

Training costs

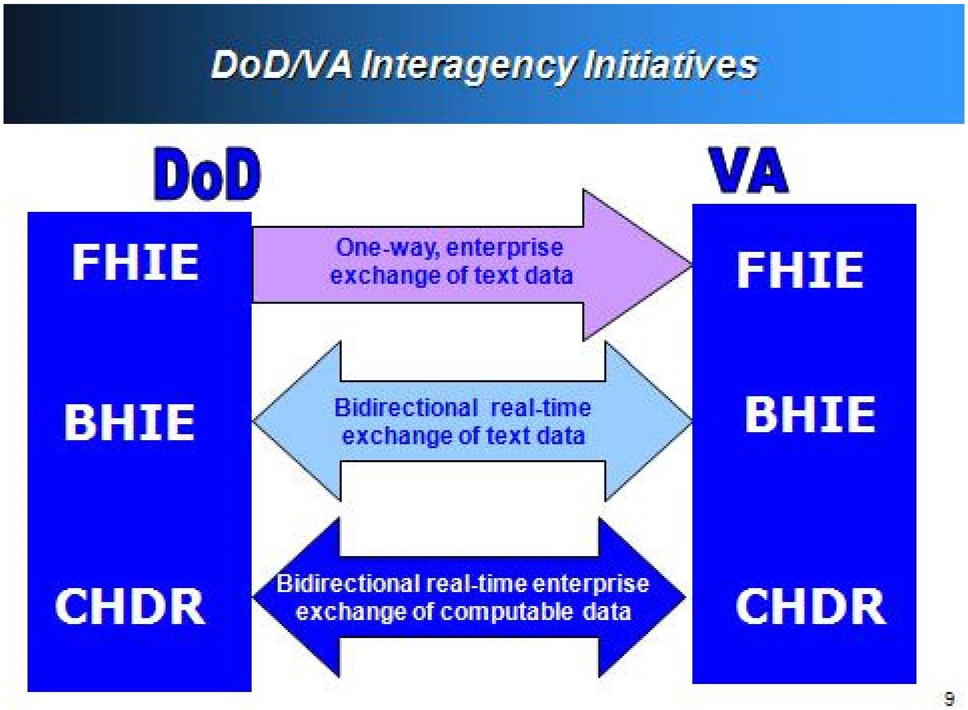
Training of employees to use an EHR system is costly, just as for training in the use of any other hospital system. New employees, permanent or temporary, will also require training as they are hired.

In the United States, a substantial majority of healthcare providers train at a VA facility sometime during their career. With the widespread adoption of the Veterans Health Information Systems and Technology Architecture (VistA) electronic health record system at all VA facilities, few recently-trained medical professionals will be inexperienced in electronic health record systems. Older practitioners who are less experienced in the use of electronic health record systems will retire over time.

Implementations

In the United States, the Department of Veterans Affairs (VA) has the largest enterprise-wide health information system that includes an electronic medical record, known as the Veterans Health Information Systems and Technology Architecture (VistA). A key component in VistA is their VistA imaging System which provides a comprehensive multimedia data from many specialties, including cardiology, radiology and orthopedics. A graphical user interface known as the Computerized Patient Record System (CPRS) allows health care providers to review and update a patient's electronic medical record at any of the VA's over 1,000 healthcare facilities. CPRS includes the ability to place orders, including medications, special procedures, X-rays, patient care nursing orders, diets, and laboratory tests.

The 2003 National Defense Authorization Act (NDAA) ensured that the VA and DoD would work together to establish a bidirectional exchange of reference quality medical images. Initially, demonstrations were only worked in El Paso, Texas, but capabilities have been expanded to six different locations of VA and DoD facilities. These facilities include VA polytrauma centers in Tampa and Richmond, Denver, North Chicago, Biloxi, and the National Capitol Area medical facilities. Radiological images such as CT scans, MRIs, and x-rays are being shared using the BHIE. Goals of the VA and DoD in the near future are to use several image sharing solutions (VistA Imaging and DoD Picture Archiving & Communications System (PACS) solutions).



Electronic Health Records Flow Chart

Clinical Data Repository/Health Data Repository (CDHR)is a program that allows for sharing of patient records, especially allergy and pharmaceutical information, between the Department of Veteran Affairs (VA) and the Department of Defense (DoD) in the United States. The program shares data by translating the various vocabularies of the information being transmitted, allowing all of the VA facilities to access and interpret the patient records. The Laboratory Data Sharing and Interoperability (LDSI) application is a new program being implemented to allow sharing at certain sites between the VA and DoD of "chemistry and hematology laboratory tests." Unlike the CHDR, the LDSI is currently limited in its scope.

One attribute for the start of implementing EHRs in the States is the development of the Nationwide Health Information Network which is a work in progress and still being developed. This started with the North Carolina Healthcare Information and Communication Alliance founded in 1994 and who received funding from Department of Health and Human Services.

The Department of Veterans Affairs works with Kaiser Permanente to further develop a software which allows to share information with private health care providers. This software called 'CONNECT' uses Nationwide Health Information Network standards and governance to make sure that health information exchanges are compatible with other exchanges being set up throughout the country. CONNECT is an open source software solution that supports electronic health information exchange. The CONNECT initiative is a Federal Health Architecture project that was conceived in 2007 and initially built by

20 various federal agencies and now comprises more than 500 organizations including federal agencies, states, healthcare providers, insurers, and health IT vendors.

The US Indian Health Service uses an EHR similar to VistA called RPMS. VistA Imaging is also being used to integrate images and co-ordinate PACS into the EHR system.

England

As of 2005, the National Health Service (NHS) in the United Kingdom also began an EHR system. The goal of the NHS is to have 60,000,000 patients with a centralized electronic health record by 2010. The plan involves a gradual roll-out commencing May 2006, providing general practitioners in England access to the National Programme for IT (NPfIT). However, the plan has been greatly delayed and frequently criticised.

Australia

Australia is dedicated to the development of a lifetime electronic health record for all its citizens. HealthConnect is the major national EHR initiative in Australia, and is made up of territory, state, and federal governments. MediConnect is a related program that provides an electronic medication record to keep track of patient prescriptions and provide stakeholders with drug alerts to avoid errors in prescribing.

Canada

The Canadian province of Alberta started a large-scale operational EHR system project in 2005 called Alberta Netcare, which is expected to encompass all of Alberta by 2008.

Estonia

Estonia is the first country in the world that has implemented a nationwide EHR system, registering virtually all residents' medical history from birth to death.

UAE

Abu Dhabi is leading the way in using national EHR data as a live longitudinal cohort in the assessment of risk of cardiovascular disease.

Saudi Arabia

Arab Health Awards 2010 recognizes Saudi Arabia National Guard Health Affairs for greatest advancement in EHR development.

Chapter 5

Electronic Medical Record

An **electronic medical record** (**EMR**) is a computerized medical record created in an organization that delivers care, such as a hospital and doctor's surgery. Electronic medical records tend to be a part of a local stand-alone health information system that allows storage, retrieval and modification of records.

Contrast with paper-based record

Paper based records are still by far the preferred method of recording patient information for most hospitals and practices in the U.S. The majority of doctors still find their ease of data entry and low cost hard to part with. However, as easy as they are for the doctor to record medical data at the point of care, they require a significant amount of storage space compared to digital records. In the US, most states require physical records be held for a minimum of seven years. The costs of storage media, such as paper and film, per unit of information differ dramatically from that of electronic storage media. When paper records are stored in different locations, collating them to a single location for review by a health care provider is time consuming and complicated, whereas the process can be simplified with electronic records. This is particularly true in the case of person-centred records, which are impractical to maintain if not electronic (thus difficult to centralise or federate). When paper-based records are required in multiple locations, copying, faxing, and transporting costs are significant compared to duplication and transfer of digital records. Because of these many "after entry" benefits, federal and state governments, insurance companies and other large medical institutions are heavily promoting the adoption of electronic medical records. Congress included a formula of both incentives (up to $44K per physician under Medicare or up to $65K over 6 years, under Medicaid) and penalties (i.e. decreased Medicare/Medicaid reimbursements for covered patients to doctors who fail to use EMR's by 2015) for EMR/EHR adoption versus continued use of paper records as part of the American Recovery and Reinvestment Act of 2009.

One study estimates electronic medical records improve overall efficiency by 6% per year, and the monthly cost of an EMR may (depending on the cost of the EMR) be offset by the cost of only a few "unnecessary" tests or admissions. Jerome Groopman disputed these results, publicly asking "how such dramatic claims of cost-saving and quality improvement could be true".

However, the increased portability and accessibility of electronic medical records may also increase the ease with which they can be accessed and stolen by unauthorized persons or unscrupulous users versus paper medical records as acknowledged by the increased security requirements for electronic medical records included in the Health Information and Accessibility Act and by recent large-scale breaches in confidential records reported by EMR users. Concerns about security contribute to the resistance shown to their widespread adoption.

Handwritten paper medical records can be associated with poor legibility, which can contribute to medical errors. Pre-printed forms, the standardization of abbreviations, and standards for penmanship were encouraged to improve reliability of paper medical records. Electronic records help with the standardization of forms, terminology and abbreviations, and data input. Digitization of forms facilitates the collection of data for epidemiology and clinical studies.

In contrast, EMRs can be continuously updated (within certain legal limitations). The ability to exchange records between different EMR systems ("interoperability") would facilitate the co-ordination of healthcare delivery in non-affiliated healthcare facilities. In addition, data from an electronic system can be used anonymously for statistical reporting in matters such as quality improvement, resource management and public health communicable disease surveillance.

Contribution under UN administration and accredited organisations

The United Nations World Health Organisation (WHO) administration intentionally does not contribute to an internationally standardised view of medical records nor to personal health records. However, WHO contributes to minimum requirements definition for developing countries.

The United Nations accredited standardisation body International Organization for Standardization (ISO) however has settled thorough word for standards in the scope of the HL7 platform for health care informatics. Respective standards are available with ISO/HL7 10781:2009 Electronic Health Record-System Functional Model, Release 1.1 and subsequent set of detailing standards.

EMRs in the United States

Usage

Even though EMR systems with computerized provider order entry (CPOE) have existed for more than 30 years, fewer than 10 percent of hospitals as of 2006 have a fully integrated system.

In the United States, 38.4% of office-based physicians reported using fully or partially electronic medical record systems (EMR) in 2008. However, the same study found that only 20.4% of all physicians reported using a system described as minimally functional and including the following features: orders for prescriptions, orders for tests, viewing laboratory or imaging results, and clinical notes.

Legal status

Electronic medical records, like medical records, must be kept in unaltered form and authenticated by the creator. Under data protection legislation, responsibility for patient records (irrespective of the form they are kept in) is always on the creator and custodian of the record, usually a health care practice or facility. The physical medical records are the property of the medical provider (or facility) that prepares them. This includes films and tracings from diagnostic imaging procedures such as X-ray, CT, PET, MRI, ultrasound, etc. The patient, however, according to HIPAA, has a right to view the originals, and to obtain copies under law.

Technical features

Using an EMR to read and write a patient's record is not only possible through a workstation but depending on the type of system and health care settings may also be possible through mobile devices that are handwriting capable. Electronic Medical Records may include access to Personal Health Records (PHR) which makes individual notes from an EMR readily visible and accessible for consumers.

Event monitoring

Some EMR systems automatically monitor clinical events, by analyzing patient data from an Electronic Health Record to predict, detect and potentially prevent adverse events. This can include discharge/transfer orders, pharmacy orders, radiology results, laboratory results and any other data from ancillary services or provider notes.

EMRs in Europe

There is no common standard on EMR in Europe neither in the entire member states of the European Union. Exception is with those states where health care system is unified, as in United Kingdom.

GP2GP project

GP2GP is an NHS Connecting for Health project in the United Kingdom. It enables GPs to transfer a patient's electronic medical record to another practice when the patient moves onto the list of other practice.

Privacy concerns

A major concern is adequate confidentiality of the individual records being managed electronically. According to the *LA Times*, roughly 150 people (from doctors and nurses to technicians and billing clerks) have access to at least part of a patient's records during a hospitalization, and over 600,000 payers, providers and other entities that handle providers' billing data have some access.

In the United States, this class of information is referred to as Protected Health Information (PHI) and its management is addressed under the Health Insurance Portability and Accountability Act (HIPAA) as well as many local laws.

In the European Union (EU), several Directives of the European Parliament and of the Council protect the processing and free movement of personal data, including for purposes of health care.

Technical standards

Though there are few standards for modern day EMR systems as a whole, there are many standards relating to specific aspects of EMRs. These include:

- HL7 - messages format for interchange between different record systems and practice management systems.
- ANSI X12 (EDI) - A set of transaction protocols used in the US for transmitting virtually any aspect of patient data.
- CEN - CONTSYS (EN 13940), a system of concepts to support continuity of care.
- CEN - EHRcom (EN 13606), a standard for the communication of information from EHR systems.
- CEN - HISA (EN 12967), a services standard for inter-system communication in a clinical information environment.
- DICOM - a standard for representing and communicating radiology images and reporting

Interoperability towards sharing records

In the United States, the development of standards for EMR interoperability is at the forefront of the national health care agenda. EMRs, while an important factor in interoperability, are not a critical first step to sharing data between practicing physicians, pharmacies and hospitals. Many physicians currently have computerized practice management systems that can be used in conjunction with a health information exchange (HIE), allowing for first steps in sharing patient information (lab results, public health reporting) which are necessary for timely, patient-centered and portable care.

Regulatory compliance

- HIPAA
- Health Level 7
- DICOM
- Title 21 CFR Part 11

Electronic Medical Records in Veterinary Medicine

In UK veterinary practice, the replacement of paper recording systems with electronic methods of storing animal patient information escalated from the 1980s and the majority of clinics now use electronic medical records. In a sample of 129 veterinary practices, 89% used a Practice Management System (PMS) for data recording. There are more than 10 PMS providers currently in the UK. Collecting data directly from PMSs for epidemiological analysis abolishes the need for veterinarians to manually submit individual reports per animal visit and therefore increases the reporting rate.

Veterinary electronic medical record data are being used to investigate antimicrobial efficacy; risk factors for canine cancer; and inherited diseases in dogs and cats, in the small animal disease surveillance project 'VEctAR' (Veterinary Electronic Animal Record) at the Royal Veterinary College, London, in collaboration with the University of Sydney.

Chapter 6

Computerized Physician Order Entry

Computerized provider order entry (CPOE), is a process of electronic entry of medical practitioner instructions for the treatment of patients (particularly hospitalized patients) under his or her care. These orders are communicated over a computer network to the medical staff or to the departments (pharmacy, laboratory, or radiology) responsible for fulfilling the order. CPOE decreases delay in order completion, reduces errors related to handwriting or transcription, allows order entry at point-of-care or off-site, provides error-checking for duplicate or incorrect doses or tests, and simplifies inventory and posting of charges. Although manufacturers use the term Computerized Physician Order Entry, a more accurate term would be Computerized Prescriber Order Entry or Computerized Pharmacist Order Entry. Order Entry is in the domain of the pharmacist because it is the pharmacist's responsibility to verify any entry into the system concerning the use of medications within the hospital or health care system. Order clarification requests will be enhanced by improved communication and collaboration amongst the health care team.

Terminology related to order entry

Filler

The application responding to, *i.e.*, performing, a request for services (orders) or producing an observation. The filler can also originate requests for services (new orders), add additional services to existing orders, replace existing orders, put an order on hold, discontinue an order, release a held order, or cancel existing orders.

Order

A request for a service from one application to a second application. In some cases an application is allowed to place orders with itself.

Order detail segment

One of several segments that can carry order information. Future ancillary specific segments may be defined in subsequent releases of the Standard if they become necessary.

Placer

The application or individual originating a request for services (order).

Placer order group

A list of associated orders coming from a single location regarding a single patient.

Features of CPOE systems

Features of the ideal computerized physician order entry system (CPOE) include:

Ordering
: Physician orders are standardized across the organization, yet may be individualized for each doctor or specialty by using order sets. Orders are communicated to all departments and involved caregivers, improving response time and avoiding scheduling problems and conflict with existing orders.

Patient-centered decision support
: The ordering process includes a display of the patient's medical history and current results and evidence-based clinical guidelines to support treatment decisions. Often uses medical logic module and/or Arden syntax to facilitate fully integrated Clinical Decision Support Systems (CDSS).

Patient safety features
: The CPOE system allows real-time patient identification, drug dose recommendations, adverse drug reaction reviews, and checks on allergies and test or treatment conflicts. Physicians and nurses can review orders immediately for confirmation.

Intuitive Human interface
: The order entry workflow corresponds to familiar "paper-based" ordering to allow efficient use by new or infrequent users.

Regulatory compliance and security
: Access is secure, and a permanent record is created, with electronic signature.

Portability
: The system accepts and manages orders for all departments at the point-of-care, from any location in the health system (physician's office, hospital or home) through a variety of devices, including wireless PCs and tablet computers.

Management
: The system delivers statistical reports online so that managers can analyze patient census and make changes in staffing, replace inventory and audit utilization and productivity throughout the organization. Data is collected for training, planning, and root cause analysis for patient safety events.

Billing
: Documentation is improved by linking diagnoses (ICD-9-CM or ICD-10-CM codes) to orders at the time of order entry to support appropriate charges.

Patient safety benefits of CPOE

In the past, physicians have traditionally hand-written or verbally communicated orders for patient care, which are then transcribed by various individuals (such as unit clerks, nurses, and ancillary staff) before being carried out. Handwritten reports or notes, manual order entry, non-standard abbreviations and poor legibility lead to errors and injuries to patients, according to a 1999 Institute of Medicine (IOM) report. A follow up IOM report in 2001 advised use of electronic medication ordering, with computer- and internet-based information systems to support clinical decisions. Prescribing errors are the largest identified source of preventable hospital medical error. A 2006 report by the Institute of Medicine estimated that a hospitalized patient is exposed to a medication error each day of his or her stay. Studies of computerized physician order entry (CPOE) has yielded evidence that suggests the medication error rate can be reduced by 80%, and errors that have potential for serious harm or death for patients can be reduced by 55%, and other studies have also suggested benefits. CPOE/e-Prescribing systems can provide automatic dosing alerts (for example, letting the user know that the dose is too high and thus dangerous) and interaction checking (for example, telling the user that 2 medicines ordered taken together can cause health problems). In this way, specialists in pharmacy informatics work with the medical and nursing staffs at hospitals to improve the safety and effectiveness of medication use by utilizing CPOE systems.

Risks of CPOE

CPOE presents several possible dangers by introducing new types of errors. Prescriber and staff inexperience may cause slower entry of orders at first, use more staff time, and is slower than person-to-person communication in an emergency situation. Physician to nurse communication can worsen if each group works alone at their workstations. Automation causes a false sense of security, a misconception that when technology suggests a course of action, errors are avoided. These factors contributed to an *increased* mortality rate in the Children's Hospital of Pittsburgh's Pediatric ICU when a CPOE systems was introduced. In other settings, shortcut or default selections can override non-standard medication regimens for elderly or underweight patients, resulting in toxic doses. Frequent alerts and warnings can interrupt work flow, causing these messages to be ignored or overridden due to alert fatigue. CPOE and automated drug dispensing was identified as a cause of error by 84% of over 500 health care facilities participating in a surveillance system by the United States Pharmacopoeia. Introducing CPOE to a complex medical environment requires ongoing changes in design to cope with unique patients and care settings, close supervision of overrides caused by automatic systems, and training, testing and re-training all users.

Implementation

CPOE systems can take years to install and configure. Despite ample evidence of the potential to reduce medication errors, adoption of this technology by doctors and hospitals in the United States has been slowed by resistance to changes in physician's practice patterns, costs and training time involved, and concern with interoperability and compliance with future national standards. According to a study by RAND Health, the US healthcare system could save more than 81 billion dollars annually, reduce adverse medical events and improve the quality of care if it were to widely adopt CPOE and other health information technology. As more hospitals become aware of the financial benefits of CPOE, and more physicians with a familiarity with computers enter practice, increased use of CPOE is predicted. A 2004 survey by Leapfrog found that 16% of US clinics, hospitals and medical practices are expected to be utilizing CPOE within 2 years. Several high profile failures of CPOE implementation have occurred, so a major effort must be focused on change management, including restructuring workflows, dealing with physicians' resistance to change, and creating a collaborative environment.

An early success with CPOE by the United States Department of Veterans Affairs (VA) is the Veterans Health Information Systems and Technology Architecture or VistA. A graphical user interface known as the Computerized Patient Record System (CPRS) allows health care providers to review and update a patient's record at any computer in the VA's over 1,000 healthcare facilities. CPRS includes the ability to place orders by CPOE, including medications, special procedures, x-rays, patient care nursing orders, diets, and laboratory tests.

The world's first successful implementation of a CPOE system was at El Camino Hospital in Mountain View, California in the early 1970s. The Medical Information System (MIS) was originally developed by a software and hardware team at Lockheed in Sunnyvale, California, which became the TMIS group at Technicon Instruments Corporation. The MIS system used a light pen to allow physicians and nurses to quickly point and click items to be ordered.

As of 2005, one of the largest projects for a national EHR is by the National Health Service (NHS) in the United Kingdom. The goal of the NHS is to have 60,000,000 patients with a centralized electronic health record by 2010. The plan involves a gradual roll-out commencing May 2006, providing general practices in England access to the National Programme for IT (NPfIT). The NHS component, known as the "Connecting for Health Programme", includes office-based CPOE for medication prescribing and test ordering and retrieval, although some concerns have been raised about patient safety features.

In 2008, the Massachusetts Technology Collaborative and the New England Healthcare Institute (NEHI) published research showing that 1 in 10 patients admitted to a Massachusetts community hospital suffered a preventable medication error. The study argued that Massachusetts hospitals could prevent 55,000 adverse drug events per year and save $170 million annually if they fully implemented CPOE. The findings prompted the Commonwealth of Massachusetts to enact legislation requiring all hospitals to implement CPOE by 2012 as a condition of licensure.

In addition, the study also concludes that it would cost approximately $2.1 million to implement a CPOE system, and a cost of $435,000 to maintain it in the state of Massachusetts while it saves annually about $2.7 million per hospital. And the hospitals will still see payback within 26 months through reducing hospitalizations generated by error. Despite the advantages and cost savings, the CPOE is still not well adapted by many hospitals in the US.

The Leapfrog's 2008 Survey showed that most hospitals are still not complying with having a fully implemented, effective CPOE system. The CPOE requirement became more challenging to meet in 2008 because the Leapfrog introduced a new requirement: Hospitals must test their CPOE systems with Leapfrog's CPOE Evaluation Tool. So the number of hospitals in the survey considered to be fully meeting the standard dropped to 7% in 2008 from 11% the previous year. Though the adoption rate seems very low in 2008, it is still an improvement from 2002 when only 2% of hospitals met this Leapfrog standard.

Chapter 7

Personal Health Record

A **personal health record** or PHR is typically a health record that is initiated and maintained by an individual. An ideal PHR would provide a complete and accurate summary of the health and medical history of an individual by gathering data from many sources and making this information accessible online to anyone who has the necessary electronic credentials to view the information.

Definition

The term “personal health record” is not new. The earliest mention of the term was in an article indexed by PubMed dated June 1978; and even earlier in 1956 reference is made to a personal health log however, search results from PubMed also reveal that most scientific articles written about PHRs have been published since 2000.

The term "PHR" has been applied to both paper-based and computerized systems; however, current usage usually implies an electronic application used to collect and store health data. In recent years, several formal definitions of the term have been proposed by various organizations.

It is important to note that PHRs are not the same as EHRs (electronic health records). The latter are software systems designed for use by health care providers. Like the data recorded in paper-based medical records, the data in EHRs are legally mandated notes on the care provided by clinicians to patients. There is no legal mandate that compels a consumer or patient to store her personal health information in a PHR.

PHRs can contain a diverse range of data but usually include information about:

- allergies and adverse drug reactions
- chronic diseases
- family history
- illnesses and hospitalizations
- imaging reports (e.g. x-ray)
- immunization records
- laboratory test results
- medications and dosing including over the counter medications and herbal remedies

- surgeries and other procedures
- vaccinations
- and Observations of Daily Living (ODLs)

In addition to storing an individual's personal health information, some PHRs provide added-value services such as drug-drug interaction checking, electronic messaging between patients and providers, managing appointments, and reminders.

PHR Solution Types

One of the principle distinguishing features of a PHR is the platform by which it is delivered. The types of platforms include: paper, electronic device, and web.

Paper-based PHRs

Personal health information is recorded and stored in paper format. Printed laboratory reports, copies of clinic notes, and health histories created by the individual may be parts of a paper-based PHR. This method is low cost, reliable, and accessible without the need for a computer or any other hardware. Paper-based PHRs may be difficult to locate, update, and share with others. Paper-based PHRs are subject to physical loss and damage, such as can occur during a natural disaster. Paper records can also be printed from most electronic PHRs.

Electronic device-based PHRs

Personal health information is recorded and stored in personal computer-based software that may have the capability to print, backup, encrypt, and import data from other sources such as a hospital laboratory. The most basic form of a PC-based PHR would be a health history created in a word-processing program. The health history created in this way can be printed, copied, and shared with anyone with a compatible word processor.

PHR software can provide more sophisticated features such as data encryption, data importation, and data sharing with health care providers. Some PHR products allow the copying of health records to a mass-storage device such as a CD-ROM, DVD, smart card, or USB flash drive.

PC-based PHRs are subject to physical loss and damage of the personal computer and the data that it contains. Some other methods of device solution may entail cards with embedded chips containing health information that may or may not be linked to a personal computer application or a web solution.

Web Based PHR Solutions

Web based PHR solutions are essentially the same as electronic device PHR solutions, however, web based solutions have the advantage of being easily integrated with other services. For example, some solutions allow for import of medical data from external sources. Solutions including HealthVault and Google Health allow for data to be shared with other applications or specific people. Mobile solutions often integrate themselves with web solutions and use the web-based solution as the platform.

Sponsors of PHRs

PHR programs are structured in the same basic way a consumer credit report is structured, in that consumers may obtain a PHR from various sponsoring organizations. Some PHRs are marketed directly to the consumer by the product vendor. The direct-to-consumer PHRs often require the consumer to pay a fee for registering a new account. Other PHRs are offered by health care organizations such as hospitals. Frequently, these hospital-based PHRs are integrated with other information systems owned by the health care delivery organization such as its EHR or laboratory information systems. Recently, PHRs are being offered to people by employers and health insurance companies, however it is unclear if the PHR is transportable or transferable if a person switches jobs or insurance companies.

EHRs, PHRs, Patient Portals and UHRs

The terms electronic health records, personal health records, and patient portals are not always used correctly. The generally agreed upon definition of these terms relates mainly to the *ownership* of the data. Although most patients might believe, "my body, my data" the FDA has started to weigh in on the issue of who owns healthcare data Million Dollar Question - Who owns your health data. Once data is in a PHR it is owned and controlled by the patient. In most EHR"s however it the property of the provider although the content can be co-created by both the provider and patient. A patient has a legal right in most states to request their healthcare data and under recent legislation those providers using a certified EHR will be required to provide an electronic copy as well. Electronic health records and electronic medical records contain clinical data created by and for health professionals in the course of providing care. The data is about the patient but the data resides in a health care provider's system. The patient portal is typically defined as a view into the electronic medical records. In addition ancillary functions that support a health care provider's interaction with a patient are also found in those systems e.g. prescription refill requests, appointment requests, electronic case management, etc. Finally PHRs are data that resides with the patient, in a system of a patient's choosing. This data may have been exported directly from an EMR, but the point is it now resides in a location of the patient's choosing. Access to that information is controlled entirely by the patient.

A new concept being discussed (as of March 2010) is the UHR or "universal health record", which would be a patient-centered and patient-controlled body of information that could be shared in a granular way with particular health care providers at the patient's discretion in support of the patient's work with health care providers. This project would enlist open source contributions and enhancements from developers, with particular emphasis on supporting patient expectations of privacy and responsible patient control of private health information (PHI). It is anticipated that effective implementation of one or more "open source" approaches to the UHR would benefit both providers and patients ("Some of us are sometimes providers - All of us are sometimes patients...") including providing more cost-effective solutions to currently difficult problems including entry/verification/update of personal health data, enabling responsible patient-controlled granular release of PHI, and supporting interoperability and effective collaboration of patients and physicians across disparate EHR/PHR platforms.

While PHRs can help patients keep track of their personal health information, the value of PHRs to healthcare organizations is still unclear.

PHRs and public health

PHRs have the ability to benefit the public health sector by providing health monitoring, outbreak monitoring, empowerment, linking to services, and research. PHRs can give consumers the potential to play a large role in protecting and promoting the public's health.

Chapter 8

Connected Health

Connected Health is a term used to describe a model for healthcare delivery that uses technology to provide healthcare remotely. Connected health aims to maximize healthcare resources and provide increased, flexible opportunities for consumers to engage with clinicians and better self-manage their care. It uses technology – often leveraging readily available consumer technologies – to deliver patient care outside of the hospital or doctor's office. Connected health encompasses programs in telehealth, remote care (such as home care) and disease and lifestyle management, often leverages existing technologies such as connected devices using existing cellular networks and is associated with efforts to improve chronic care.

The United States and European Union are two dominant markets for the use of connected health in home care service, in part due to the high availability of telephone and Internet service as compared to other parts of the world. Within the United States, over 260 million people have a land line connected, over 190 million are cell phone users, and approximately 200 million are Internet users. The European Union has roughly an equivalent number of people connected to land lines, but prevails over the U.S. with more than 300 million cell phone users and 230 million Internet users. More recent data collected by Pew Internet: Americans and their Gadgets suggest that 86% of US residents own a mobile phone and this number is as high as 96% among Americans aged 18 to 29 years. According to the International Communications Union, it is predicted that there will be 4 billion mobile phone users worldwide by the end of 2008[1].

The vision of the connected health model can be implicitly understood by contemplating the significant impact of technology on other industries, such as in banking, shopping, logistics and personal communications. Proponents of connected health believe that technology can transform healthcare delivery and address many inefficiencies especially in the area of work flow management, chronic disease management and patient compliance of the US and global healthcare systems.

History

Connected health has its roots in telemedicine, and its more recent relative, telehealth. The first telemedicine programs were primarily undertaken to address healthcare access and/or provider shortages. Connected health is distinguished from telemedicine by:

- A broader concern for healthcare cost, quality and efficiency, particularly as related to the chronically ill
- Concomitant interests in making healthcare more patient centric by promoting healthcare consumerism through education, and patient feedback
- Efforts in the direction of integrating of data generated outside of traditional healthcare settings such as the home with centralised, often electronic patient record

One of the first telemedicine clinics was founded by Dr. Kenneth Bird at Massachusetts General Hospital in 1967. The clinic addressed the fundamental problems of delivering occupational and emergency health services to employees and travellers at Boston's Logan International Airport, located three congested miles from the hospital. Over 1,000 patients are documented as having received remote treatment from doctors at MGH using the clinic's two-way audiovisual microwave circuit[2]. The timing of Dr. Bird's clinic more or less coincided with NASA's foray into telemedicine through the use of physiologic monitors for astronauts[3]. Other pioneering programs in telemedicine were designed to deliver healthcare services to people in rural settings.

Connected Health in Operation

Two "core platforms" are emphasized in connected health, self-care and remote care, with programs primarily focused on monitoring and feedback for the chronically ill, elderly, and those patients located at an untenable distance from primary or specialty providers. Programs designed to improve patient-provider communication within an individual medical practice (for example, the use of email to communicate with patients between office visits) also fall within the purview of connected health. There are also "lifestyle coaching" programs, in which an individual receives healthcare information to facilitate behavior change to improve their fitness and/or general well being, or to reduce or eliminate the impact of a particular behavior that presents a risk to their health status. Some of the most common types of connected health programs in operation today include:

- Home care via remote monitoring of chronically ill patients including surveillance connected devices or patient controlled monitoring of health parameters
- Traditional telehealth programs, where care is provided in remote areas by teams of local clinicians or community healthcare workers teamed up with specialists in medical centers
- Monitoring programs whose aim is to ensure the safety and quality of life of elderly parents living at a distance from their relatives
- Web-based second opinion services for patients in need of medical care
- Lifestyle and fitness coaching for wellness or health risk reduction

The Center for Connected Health is implementing a range of programs in high-risk, chronic and remotely located populations.

Inherent in the concept of connected health is flexibility in terms of technological approaches to care delivery and specific program objectives. For instance, remote monitoring programs might use a combination of cell phone and smart phone technology, online communications or biosensors and may aim to increase patient-provider communication, involve patients in their care through regular feedback, or improve upon a health outcome measure in a defined patient population or individual. Digital pen technology, global positioning, videoconferencing and environmental sensors are all playing a role in connected health today.

Goals of Connected Health

Connected health is viewed by its proponents as a critical component of change in human healthcare. They envision:

- Reductions in the cost of providing quality care to the chronically ill, estimated by the Center for Health Care Economics at the Milken Institute to be over $1 trillion per year
- Improved global and local public health surveillance, with a resultant reduction in epidemics, increased control over infectious disease and improved drug safety
- Diminished rate of medical errors
- Better “customer service” in healthcare
- Ongoing preventive health, with attendant reductions in: morbidity, mortality and the cost of care
- Consumer engagement in health and self-management
- Safer and more effective clinical trials

The Evolution of Connected Health

Healthcare is consistently cited in political polls and in surveys as a chief concern for consumers, administrators, employers and clinicians alike.

The formal establishment of quality improvement organizations in 2002 and rise of independent organizations such as The National Committee for Quality Assurance, The Leapfrog Group and Bridges to Excellence - all of which are dedicated to promoting and monitoring healthcare quality - illustrate intense concern over inefficiency, safety, and customer service in healthcare.

In addition, skyrocketing costs, increases in chronic diseases, geographic dispersion of families, growing provider shortages, troubling ethnic disparities in care, better survival rates among patients fighting serious diseases, an aging U.S. population and longer lifespan are all factors pointing to a need for better ways of delivering healthcare.

Consumer demand for better service and quality in healthcare is the latest source of pressure to improve the healthcare system. Experts speculate that, having acclimated to greater speed, efficiency and cost transparency - as well as vastly improved access to information about products and services - in other industries, consumers are calling for the same responsiveness from the healthcare system. Direct-to-consumer advertising is a demonstrated contributor to the rise in consumer demand, as is the mass availability of inexpensive technology and ubiquity of the Internet, cell phones and PDAs.[8,9] Connected health experts such as Joseph C. Kvedar, M.D., believe that consumer engagement in healthcare is on its way to becoming a major force for change.

In summary, connected health has arisen from: 1) a desire on the part of individual physicians and healthcare organizations to provide better access, quality and efficiency of care 2) dynamics of the healthcare economy (such as rising costs and changing demographics) 3) consumerism in health care and a drive towards patient centric healthcare. Together, these factors are providing impetus for connected healthcare in the United States and many other industrialised nations and forcing innovation both from within and outside the system.

Evidence

While connected health is yet emerging, there is evidence of its benefit. For example, in a program being implemented by the Center for Connected Health and Partners Home Care, over 500 heart failure patients have now been monitored remotely through the collection of vital signs, including heart rate, blood pressure and weight, using simple devices in the patient's home. The information is sent daily to a home health nurse, who can identify early warning signs, notify the patient's primary care physician, and intervene to avert potential health crises. A pilot of this program demonstrated reduced hospitalizations[10]. Another initiative at the Center for Connected Health uses cellular telephone technology and a "smart" pill bottle to detect when a patient has not taken their scheduled medication. A signal is then sent that lights up an ambient orb device in the patient's home to remind them to take their medication.

Funding and Implementation

Today, it appears that connected health programs are operated and funded primarily by home care agencies and large healthcare systems. However, insurers and employers, who bear enormous cost to insure their employees, are increasingly interested in connected health for its potential to reduce direct and indirect healthcare costs. For example, EMC Corporation recently launched the first employer-sponsored connected health program, currently in the beta phase of implementation, which is aimed at improving outcomes and cost of care for patients with high blood pressure.

US Government and Connected Health

Government agencies involved in connected health include:

- The Office for the Advancement of Telehealth
- The Centers for Medicare & Medicaid Services (CMS), to the extent that Medicaid reimburses for telemedicine programs, at the state's option. According to the CMS Web site, at least 18 states are allowing reimbursement for services

provided via telemedicine for reasons that include improved access to specialists for rural communities and reduced transportation costs.

- The Office of the National Coordinator for Health Information Technology (ONC) is charged with creating an interoperable health information technology infrastructure for the nation. That infrastructure has been primarily defined as an electronic health records system, however, former National Coordinator David Brailer indicated his support for personal health records that are portable and controlled by consumers. It remains to be seen how his successor, Robert Kolodner, will interpret this charge.[12]

Personal Health Records

Personal health records, or PHRS – are essentially medical records controlled and maintained by the healthcare consumer. PHRs intersect with connected health in that they attempt to increase the involvement of healthcare consumers in their care. By contrast, electronic medical records (EMRs) are digital medical records or medical records systems maintained by hospitals or medical practices and are not part of connected health delivery.

Chapter 9

Telehealth

Telehealth is the delivery of health-related services and information via telecommunications technologies. Telehealth delivery could be as simple as two health professionals discussing a case over the telephone, or as sophisticated as using videoconferencing between providers at facilities in two countries, or even as complex as robotic technology.

Telehealth is an expansion of telemedicine, and unlike telemedicine (which more narrowly focuses on the curative aspect) it encompasses preventive, promotive *and* curative aspects. Originally used to describe administrative or educational functions related to telemedicine, today telehealth stresses a myriad of technology solutions. For example, physicians use email to communicate with patients, order drug prescriptions and provide other health services.

Clinical uses of telehealth technologies

- Transmission of medical images for diagnosis (often referred to as store and forward telehealth)
- Groups or individuals exchanging health services or education live via videoconference (real-time telehealth)
- Transmission of medical data for diagnosis or disease management (sometimes referred to as remote monitoring)
- Advice on prevention of diseases and promotion of good health by patient monitoring and followup.
- Health advice by telephone in emergent cases (referred to as teletriage)

Nonclinical uses of telehealth technologies

- Distance education including continuing medical education, grand rounds, and patient education
- administrative uses including meetings among telehealth networks, supervision, and presentations
- research on telehealth
- online information and health data management
- healthcare system integration

- asset identification, listing, and patient to asset matching, and movement
- overall healthcare system management
- patient movement and remote admission

Telehealth modes

Store-and-forward telehealth

In store-and-forward telehealth, digital images, video, audio, Observations of Daily Living (ODLs) , and clinical data are captured and "stored" on the client computer or mobile device; then at a convenient time transmitted securely ("forwarded") to a clinic at another location where they are studied by relevant specialists. The opinion of the specialist is then transmitted back. Based on the requirements of the participating healthcare entities, this roundtrip could take between 1 minute to 48 hours. In the simplest form of Telehealth application, basic vital signs like Blood Pressure, Weight, Pulse Oximeter, Blood Sugar values are monitored and trended for long term Chronic care. In many store-and-forward specialties, such as dermatology, radiology and pathology an immediate response is not critical and are conducive to store-and-forward technologies. Automated screening and diagnostic tele-audiology is fast becoming another specialty conducive to store-and-forward audiology.

Real-time telehealth

In real-time telehealth, a telecommunications link allows instantaneous interaction. Videoconferencing equipment is one of the most common forms of synchronous telemedicine. Peripheral devices can also be attached to computers or the video-conferencing equipment which can aid in an interactive examination. With the availability of better and cheaper communication channels, direct two-way audio and video streaming between centers through computers is leading to lower costs.

Examples of real-time clinical telehealth include:

- Tele-audiology
- Telecardiology
- Teledentistry
- Telemental Health -- the use of videoconferencing technology to connect a psychiatrist with a mental health client
- Teleneurology
- Telenursing
- Teleradiology
- Telerehabilitation

In an effort to enhance the real-time telehealth experience, Google Health, a personal health information centralization service, recently began establishing relationships with telehealth providers that will allow their users to sync the data shared during telehealth consultations with their online health records. To date, partnerships have been formed with the following companies: MDLiveCare and Hello Health.

Remote patient monitoring

In remote monitoring, sensors are used to capture and transmit biometric data. For example, a tele-EEG device monitors the electrical activity of a patients brain and then transmits that data to a specialist. This could be done in either real time or the data could be stored and then forwarded.

Examples of remote monitoring include:

- Home-based nocturnal dialysis
- Cardiac and multi-parameter monitoring of remote ICUs
- Home telehealth
- Disease management

Benefits of telehealth

Telehealth adds a new paradigm in healthcare, where the patient is monitored between physician office visits. This has been shown to significantly reduce hospitalizations and visits to the Emergency Room, while improving patient's quality of life. Telehealth also benefits patients where traditional delivery of health services are affected by distance and lack of local specialist clinicians to deliver services.

The rate of adoption of telehealth services in any jurisdiction is frequently influenced by factors such as the adequacy and cost of existing conventional health services in meeting patient needs; the policies of governments and/or insurers with respect to coverage and payment for telehealth services; and medical licensing requirements that may inhibit or deter the provision of telehealth second opinions or primary consultations by physicians.

There may also be some significant carbon reductions for the NHS to be gained from developing Telehealth and therefore reducing the need to travel (often, in the case of patients, by car) as well as encouraging healthy, sustainable behaviour through monitoring and improved communications and reducing the requirements to expand sites to meet increases in Healthcare demands.

The state of the market

Projections for the growth of the telehealth market are optimistic, and much of this optimism is predicated upon the increasing demand for remote medical care. According to a recent survey, nearly three-quarters of U.S. consumers say they would use telehealth. At present, several major companies are scrambling to establish a foothold in a market that, according to market-research firm Datamonitor, is expected to grow to more than $6 billion by 2012 from 900 million in 2007.

Chapter 10

Telemedicine

Telemedicine is a rapidly developing application of clinical medicine where medical information is transferred through interactive audiovisual media for the purpose of consulting, and sometimes remote medical procedures or examinations.

Telemedicine may be as simple as two health professionals discussing a case over the telephone, or as complex as using satellite technology and videoconferencing equipment to conduct a real-time consultation between medical specialists in two different countries. Telemedicine generally refers to the use of communications and information technologies for the delivery of clinical care.

Care at a distance (also called *in absentia* care), an old practice which was often conducted via post. There has been a long and successful history of in absentia health care which, thanks to modern communication technology, has evolved into what we know as modern telemedicine.

In its early manifestations, African villagers used smoke signals to warn people to stay away from the village in case of serious disease. In the early 1900s, people living in remote areas of Australia used two-way radios, powered by a dynamo driven by a set of bicycle pedals, to communicate with the Royal Flying Doctor Service of Australia.

The terms eHealth and telehealth are at times incorrectly interchanged with telemedicine. Like the terms "medicine" and "health care", telemedicine often refers only to the provision of clinical services while the term telehealth can refer to clinical and non-clinical services such as medical education, administration, and research. The term eHealth is often, particularly in the U.K. and Europe, used as an umbrella term that includes telehealth, electronic medical records, and other components of health IT.

Types of telemedicine

Telemedicine can be broken into three main categories: **store-and-forward**, **remote monitoring** and **interactive** services.

Store-and-forward telemedicine involves acquiring medical data (like medical images, biosignals etc) and then transmitting this data to a doctor or medical specialist at a convenient time for assessment offline. It does not require the presence of both parties at the same time. Dermatology (cf: teledermatology), radiology, and pathology are common specialties that are conducive to asynchronous telemedicine. A properly structured medical record preferably in electronic form should be a component of this transfer. A key difference between traditional in-person patient meetings and telemedicine encounters is the omission of an actual physical examination and history. The 'store-and-forward' process requires the clinician to rely on a history report and audio/video information in lieu of a physical examination.

Remote monitoring, also known as self-monitoring or testing, enables medical professionals to monitor a patient remotely using various technological devices. This method is primarily used for managing chronic diseases or specific conditions, such as heart disease, diabetes mellitus, or asthma. These services can provide comparable health outcomes to traditional in-person patient encounters, supply greater satisfaction to patients, and may be cost-effective.

Interactive telemedicine services provide real-time interactions between patient and provider, to include phone conversations, online communication and home visits. Many activities such as history review, physical examination, psychiatric evaluations and ophthalmology assessments can be conducted comparably to those done in traditional face-to-face visits. In addition, “clinician-interactive” telemedicine services may be less costly than in-person clinical visit

Emergencies Telemedicine

The most common Emergency Telemand current daily Telemedecine is done by SAMU's Regulator Physician in the word like in France ,Spain, Chile, Brazil. Onboard aircaft or maritime emergency telemedecine is also current in Paris Lisbon Toulouse Samus.

Benefits and uses

Telemedicine can be extremely beneficial for people living in isolated communities and remote regions and is currently being applied in virtually all medical domains. Patients who live in such areas can be seen by a doctor or specialist, who can provide an accurate and complete examination, while the patient may not have to travel or wait the normal distances or times like those from conventional hospital or GP visits.

Specialties that use telemedicine often use a 'tele-' prefix; for example, telemedicine as applied by radiologists is called 'teleradiology'. Similarly telemedicine as applied by cardiologists is termed as 'telecardiology', etc...

Telemedicine is also useful as a communication tool between a general practitioner and a specialist available at a remote location. Telemedicine can be used as a teaching tool, by which experienced medical staff can observe, show and instruct medical staff in another location, more effective or faster examination techniques. It improved access to healthcare for patients in remote locations. "Telemedicine has been shown to reduce the cost of healthcare and increase efficiency through better management of chronic diseases,shared health professional staffing, reduced travel times, and fewer or shorter hospital stays." Several studies have documented increase patient satisfaction of telemedicine over past fifteen years.

The first interactive telemedicine system, operating over standard telephone lines, for remotely diagnosing and treating patients requiring cardiac resuscitation (defibrillation) was developed and marketed by MedPhone Corporation Telemonitoring is a medical practice that involves remotely monitoring patients who are not at the same location as the health care provider. In general, a patient will have a number of monitoring devices at home, and the results of these devices will be transmitted via telephone to the health care provider. Telemonitoring is a convenient way for patients to avoid travel and to perform some of the more basic work of healthcare for themselves.

In addition to objective technological monitoring, most telemonitoring programs include subjective questioning regarding the patient's health and comfort. This questioning can take place automatically over the phone, or telemonitoring software can help keep the patient in touch with the health care provider. The provider can then make decisions about the patient's treatment based on a combination of subjective and objective information similar to what would be revealed during an on-site appointment.

Some of the more common things that telemonitoring devices keep track of include blood pressure, heart rate, weight, blood glucose, and hemoglobin. Telemonitoring is capable of providing information about any vital signs, as long as the patient has the necessary monitoring equipment at his or her location. Depending on the severity of the patient's condition, the provider may check these statistics on a daily or weekly basis to determine the best course of treatment.

Cardiac MonitorRemote Patient MonitoringVital Signs MonitorTelemedicine SystemPortable Heart MonitorHolter MonitorPortable Ekg Monitor in 1989 under the leadership of its president and founder, S.Eric Wachtel. A year later the company introduced a mobile cellular version, the MDphone. Twelve hospitals in the U.S. served as receiving and treatment centers.

The first Ayurvedic telemedicine center was established in India in 2007 by Partap Chauhan, a well-known Indian Ayurvedic doctor.

Monitoring a patient at home using known devices like blood pressure monitors and transferring the information to a caregiver is a fast growing emerging service. These remote monitoring solutions have a focus on current high morbidity chronic diseases and are mainly deployed for the First World. In developing countries a new way of practicing telemedicine is emerging better known as Primary Remote Diagnostic Visits, whereby a doctor uses devices to remotely examine and treat a patient. This new technology and principle of practicing medicine holds significant promise of improving on major health care delivery problems, in for instance, Southern Africa, because Primary Remote Diagnostic Consultations not only monitors an already diagnosed chronic disease, but has the promise to diagnose and manage the diseases a patient will typically visit a general practitioner for.

Telecardiology

ECGs, or electrocardiographs, can be transmitted using telephone and wireless. Willem Einthoven, the inventor of the ECG, actually did tests with transmission of ECG via telephone lines. This was because the hospital did not allow him to move patients outside the hospital to his laboratory for testing of his new device. In 1906 Einthoven came up with a way to transmit the data from the hospital directly to his lab.

Teletransmission of ECG using indigenous methods. One of the oldest known telecardiology system (teletransmission of ECG) was established in Gwalior, India in 1975 at GR Medical college by Dr. Ajai Shanker, Dr. S. Makhija, P.K. Mantri using indegenous technique for the first time in India.

This system enabled wireless transmission of ECG from the moving ICU van or the patients home to the central station in ICU of the department of Medicine. Transmission using wireless was done using frequency modulation which eliminated noise. Transmission was also done through telephone lines. The ECG output was connected to the telephone input using a modulator which converted ECG into high frequency sound. At the other end a demodulator reconverted the sound into ECG with a good gain accuracy. The ECG was converted to sound waves with a frequency varying from 500 Hz to 2500 Hz with 1500 Hz at baseline.

This system was also used to monitor patients with pacemakers in remote areas. The central control unit at the ICU was able to correctly interpret arrhythmia. This technique helped medical aid reach in remote areas.

In addition, Electronic stethoscopes can be used as recording devices, which is helpful for purposes of telecardiology.

In Pakistan a pilot project in telemedicine was initiated by the Electronic Government Directorate in collaboration with Oratier Technologies (a pioneer company within Pakistan dealing with healthcare and HMIS) and PakDataCom (a bandwidth provider). Three hub stations through were linked with VSat and four districts were linked with another hub. A 312 Kb link was also established with remote sites and 1 Mbps bandwidth was provided at each hub. Three Hubs, i.e. Mayo Hospital (the largest hospital in Asia), JPMC Karachi and Holy Family Rawalpindi were established. These 12 remote sites were connected and on average 2,000 patient were being treated per month by a single hub.

Teleradiology

A CT exam displayed through teleradiology

Teleradiology is the ability to send radiographic images (x-rays, CT, MR, PET/CT, SPECT/CT, MG, US...) from one location to another. For this process to be implemented, three essential components are required, an image sending station, a transmission network, and a receiving-image review station. The most typical implementation are two computers connected via the Internet. The computer at the receiving end will need to have a high-quality display screen that has been tested and cleared for clinical purposes. Sometimes the receiving computer will have a printer so that images can be printed for convenience.

The teleradiology process begins at the image sending station. The radiographic image and a modem or other connection are required for this first step. The image is scanned and then sent via the network connection to the receiving computer.

Today's high-speed broadband based Internet enables the use of new technologies for teleradiology : the image reviewer can now have access to distant servers in order to view an exam. Therefore, they do not need particular workstations to view the images ; a standard Personal Computer (PC) and Digital Subscriber Line (DSL) connection is enough to reach keosys central server. No particular software is necessary on the PC and the images can be reached from wherever in the world.

Teleradiology is the most popular use for telemedicine and accounts for at least 50% of all telemedicine usage.

Telepsychiatry

Telepsychiatry, another aspect of telemedicine, also utilizes videoconferencing for patients residing in underserved areas to access psychiatric services. It offers wide range of services to the patients and providers, such as consultation between the psychiatrists, educational clinical program, diagnosis and assessment, medication therapy management, etc.

The following are some of the model programs and projects which are undergoing for implementation of telepsychiatry in rural areas in the US.

1. University of Colorado Health Sciences Center (UCHSC) supports two programs for American Indian and Alaskan Native populations

    a. The Center for Native American Telehealth and Tele-education (CNATT) and
    b. Telemental Health Treatment for American Indian Veterans with Posttraumatic Stress Disorder (PTSD)

2. Military Psychiatry, Walter Reed Army Medical Center.

Links for several sites related to telemedicine, telepsychiatry policy, guidelines, and networking are available at the website for the American Psychiatric Association.

Telepharmacy

Telepharmacy is another growing trend for providing pharmaceutical care to the patients at remote locations where they may not have physical contact with pharmacists. It encompasses drug therapy monitoring, patient counseling, prior authorization, refill authorization, monitoring formulary compliance with the aid of teleconferencing or videoconferencing. In addition, video-conferencing is vastly utilized in pharmacy for other purposes, such as providing education, training, and performing several management functions.

A notable telepharmacy program in the United States conducted at a federally qualified community health center, Community Health Association of Spokane (CHAS) in 2001, which allowed the low cost medication dispensing under federal government's program. This program utilized videotelephony for dispensing medication and patient counseling at six urban and rural clinics. There were one base pharmacy and five remote clinics in several areas of Spokane, Washington under the telepharmacy program at CHAS. "The base pharmacy provided traditional pharmacy study to the clients at Valley clinic and served as the hub pharmacy for the other remote clinics."

The remote site dispensing and patient education process was described as follows: once the prescription is sent from the remote clinics to the base pharmacy, the pharmacist verifies the hard copy and enters the order. The label is also generated simultaneously, and the label queue is transmitted to the remote site. When the label queue appears on the medication dispensing cabinet known as ADDS, the authorized person can access the medicine from ADDS followed by medication barcode scanning, and the printing and scanning of labels. Once those steps are done, the remote site personnel are connected to the pharmacist at base pharmacy via videoconferencing for medication verification and patient counseling.

In recent time, the U.S. Navy Bureau of Medicine took a significant step in advancing telepharmacy worldwide. The telepharmacy program was piloted in 2006 “in the regions served by Naval Hospital Pensacola, Florida, and Naval Hospital Bremerton, Washington.” Starting from March 2010, the Navy expanded its telepharmacy system to more sites throughout the world. According to Navy Lieutenant Justin Eubanks at Navy Hospital Pensacola, Florida, telepharmacy would be initiated at more than 100 Navy sites covering four continents by the end of 2010.

Licensing, regulatory issues & telemedicine

Restrictive licensure laws in the United States require a practitioner to obtain a full license to deliver telemedicine care across state lines. Typically, states with restrictive licensure laws also have several exceptions (varying from state to state) that may release an out-of-state practitioner from the additional burden of obtaining such a license. A number of States require practitioners who seek compensation to frequently deliver interstate care to acquire a full license. If a practitioner serves several states, obtaining this license in each state could be an expensive and time-consuming proposition. Even if the practitioner never practices medicine face-to-face with a patient in another state, he/she still must meet a variety of other individual state requirements, including paying substantial licensure fees, passing additional oral and written examinations, and traveling for interviews. Regulations concerning the practice of Telemedicine vary from state to state.. Physicians who will be prescribing over the Internet to patients should mandate strict controls on their practice to insure that they stay compliant with the various State Medical Board Regulations concerning Internet Prescribing.

Chapter 11

Telephone Triage & Telecare

Telephone Triage

Telephone triage is defined as the management of patient health concerns and symptoms via a telephone interaction (telecommunications) by “advice nurses”. It is thus an aspect of telenursing. It can also be considered an aspect of telemedicine and telehealth utilizing an older form of technology (telephone lines). Telehealth is defined as the delivery of health related services and information via telecommunications technologies and is now the umbrella term describing all the possible variations of healthcare services using telecommunications.

Uses of Telephone Triage

Triage means a sorting out. Telephone triage nurses utilize protocols or guidelines, in paper or electronic format to help sort symptoms, from “chest pain to chicken pox”. Telephone triage involves ranking clients' health problems according to their urgency, educating and advising clients, and making safe, effective, and appropriate dispositions—all by telephone. It may include everything from disease management, AIDS counseling and child abuse hotlines to 911 and telemetry monitoring, and takes place in settings as diverse as emergency rooms, large call centers and hospices.

Telephone triage nurses have a range of titles: “advice nurses”, “telepractitioners”, “telenurses”, “telepractice nurses” or “consulting nurses”. In one 8-hour shift, a telenurse may field 60-80 telephone calls—one every 6 – 10 minutes—painstakingly assessing headaches, newborn rashes, chest pain, possible allergic reactions, medication questions, and seasonal flu and fevers. Nurses may also direct clients to obtain a second medical opinion, or advise them where to find relevant, current health information. They might counsel or perform crisis intervention for a threatened suicide. What was traditionally done informally in emergency rooms, clinics, and physicians' offices for years has evolved into a new nursing subspecialty called telephone triage.

Telenurses practice in a range of settings, from large medical call centers, physician’s offices, clinics, hospices, college health centers, disease management call centers, poison centers, and emergency departments.

Research on Telenurse Decision-making

Telephone triage — the safe, effective and appropriate disposition of health related problems by RNs — always involves "decision-making under conditions of uncertainty and urgency." (Patel, 1996) "Uncertainty" because decisions are often made based on partial or inaccurate information; "urgency" because calls must be processed within a brief time frame — usually 6–10 minutes average. In new research, telephone triage has been compared to the work of air traffic controllers, EMDs and firefighters — all high stakes activities. Vimla Patel, Ph.D., described how a group of RNs working in an emergency department setting made "real world" decisions in telephone triage. She discovered that these nurses used pattern recognition, rules of thumb and context as major strategies to make decisions.

Protocols

Protocols or guidelines are essentially" standing orders" for nurses for the assessment and management of a range of symptoms. Protocols may be in paper or electronic format. Some developers see protocols as decision-making tools; others as decision support tools. This is an area of controversy in this new field.

The research on nurse decision-making by Patel and other experts has important implications for protocol design. The strategies of pattern recognition, rules of thumb and context should be incorporated into all elements of any decision support system as well as telenurse training and forms. The goal should be to mimic how the brain naturally solves problems in "real world" situations.

Telephone triage is a high-risk area of practice, primarily because nurses cannot see the patient with whom they are speaking. Thus, training and guidelines are essential to support the nurse. Relying on protocols to take the place of formal instruction can be a mistake, and over reliance on a decision-making tool can lead to mistriage.

Generally, experience and specialized training combined with strong decision support tools are the best approach to telepractice. Potential problems and misunderstandings can be averted through instruction in the correct and safe operation of the protocols and documentation form. gowri

Brief history

Informal telephone triage is as old as the telephone itself. In fact, one of the first calls made by Alexander Graham Bell was for assistance following a battery acid burn (Grumet, 1979). In the early days, physicians were quick to install telephones in their offices, seeing that these new tools could help their practices. Initially, physicians performed telephone advice. Telephone management has always comprised a large percentage of several physicians' practices – pediatrics, Women's Health and Family Practice specialties.

In the 1970s, several health maintenance organizations began utilizing nurses to give telephone advice—in the role that physicians once served. A wide variety of similar systems have sprung up over the last decade. In 1990, the term "telephone triage" appeared on Medline indexes—a formal acknowledgement of this new subspecialty.

Telephone triage formalization

In the early 70's, telephone triage had few job qualifications—most nurses were felt to be qualified. As the field evolved into a recognized subspecialty, managers discovered that the high-stakes, high stress work required seasoned RNs with many years of "bedside" decision-making experience. Thus, new graduates were not considered the best candidates for the task of telephone triage.

Certainly, there are exceptions to this rule. However, we know that less experience results in over triage (Patel, 1996), while increased experience results in more appropriate decisions. The new RN, with little or no bedside decision-making experience will require time to build up these skills. Whether in the clinic, office, hospital or in the emergency department setting, five to ten year's experience provides the foundation necessary for good decision making by phone—a considerably more difficult task.

RNs are considered the best choice not only because they are autonomous professionals, but they are also "the lowest paid person who can safely do the job" (Schmitt, 1980). Telephone triage requires excellence in interpersonal skill or "telephone charisma" (articulate, personable, resourceful, dedication to service). There must be a good match between the work—high volume, high-pressure decision making under conditions of uncertainty and urgent—and the practitioner's temperament—calm, mature and patient. Computer literacy is desirable.

Since the 70's most training was "on the job", essentially "see one, do one, teach one". Each new advice nurse had to learn through trial and error, essentially "reinventing the training wheel" with each new employee. In the 90's, formal training programs emerged. Currently, the best training programs have a minimum of 40 hours. Orientation addresses an overview of the field and the nursing role, the nursing process, communication aspects, history taking, interview and documentation skills, protocol use and medical legal aspects.

Two types of training and education currently exist—in-house and national conferences. In house trainers employ a variety of training methodologies, since research demonstrates that individuals learn differently and learning happens best when all senses are utilized. In-house training techniques include reading, lecture, discussion, "shadowing", written exercises in interview and documentation, audiotapes analysis/critique, preceptor programs and role-play of mock calls. Role-play is an excellent method to cumulatively integrate the new skills and tools (protocols and documentation form) and to simulate the actual task. Preceptors can support and counsel the new advice nurse in the first three to six months.

National conferences provide a broad perspective and opportunity to network and problem solves. Since 1994, conferences on telephone triage have provided a national forum for manager and practitioner alike to network and share experience and expertise. The final step in formal education will be accreditation—not yet a reality—but anticipated within the next five to ten years.

Telecare

Telecare is a term given to offering remote care of old and physically less able people, providing the care and reassurance needed to allow them to remain living in their own homes. The use of sensors may be part of a package which can provide support for people with illnesses such as dementia, or people at risk of falling. In 2005 the UK's Department of Health published *Building Telecare in England* to coincide with the announcement of a grant to help encourage its take up by local councils with social care responsibilities.

Most telecare mitigates harm by reacting to untoward events and raising a help response quickly. Some telecare, such as safety confirmation and lifestyle monitoring have a preventive function in that a deterioration in the telecare user's wellbeing can be spotted at an early stage.

Telecare is specifically different from telemedicine and telehealth. Telecare refers to the idea of enabling people to remain independent in their own homes by providing person-centred technologies to support the individual or their carers.

In its simplest form, it can refer to a fixed or mobile telephone with a connection to a monitoring centre through which the user can raise an alarm. Technologically more advanced systems use sensors, whereby a range of potential risks can be monitored. These may include falls, as well as environmental changes in the home such as floods, fire and gas leaks. Carers of people with dementia my be alerted if the person leaves the house or other defined area. When a sensor is activated it sends a radio signal to a central unit in the user's home, which then automatically calls a 24-hour monitoring centre where trained operators can take appropriate action, whether it be contacting a local key holder, doctor or the emergency services.

Telecare also comprises standalone telecare which does not send signals to a response centre but supports carers through providing local (in-house) alerts in a person's home to let the carer know when a person requires attention.

The meaning and usage of the term 'telecare' has not yet settled into consistent use. In the UK it is grounded in the social care framework and focuses on the meaning described above. In other countries 'telecare' may be applied to the practice of healthcare at a distance.

Technological advances result in the possibility of promoting independence and for providing care from the social initiative sector, which now contemplates eCare, and navigation/positioning systems, such as GPS for people with dementia or other cognitive impairments.

It is important to note that 'telecare' is not just a warning system if someone strays from home but is also preventative measure whereby people are brought back and kept in the community through regular communication.

Chapter 12

Telenursing & Remote Guidance

Telenursing

Telenursing refers to the use of telecommunications and information technology for providing nursing services in health care whenever a large physical distance exists between patient and nurse, or between any number of nurses. As a field it is part of telehealth, and has many points of contacts with other medical and non-medical applications, such as telediagnosis, teleconsultation, telemonitoring, etc.

Telenursing is achieving a large rate of growth in many countries, due to several factors: the preoccupation in driving down the costs of health care, an increase in the number of aging and chronically ill population, and the increase in coverage of health care to distant, rural, small or sparsely populated regions. Among its many benefits, telenursing may help solve increasing shortages of nurses; to reduce distances and save travel time, and to keep patients out of hospital. A greater degree of job satisfaction has been registered among telenurses.

Applications

One of the most distinctive telenursing applications is home care. For example, patients who are immobilized, or live in remote or difficult to reach places, citizens who have chronic ailments, such as chronic obstructive pulmonary disease, diabetes, congestive heart disease, or disabilitating diseases, such as neural degenerative diseases (Parkinson's disease, Alzheimer's disease, ALS), etc., may stay at home and be "visited" and assisted regularly by a nurse via videoconferencing, internet, videophone, etc. Still other applications of home care are the care of patients in immediate post-surgical situations, the care of wounds, ostomies, handicapped individuals, etc. In normal home health care, one nurse is able to visit up to 5-7 patients per day. Using telenursing, one nurse can “visit” 12-16 patients in the same amount of time. [Needs source]

A common application of telenursing is also used by call centers operated by managed care organizations, which are staffed by registered nurses who act as case managers or perform patient triage, information and counseling as a means of regulating patient access and flow and decrease the use of emergency rooms.

Telenursing can also involve other activities such as patient education, nursing teleconsultations, examination of results of medical tests and exams, and assistance to physicians in the implementation of medical treatment protocols.

Legal, ethical and regulatory issues

Telenursing is fraught with legal, ethical and regulatory issues, as it happens with telehealth as a whole. In many countries, interstate and intercountry practice of telenursing is forbidden (the attending nurse must have a license both in her state/country of residence and in the state/country where the patient receiving telecare is located). Legal issues such as accountability and malpractice, etc. are also still largely unsolved and difficult to address.

In addition, there are many considerations related to patient confidentiality and safety of clinical data.

Remote Guidance

Remote guidance, in the medical context, refers to the supervision or guidance of a medical task, usually a procedures or test, from a remote location. This falls in the realm of real time telemedicine applications. By way of example, a radiologist may guide an ultrasound examination from a remote location. As such the proximate requisite expertise to accomplish a medical task is significantly diminished. In the previous example, a diagnostic quality ultrasound can be accomplished by non-medically trained individuals manipulating an ultrasound device located with the patient under guidance from a remote location. This is an example of teleradiology If appropriately configured, the remote guidance can originate from another room or floor in the same building, to as far away as another continent or even planet. NASA researchers have successfully demonstrated remote guidance of diagnostic level cardiac ultrasonography using an ultrasound on the space station, non-medical astronauts performing the exam as guided by a terrestrially located expert.

Remote diagnostics

Remote diagnostics refers to a real time telemedical application which achieves diagnostic level quality and information exchange. In this sense, it refers to an expectation for quality sufficient for making or excluding a medical diagnosis. In the tele-medical context specific to radiologic images these images often are consistent with the DICOM standard. Given bandwidth issues universally plaguing the healthcare environment imagery beyond still images and brief video has not yet become standard expectation of care environments or PACS systems. Ultrasound scanning commonly utilized for abdomen, musculoskeletal, pelvis, gynecologic, cardiac and vascular evaluations has shown potential for remote diagnosis only of late.

More general Remote Diagnostics (RD) refers to detecting which fault or faults are present in a system, body of object, from a distance. Examples of use: aeroplanes, spacecrafts, Formula 1 and major assests such as ships,trains etc. In cases where also corrective actions are made, the term 'Remote Diagnostic & Maintenance' is more appropriate.

Technical aspects

While still imagery can be e-mailed and forwarded in a multitude of methods, video product of medical devices has typically not been available for remote interaction. Recent improvements in scanning devices, for example ultrasound machines has facilitated this new capability. The inclusion of the VGA output gives the opportunity for frame grabber devices to stream such outputs to the internet.

Chapter 13

Teledermatology

Teledermatology is a subspecialty in the medical field of dermatology and probably one of the most common applications of telemedicine and e-health. In teledermatology, telecommunication technologies are used to exchange medical information (concerning skin conditions and tumours of the skin) over a distance using audio, visual and data communication. Applications comprise health care management such as diagnoses, consultation and treatment as well as (continuous) education.

The dermatologists Perednia and Brown were the first to coin the term "teledermatology" in 1995. In a scientific publication, they described the value of a teledermatologic service in a rural area underserved by dermatologists.

Modes of data transmission

Teledermatology (as telemedicine) is practised on the basis of two concepts: **Store and forward (SAF)** and **real time/live interactive teledermatology**. Hybrid modes also exist (combining SAF and real time applications).

The SAF method is most commonly used in teledermatology: It involves sending (forwarding) digital images associated with (anonymous) medical information to the data storage unit of a consulted specialist. It can be as easy as sending an email with a digital image of a lesion to seek advice for a skin condition. Advantages of this method are that it does not demand the presence of both parties at the same time and does not usually require expensive equipment.

In real-time/ live interactive teledermatology applications, provider and individuals usually interact via live videoconferencing. It may also involve remote surgery and the use of telerobotic microscopes in dermatopathology. This mode generally requires more sophisticated and costly technology than used in the SAF mode. Both participants must be available at the same time.

Areas of application

Health care management

Direct consultation involves an individual with a skin condition contacting a dermatologist via telecommunication to request diagnosis and treatment. In this field, mobile applications of teledermatology gain importance.

Telediagnosis in the absence of personal contact with health care workers to the individual is complex. It requires active participation of the individual and without appropriate guidance may lead to improper management. However, as a triage tool, leading the individual directly to the appropriate specialist for his/her disease, it could be very valuable in the near future.

Specialist referral is a major area of application in teledermatology A general practitioner (or other medical professional) that sees the individual consults a specialist/ specialised centre via telecommunication in order to get a second opinion. The specialist then helps the GP in rendering a diagnosis, providing management options et cetera.

Home telehealth/telehomecare involves an individual with a chronic condition being examined and managed remotely at home. An important field of interest of telehomecare in dermatology is the follow-up treatment of individuals with skin conditions requiring regular follow-up such as crural ulcers. Crural ulcers are a common skin condition that needs follow up visits up to twice a week demanding significant time commitments by the individuals in addition to causing a financial burden on the health care system. Teledermatology can help to reduce the time and costs involved in the follow up of such conditions.

Education and information

Medical education/continuous education are a major advantage of telemedicine/e-health. Numerous universities offer online courses, computer based training and Web applications in this field principally aimed at medical students. Specialist training courses via internet are also available, particularly in dermoscopy.

General medical/health information may be accessed by non-professionals, such as individuals affected by a skin condition, and their relatives, through the internet. They are also able to join peer support groups with others affected by the same condition.

Domains with special interest

Teledermoscopy

In teledermoscopy, digital dermoscopic lesion images (with or without clinical images) are transmitted electronically to a specialist for examination.

Dermoscopy (dermatoscopy, epiluminescence microscopy) is the technical field of using an epiluminescence microscope for viewing skin lesions in magnification in-vivo. It is particularly useful in the early detection of malignant skin lesions (i.e., melanoma). Digital dermoscopic images can be taken with a digital camera attached to a dermatoscope or special video cameras suited for dermoscopy, e.g. the FotoFinder. Since dermoscopy is based on examination of a two-dimensional image it is very well suited for digital imaging and teledermatology.

Teledermatopathology

Teledermatopathology is the transmission of dermatopathologic images either in real-time with the aid of a robotic microscope or using a store-and-forward system (transmission as a single file). In the latter method (SAF) a rather new development is the introduction of virtual slide systems (VSS).

Virtual slides are made by digitally scanning an entire glass slide at a high resolution and then sending the images to a storage system. These can be then assessed on a computer screen similar to conventional microscopy, allowing the pathologist to maneuver around the image and view every part of the slide at any magnification.

Teledermoscopically-aided dermatopathology

This is the transmission of crucial medical data and dermoscopic as well as clinical images to a pathologist who renders the conventional histopathologic diagnosis.

In the everyday clinical setting, skin biopsies are taken by the physician directly responsible for the individual and are assessed by a dermatopathologist. This pathologist has most likely never seen the clinical aspect of the lesion and might not have any information about the person. These limitations can be overcome by teledermoscopically-aided dermatopathology whereby a patient history and clinical data may increase the sensitivity of diagnosis.

Additionally it has been shown that provision of such data may improve the level of diagnostic confidence held by the assessing dermatopathologists.

Mobile Teledermatology

Mobile telemedicine is a system in which at least one participant (the person seeking advice or the doctor, for instance) uses wireless or mobile equipment (i.e. mobile phones, handheld devices), in contrast to conventional stationary telemedicine platforms. Travellers who develop skin lesions as well as doctors who are on the move in hospital/non-hospital area can benefit from this new development in teledermatology. In order to facilitate access to medical advice and enable individuals to play a more active role in managing their own health status, mobile teledermatology seems to be especially suited for patient filtering or triage. (i.e. referral based on the severity and character of their skin condition). Another possible practical application is for follow-up of individuals with chronic skin conditions mentioned above.

Suitability of cases for Teledermatology

Not all cases are suitable for teledermatology.The type of cases suited for teledermatology is a topic, which requires more studies. Some studies have observed that eczema and follicular lesions were diagnosed with relatively more certainty,while in some other studies it was seen that diagnoses were made with more certainty in cases like viral warts, herpes zoster, acne vulgaris, irritant dermatitis, vitiligo, and superficial bacterial and fungal infections. Unlike in western studies where pigmented lesions suspicious of melanomas are one of the most referred cases for teledermatology (with or without teledermatoscopy), Asian studies have fewer cases referred based on the suspicion of melanoma.

Chapter 14

Teleradiology

Teleradiology is the transmission of radiological patient images, such as x-rays, CTs, and MRIs, from one location to another for the purposes of interpretation and/or consultation. Teleradiology is a growth technology given that imaging procedures are growing approximately 15% annually against an increase of only 2% in the Radiologist population.

Teleradiology improves patient care by allowing Radiologists to provide services without actually having to be at the location of the patient. This is particularly important when a sub-specialist such as a MRI Radiologist, Neuroradiologist, Pediatric Radiologist, or Musculoskeletal Radiologist is needed, since these professionals are generally only located in large metropolitan areas working during day time hours. Teleradiology allows for trained specialists to be available 24/7.

Teleradiology utilizes standard network technologies such as the internet, telephone lines, wide area network (WAN), or over a local area network (LAN). Specialized software is used to transmit the images and enable the Radiologist to effectively analyze what can be hundreds of images for a given study. Technologies such as advanced graphics processing, voice recognition, and image compression are often used in Teleradiology. Through Teleradiology, images can be sent to another part of the hospital, or to other locations around the world.

Reports

Teleradiologists can provide a Preliminary Read for emergency room cases and other emergent cases or a Final Read for the official patient record and for use in billing.

Preliminary Reports include all pertinent findings and a phone call for any critical findings. For some Teleradiology services, the turnaround time is extremely rapid with a 30 minute standard turnaround and expedited for critical and stroke studies.

Teleradiology Final Reports can be provided for emergent and non-emergent studies. Final reports include all findings and require access to prior studies and all relevant patient information for a complete diagnosis. Phone calls with any critical findings are signs of quality services.

Teleradiology Preliminary or Final Reports can be provided for all doctors and hospitals overflow studies. Teleradiology can be available for intermittent coverage as an extension of practices and will provide patients with the highest quality care.

Subspecialties

Some teleradiologists are fellowship trained and have a wide variety of subspecialty expertise including such difficult-to-find areas as Neuroradiology, Pediatric Neuroradiology, Musculo-skeletal MRI, Mammography, Nuclear Cardiology.

Regulations

In the United States, Medicare and Medicaid laws require the Teleradiologist to be on U.S. soil in order to qualify for reimbursement of the Final Read.

In addition, advanced teleradiology systems must also be HIPAA compliant, which helps to ensure patients' privacy. HIPAA (Health Insurance Portability and Accountability Act of 1996) is a uniform, federal floor of privacy protections for consumers. It limits the ways that entities can use patients' personal information and protects the privacy of all medical information no matter what form it is in. Quality teleradiology must abide by important HIPAA rules to ensure patients' privacy is protected.

Also State laws governing the licensing requirements and medical malpractice insurance coverage required for physicians vary from state to state. Ensuring compliance with these laws is a significant overhead expense for larger multi-state teleradiology groups.

Industry growth

Until the late 1990s teleradiology was primarily used by individual radiologists to interpret occasional emergency studies from offsite locations, often in the radiologists home. The connections were made through standard analog phone lines.

Teleradiology expanded rapidly as the growth of the internet and broad band combined with new CT scanner technology to become an essential tool in trauma cases in emergency rooms throughout the country. The occasional 2-3 x ray studies a week soon became 3-10 CT scans, or more, a night. Because ER physicians are not trained to read CT scans or MRI's, radiologists went from working 8–10 hours a day, five and half days a week to a schedule of 24 hours a day, 7 days a week coverage. This became a particularly acute challenge in smaller rural facilities that only had one solo radiologist with no other to share call.

These circumstances spawned a post dot.com boom of firms and groups that provided outsourced, off-site teleradiology on-call services to hospitals and Radiology Groups around the country. As an example, a teleradiology firm might cover trauma at a hospital in Indiana with doctors based in Texas. Some firms even used overseas doctors in locations like Australia and India. Nighthawk, founded by Dr. Paul Berger, was the first to station U.S. licensed radiologists overseas (initially Australia and later Switzerland) to maximize the time zone difference to provide nightcall in U.S. hospitals.

The early innovators in this field like Teleradiology Solutions, Nighthawk Radiology, The Radlinx Group, and Virtual Radiology Consultants (VRC or VRN most recently), became multi million dollar companies today. Nighthawk (symbol: NHWK) and VRC (symbol: VRAD) ultimately went public and established almost a billion dollars in market capitalization.

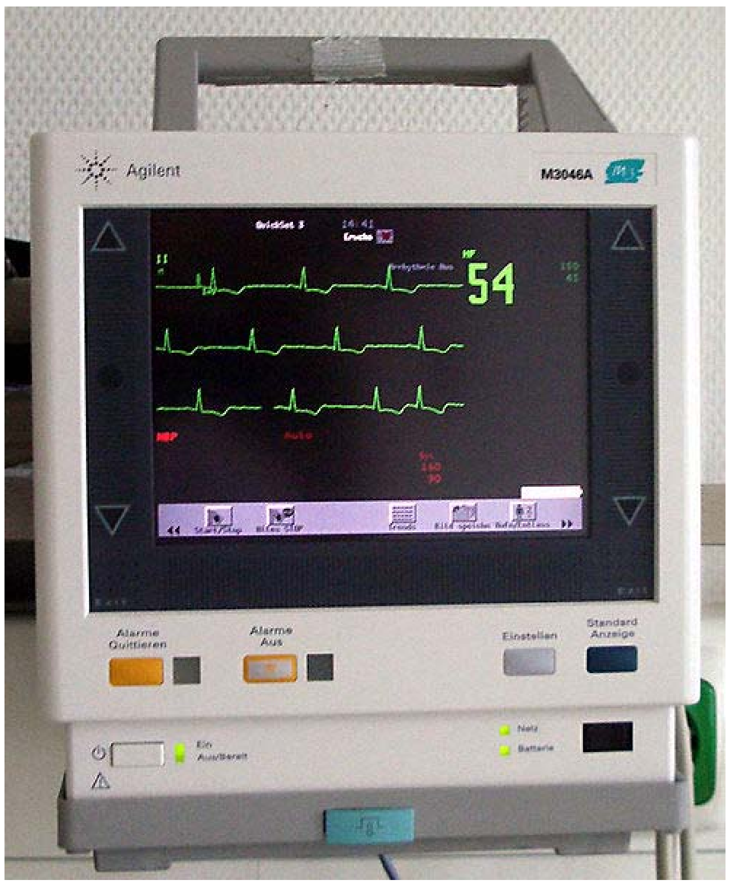
However, on May 17, 2010 Providence Equity Partners acquired and took private Virtual Radiologic. Moreover, on September, 27, 2010, Virtual Radiologic and NightHawk Radiology Announced their Merger.

The Radlinx Group, founded by Greg Lowenstein and Mark Bakken, pioneered the expansion of teleradiology services beyond just night coverage to also provide coverage to hundreds of small rural hospitals and clinics, throughout the U.S., who otherwise had no on-site access to full-time radiologists.

Currently teleradiology firms are facing pricing pressures. Industry consolidation is likely as there are more than 500 of these firms, large and small, throughout the United States.

Chapter 15

Medical Monitor



Medical monitor as used in anesthesia

A **medical monitor** or **physiological monitor** or display, is an electronic medical device that measures a patient's vital signs and displays the data so obtained, which may or may not be transmitted on a monitoring network. Physiological data are displayed continuously on a CRT or LCD screen as data channels along the time axis, They may be accompanied by numerical readouts of computed parameters on the original data, such as maximum, minimum and average values, pulse and respiratory frequencies, and so on.

In critical care units of hospitals, bedside units allow continuous monitoring of a patient, with medical staff being continuously informed of the changes in general condition of a patient. Some monitors can even warn of pending fatal cardiac conditions before visible signs are noticeable to clinical staff, such as atrial fibrillation or premature ventricular contraction (PVC).

Analog monitoring

Old analog patient monitors were based on oscilloscopes, and had one channel only, usually reserved for electrocardiographic monitoring (ECG). So, medical monitors tended to be highly specialized. One monitor would track a patient's blood pressure, while another would measure pulse oximetry, another the ECG. Later analog models had a second or third channel displayed in the same screen, usually to monitor respiration movements and blood pressure. These machines were widely used and saved many lives, but they had several restrictions, including sensitivy to electrical interference, base level fluctuations, and absence of numeric readouts and alarms. In addition, although wireless monitoring telemetry was in principle possible (the technology was developed by NASA in the late 1950s for manned spaceflight, it was expensive and cumbersome.

Digital monitoring

With the development of digital signal processing (DSP) technology, however, medical monitors evolved enormously, and all current models are digital, which also has the advantages of miniaturization and portability. Today the trend is toward multiparameter monitors that can track many different vital signs at once. The parameters (or measurements) now consist of pulse oximetry (measurement of the saturated percentage of oxygen in the blood, referred to as SpO2, and measured by an infrared finger cuff), ECG (electrocardiograph of the QRS waves of the heart with or without an accompanying external heart pacemaker), blood pressure (either invasively through an inserted blood pressure transducer assembly, or non-invasively with an inflatable blood pressure cuff), and body temperature through an adhesive pad containing a thermoelectric transducer. In some situations, other parameters can be measured and displayed, such as cardiac output (via an invasive Swan-Ganz catheter), capnography (CO_2 measurements, referred to as EtCO2 or end-tidal carbon dioxide concentration), respiration (through a thoracic transducer belt, an ECG channel or via EtCO2, when it is called AWRR or airway respiratory rate), etc.

Besides the tracings of physiological parameters along time (X axis), digital medical monitors have automated numeric readouts of the peak and/or average parameters displayed on the screen, and high/low alarm levels can be set, which alert the staff when some parameter exceeds of falls the level limits, using audible signals.

Several models of multiparameter monitors are networkable, i.e., they can send their output to a central ICU monitoring station, where a single staff member can observe and respond to several bedside monitors simultaneously. Ambulatory telemetry can also be achieved by portable, battery-operated models which are carried by the patient and which transmit their data via a wireless data connection.

Monitor/Defibrillators

Some digital patient monitors, especially those used EMS services,often incorporate a defibrillator into the patient monitor itself. These monitor/defibrillators usually have the normal capabilities of an ICU monitor, but have manual (and usually semi-automatic AED)defibrillation capability. This is particular good for EMS services, who need a compact, easy to use monitor and defibrillator, as well as for inter- or intrafacility patient transport. Most monitor defibrillators also have transcutaneous pacing capability via large AED like adhesive pads (which often can be used for monitoring, defibrillation and pacing)that are applied to the patient in an anterior-posterior configuration. The monitor defibrillator units often have specialized monitoring parameters such as waveform capnography, invasive BP, and in some monitors, Masimo Rainbow SET pulse oximetry. Examples of monitor defibrillators are the Lifepak 12, 15 and 20 made by Physio Control, the Phillips Heartstart MRx, and the E Series and R Series by ZOLL Medical.

A Welch Allyn PIC 50 monitor/defibrillator from an Austrian EMS service

A closeup view of the screen of the PIC 50

ZOLL R Series Plus external monitor/defibrillator

Special applications

Portable wireless ECG monitor

There are special patient monitors for several applications, such as anesthesia monitoring, which incorporate the monitoring of brain waves (EEG, gas anesthetic concentrations, bispectral index (BIS), etc. They are usually incorporated into anesthesia machines. In neurosurgery intensive care units, brain EEG monitors have a larger multichannel capability and can monitor other physiological events, as well.

Portable heart monitors are now very common too, and they exist in several configurations, ranging from single-channel models for domestic use, which are capable of storing or transmitting the signals for appraisal by a physician, to 12-lead complete, portable ECG machines which can store for 24 hours or more (so-called Holter monitoring devices). There are also portable monitors for blood pressure (MAPA) and EEG.

Monitor types

Monitors may be classified as:

1. Handheld
2. Portable
3. Monitor/Defibrillator (usually portable)
4. Tabletop
5. Networkable / non-networkable

6. Wired / wireless data transmission
7. Mains powered or mains + battery powered

Integration with EHR

Digital monitoring has created the possibility, which is being fully developed, of integrating the physiological data from the patient monitoring networks into the emerging hospital electronic health record and digital charting systems, using appropriate health care standards which have been developed for this purpose by organizations such as IEEE and HL7. This newer method of charting patient data reduces the likelihood of human documentation error and will eventually reduce overall paper consumption. In addition, automated ECG interpretation incorporates diagnostic codes automatically into the charts. Medical monitor's embedded software can take care of the data coding according to these standards and send messages to the medical records application, which decodes them and incorporates the data into the adequate fields.

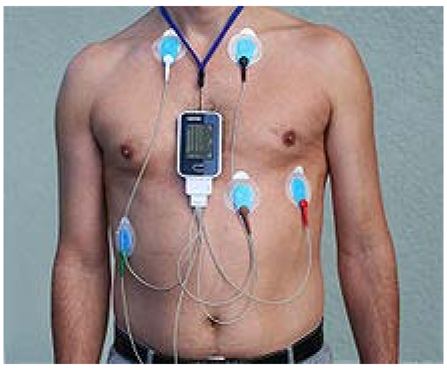
Patient safety

Medical monitors have been safety engineered so that failures are either apparent or unimportant. Some monitors (for example ECG and EEG) have an electrical contact with the patient, so they can be hazardous if electrical current passes through these electrodes in case of grounding failures. There are strict limits on how much current and voltage can be applied, even if the unit fails or becomes wet. They must typically withstand electrical defibrillation without damage.

Chapter 16

Holter Monitor

Holter monitor



Holter monitor

Inventor	Norman Holter

In medicine, a **Holter monitor** (often simply "Holter" or occasionally **ambulatory electrocardiography device**) is a portable device for continuously monitoring various electrical activity of the central nervous system for at least 24 hours (often for two weeks at a time). The Holter's most common use is for monitoring heart activity (electrocardiography or ECG), but it can also be used for monitoring brain activity (electroencephalography or EEG). Its extended recording period is sometimes useful for observing occasional cardiac arrhythmias or epileptic events which would be difficult to identify in a shorter period of time. For patients having more transient symptoms, a cardiac event monitor which can be worn for a month or more can be used.

The Holter monitor is named for physicist Norman J. Holter who invented telemetric cardiac monitoring in 1949. Clinical use started in the early 1960s.

When used for the heart, much like standard electrocardiography the Holter monitor records electrical signals from the heart via a series of electrodes attached to the chest. Electrodes are placed over bones to minimize artifacts from muscular activity. The number and position of electrodes varies by model, but most Holter monitors employ between three and eight. These electrodes are connected to a small piece of equipment that is attached to the patient's belt or hung around the neck, and is responsible for keeping a log of the heart's electrical activity throughout the recording period.

Older devices used reel to reel tapes or a standard C90 or C120 audio cassette and ran at a 1.7mm or 2mm/second speed to record the data. Once a recording was made, it could be played back and analysed at 60x speed so 24 hours of recording could be analysed in 24 minutes. More modern units record onto digital flash memory devices. The data are uploaded into a computer which then automatically analyzes the input, counting ECG complexes, calculating summary statistics such as average heart rate, minimum and maximum heart rate, and finding candidate areas in the recording worthy of further study by the technician.

Recorder

Each Holter system consists of two basic parts – the hardware (called monitor or recorder) for recording the signal and software for review and analysis of the record. Advanced Holter recorders are able to display the signal, which is very useful for checking the signal quality. Very often there is also a “patient button” located on the front site allowing the patient to press it in specific cases such as sickness, going to bed, taking pills…. A special mark will be then placed into the record so that the doctors or technicians can quickly pinpoint these areas when analyzing the signal. More modern devices also have the ability to record a vocal patient diary entry.

Size of recorder differs depending on manufacturer of the device. The average dimensions of today’s Holter monitors are about 110x70x30 mm. Most of the devices operate with two AA batteries. In case the batteries die, some Holters allow their replacement even during monitoring.

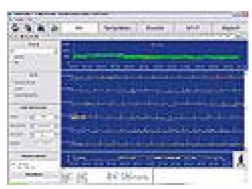
Most of the Holters monitor the ECG just in 2 or 3 channels. Depending on the model (manufacturer), different count of leads and lead systems are used. Today’s trend is to minimize such number to insure the patient’s comfort during recording. Although 2/3 channel recording has been used for a long time in the Holter monitoring history, recently 12 channel Holters have appeared. These systems use the classic Mason-Likar lead system, thus producing the signal in the same representation as during the common rest ECG and/or stress test measurement. These Holters then allow to substitute stress test examination in cases the stress test is not possible for the current patient. They are also suitable when analyzing patients after myocardial infarction. Recordings from these 12 lead monitors are of a significantly lower resolution than those from a standard 12 lead ECG and in some cases have been shown to provide misleading ST segment representation, even though some device allow to set the sampling frequency up to 1000 Hz for special purposes exams like the late potential.

Another interesting innovation is the presence of a 3 axis movement sensor, which record the patient physical activity, and later show in the software three different status: sleep, stand-up, walking. This helps the cardiologist to better analyze the recorded events belong to the patient activity and diary.

Analysing software

When the recording of ECG signal is finished (usually after 24 or 48 hours), it is up to the physician to perform the signal analysis. Since it would be extremely time demanding to browse through such a long signal, there is an integrated automatic analysis process in each Holter software which automatically determines different sorts of heart beats, rhythms, etc. However the success of the automatic analysis is very closely associated with the signal quality. The quality itself mainly depends on the attachment of the electrodes to the patient body. If these are not properly attached, the electromagnetic disturbance surrounding us will influence the ECG signal resulting thus in a very noisy record. If the patient moves rapidly, the distortion will be even bigger. Such record is then very difficult to process. Besides the attachment and quality of electrodes, there are other factors affecting the signal quality, such as muscle tremors, sampling rate and resolution of the digitized signal (high quality devices offer 2000Hz and 16 bits or higher).

The automatic analysis commonly provides the physician with information about heart beat morphology, beat interval measurement, heart rate variability, rhythm overview and patient diary (moments when the patient pressed the patient button). Advanced systems also perform spectral analysis, ischemic burden evaluation, graph of patient's activity or PQ segment analysis. Another requirement is the ability of pacemaker detection and analysis. Such ability is useful when one wants to check the correct pacemaker function.



Screenshot of an holter ecg software

Wearing the monitor

Although some patients may feel uncomfortable about a Holter examination, there is nothing to worry about. No hazards are involved, and it should have little effect on one's normal daily life.

The recording device can be worn in a case on a belt or on a strap across the chest. The device may be visible under light clothing, and those wearing a Holter monitor may wish to avoid shirts with a low neckline.

Persons being monitored should not limit normal daily activities, since its purpose is to record how a heart works under various actual conditions over an extended period. It is an electrical device, however, and should be kept dry; showering or swimming should probably be avoided. Monitors can be removed for a few minutes without invalidating collected data, but proper reattachment is critical to avoid degradation of its signals. Beyond changing batteries, one should leave its handling to trained personnel.

A Holter monitor can be worn for many days without causing significant discomfort

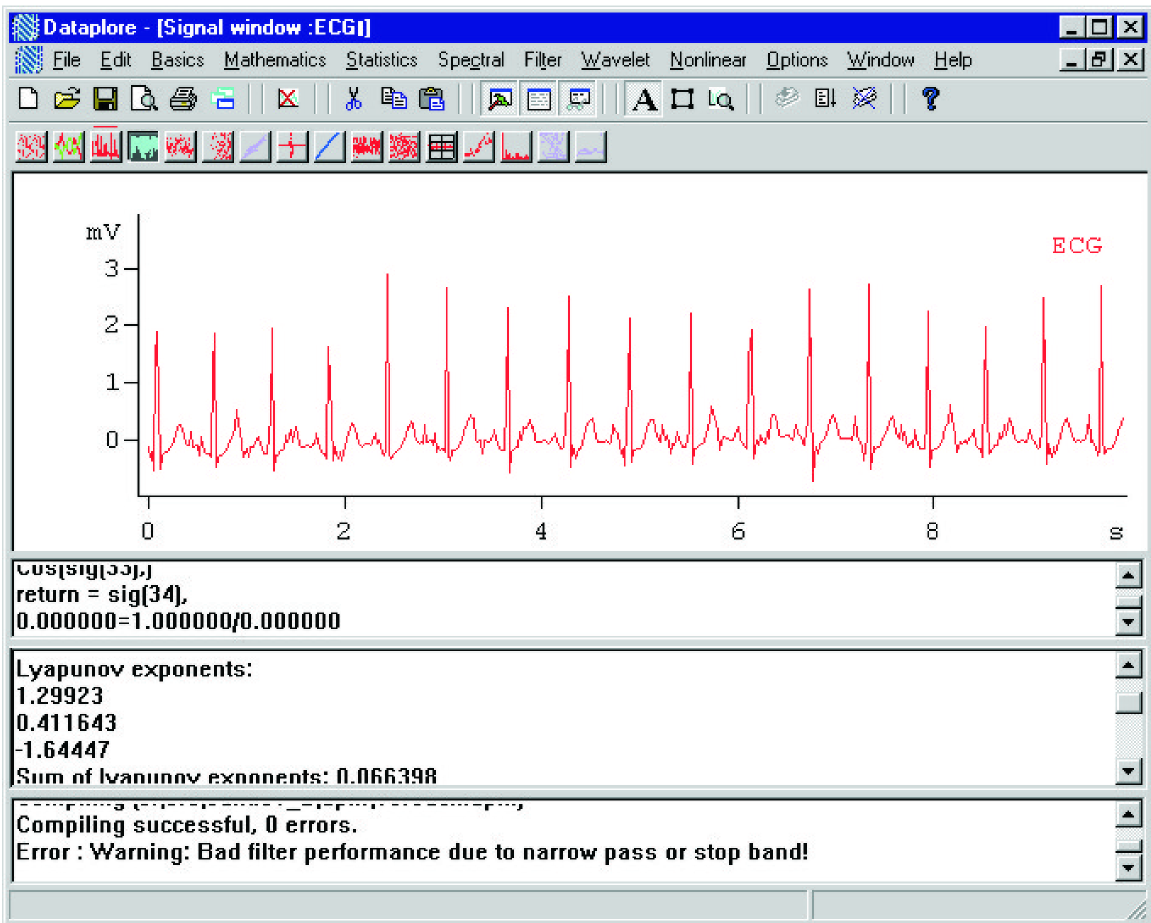
Canine Holter Monitor with DogLeggs Vest

A Holter monitor with a US quarter dollar coin to show scale

Holter monitor can be worn with bra on woman, with no discomfort

Chapter 17

Automated ECG Interpretation



Screenshot of a software for digital ECG processing

Automated ECG interpretation is the use of artificial intelligence and pattern recognition software and knowledge bases to carry out automatically the interpretation, test reporting and computer-aided diagnosis of electrocardiogram tracings obtained usually from a patient.

History

The first automated ECG programs were developed in the 1970s, when digital ECG machines became possible by third generation digital signal processing boards. Commercial models, such as those developed by Hewlett Packard incorporated these programs into clinically-used devices.

During the 1980s and 1990s, extensive research was carried out by companies and by university labs in order to improve the accuracy rate, which was not very large in the first models. For this purpose, several signal databases with normal and abnormal ECGs were built up by institutions such as MIT and used to test the algorithms and its accuracy.

Phases

1. A digital representation of each recorded ECG channel is obtained, by means of an analog-digital conversion device and a special data acquisition software or a digital signal processing (DSP) chip.
2. The resulting digital signal is processed by a series of specialized algorithms, which start by conditioning it, e.g., removal of noise, baselevel variation, etc.
3. Feature extraction: matemathical analysis is now performed on the clean signal of all channels, to identify and measure a number of features which are important for interpretation and diagnosis, this will constitute the input to AI-based programs, such as the peak amplitude, area under the curve, displacement in relation to baseline, etc., of the P, Q, R, S and T waves, the time delay between these peaks and valleys, heart rate frequency (instantaneous and average), and many others. Some sort of secondary processing such as Fourier analysis and wavelet analysis may also be performed in order to provide input to pattern recognition-based programs.
4. Logical processing and pattern recognition, using rule-based expert systems, probabilistic Bayesian analysis or fuzzy logics algorithms, cluster analysis, artificial neural networks, genetic algorithms and others techniques are used to derive conclusions, interpreation and diagnosis
5. A reporting program is activated and produces a proper display of original and calculated data, as well as the results of automated interpretation.
6. In some applications, such as automatic defibrillators, an action of some sort may be triggered by results of the analysis, such as the occurrence of an atrial fibrillation or a cardiac arrest, the sounding of alarms in a medical monitor in intensive-care unit applications, and so on.

Applications

The manufacturing industries of ECG machines is now entirely digital, and many models incorporate embedded software for analysis and interpretation of ECG recordings with 3 or more leads. Consumer products, such as home ECG recorders for simple,1-channel heart arrhythmia detection, also use basic ECG analysis, essentially to detect abnormalities. Some application areas are:

- Incorporation into automatic defibrillators, so that autonomous decision can be reached wheter there is a cause for administering the electrical shock on basis of an atrial or ventricular arryhtmia;
- Portable ECG used in telemedicine. These machines are used to send ECG recordings via a telecommunications link, such as telephone, cellular data communication or Internet
- Conventional ECG machines to be used in primary healthcare settings where a trained cardiologist is not available

Chapter 18

Patient Registration

Patient registration is the concept and set of methods needed to correlate the reference position of a virtual 3D dataset gathered by computer medical imaging with the reference position of the patient. This procedure is crucial in computer assisted surgery, in order to insure the reproducitibility of the preoperative registration and the clinical situation during surgery. The use of the term "patient registration" out of this context can lead to a confusion with the procedure of registering a patient into the files of a medical institution.

The larger context

In computer assisted surgery, the first step is to gather a 3D dataset that reproduces with great accuracy the geometry of the normal and pathological tissues in the region that has to be operated on. This is mainly obtained by using CT or MRI scans of that region. The role of patient registration is to obtain a close-to-ideal reference reproducitibility of the dataset – in order to correlate the position (offset) of the gathered dataset with the patient's position during the surgical intervention. Patient registration (1) eliminates the necessity of maintaining the same strict position of the patient during both preoperative scanning and surgery, and (2) provides the surgical robot the necessary reference information to act accurately on the patient, even if he has (been) moved during the intervention.

Evolution of the concept

Patient registration was used mostly in head surgery – oral and maxillofacial surgery, neurosurgery, otolaryngology. With the advent of marker- and markerless-registration, the concept has been extended for abdominal surgery.

Patient registration using headframes

The first attempts in 3D mapping of human tissues were made by V. Horsley and R. Clarke in 1906. They have built a rectangular stereotactic headframe that had to be fixed to the head. It was based on cartesian principles and allowed them to accurately and reproductibly guide needle-like electrodes for neurophysiological experiments. They have experimented animals and were able to contribute to the mapping of the cerebellum.

Improved versions of the Horsley–Clarke apparatus are still in used today in experimental neurosurgery.

The first stereotactic device for humans was also developed in neurosurgery, by E. Spiegel and H. Wycis in 1947. It was used for surgical treatment of Parkinson's disease and, during time, its applicability was extended for the surgical treatment of tumors, vascular malformations, functional neurosurgery etc. The system was based both on headframes and X-ray images taken for all three planes of space.

Further development of stereotactic surgery was made by Brown, Roberts and Wells in 1980. They have developed a halo ring that was applied on the skull, during a CT scan and neurosurgical interventions. This method provided improved surgical guidance and was in fact the first development of computer guided surgery.

Patient registration for the head area has developed for nearly two decades on the same principle of combining CT scans with mechanical reference devices such as headframes or halo rings. But the clinical experience showed that headgear is very uncomfortable to wear and even impossible to apply on little children, because their lack of cooperation; furthermore, the headframes can create artifacts in preoperative data gathering, or during surgery.

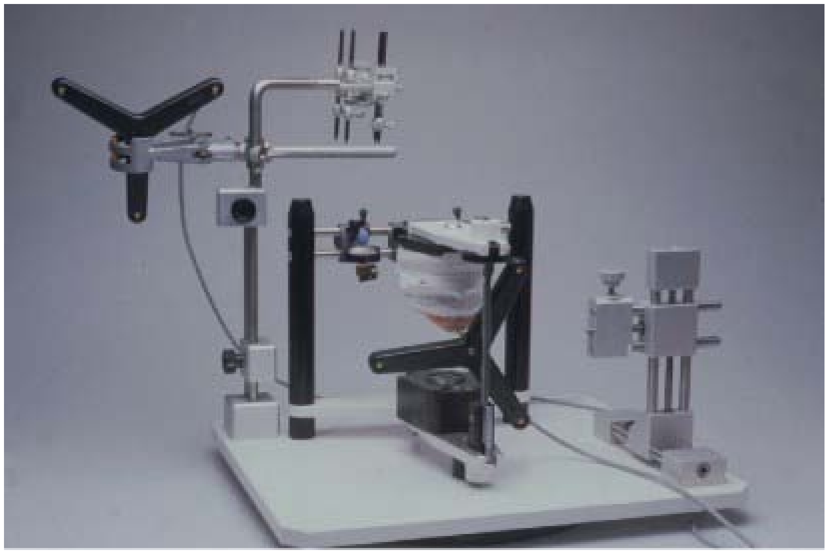
Patient registration using reference markers

Patient registration using skin markers

In 1986, a different approach was developed by Roberts und Strohbehn. They have used as landmarks several markers on the patient's skin both preoperative CT registration, and intraoperatively. This was a new current of the time in patient registration. Still, the method is time-consuming, and the exact reproducitibility of the marker positions is questionable.

Patient registration using bone markers

The bony structures can provide a much better stability and reproducibility of the landmarks for patient registration. Based on this concept, a further technique was used: to implant temporary markers into bone structures that are superficial to the skin, under local anestesia. This was also combined with surface markers and CT registration. The technique has the disadvantage of a further minimal surgical procedure of placing the bone implants, with some risk of infection for the patient.



Surgical planning using bone segment navigation for the osteotomy of the jaw bones, based on models fixed into an articulator (registration based on infrared devices)

Patient registration using markers on a dental splint

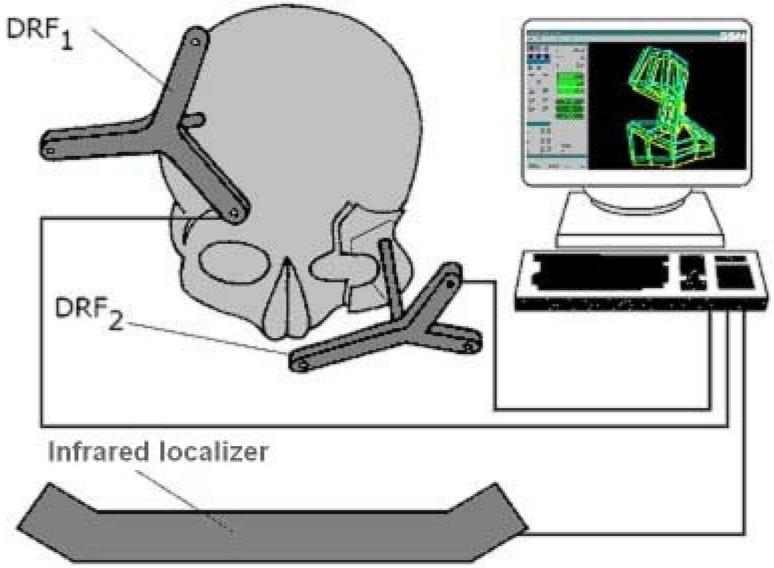
Dental splints have been traditionally used for transferring and reproducing 3D reference landmarks for positioning cast models in articulators – in dental prosthetics, orthodontics and orthognatic surgery. By applying several infrared markers on the splints and using an infrared camera, a better registration was obtained.

Markerless patient registration

Markerless patient registration using anatomical landmarks

The first attempts, based on the identification of anatomical landmarks were made by Caversaccio and Zulliger. The method was based on identifying certain antropometrical points and other anatomical landmarks on the skull, in corelation with the CT registration. But the landmarks cannot be exactly pointed out and reproduced during patient dataset registration and surgery, therefore the method is not precise enough.

Actual usage of the SSN system in the operating room



Schematic representation of the SSN system

Markerless patient registration using surface registration

Since 1998, new procedures have been developed by Marmulla and co-workers, using a different approach to the problem. Both during CT dataset gathering and surgical intervention, the patient registration was made by registering complete areas and surfaces, instead of distinctive surface markers. This was achieved by using laser scanners and a small guiding transmitter. The precision of the patient registration was significantly improved with this method.

Based on this concept, several registration and navigation systems were built by the same team. The Surgical Segment Navigator (SSN and SSN++) is such a system, developed for the first time for oral and maxillofacial surgery. This system correlates three different coordinate sets: CT data set, surface laser scan data set and the dataset produced by a small guiding transmitter, placed on the patient's head. The Laboratory Unit for Computer-Assisted Surgery (LUCAS) is used for planning surgery in the laboratory. This technological and surgical advance has permitted the elimination of mechanical guidance systems and improved the accuracy of the determinations, and thus the surgical act.

Chapter 19

Digital Radiography

Digital radiography is a form of x-ray imaging, where digital X-ray sensors are used instead of traditional photographic film. Advantages include time efficiency through bypassing chemical processing and the ability to digitally transfer and enhance images. Also less radiation can be used to produce an image of similar contrast to conventional radiography.

Digital Radiography (DR) or (DX) is essentially filmless X-ray image capture. In place of X-ray film, a digital image capture device is used to record the X-ray image and make it available as a digital file that can be presented for interpretation and saved as part of the patient's medical record. The advantages of DR over film include immediate image preview and availability, a wider dynamic range which makes it more forgiving for over- and under-exposure as well as the ability to apply special image processing techniques that enhance overall display of the image. The largest motivator for healthcare facilities to adopt DR is its potential to reduce costs associated with processing, managing and storing films. Typically there are two variants of digital image capture devices. These devices include Flat Panel detectors (FPDs), and High Density Line Scan Solid State detectors.

FPDs are classified in two main categories:

1. **Indirect FPD's** - Amorphous silicon (a-Si) is the most frequent type of FPD sold in the medical imaging industry today. Combining a-Si detectors with a scintillator in the detector's outer layer, which is made from Cesium Iodide (CsI), or Gadolinium Oxysulfide (Gd_2O_2S), converts X-ray to light. Because the X-ray energy is converted to light, the a-Si detector is considered an indirect image capture technology. The light is then channeled through the a-Si photodiode layer where it is converted to a digital output signal. The digital signal is then read out by Thin Film Transistors (TFT's) or by fiber coupled Charged Couple Devices (CCD's). The image data file is sent to a computer for display where the X-ray technologist can determine whether the image is appropriate for the intended anatomy. Once the Technologist determines the image is appropriate it can be sent to the radiologist's workstation or printed on film for interpretation.

2. **Direct FPD's** - Amorphous Selenium Flat Panel Detectors (a-Se) are known as "direct" detectors because X-ray photons are converted directly to charge. The outer layer of the flat panel in this design is typically a high voltage bias electrode. The bias

electrode accelerates the captured energy from an X-ray exposure through the amorphous selenium layer. X-ray photons flowing through the selenium layer create electron hole pairs. These electron holes transit through the selenium based on the potential of the bias voltage charge. As the electron holes are replaced with electrons, the resultant charge pattern in the selenium layer is read out by a TFT array, Active Matrix Array, Electrometer Probes or Microplasma Line Addressing. The image data file is sent to a computer for display where the X-ray technologist can review the image and check positioning and if desired, transmit the image to the radiologist's workstation for diagnosis.

A **High Density Line Scan Solid State detector** device is composed of a Photostimulable Barium Fluoro Bromide doped with Europium (BaFlBr:Eu) or Cesium Bromide (CsBr) phosphor. The phosphor detector records the X-ray energy during exposure and is scanned by a linear laser diode to excite the stored energy which is released and read out by a digital image capture array of Charge Coupled Devices (CCD's). The image data file is transmitted to the X-ray technologist at a computer for review and then sent to the radiologist for further interpretation.

Radiological examinations

Dental

The radiological examinations in dentistry may be classified in: **intraoral** - where the film or the sensor is placed in the mouth, the purpose being to visualize a limited region and **extraoral** where the film or the sensor is outside the mouth and the purpose is to visualize a wide region. In dentistry, extraoral imaging splits in: **Panoramic X-ray** (aka "panorex" or "pano") showing a section, curved following more or less mandible shape, of the whole maxillo-facial block and the **Cephalometric** X-ray showing a projection, as parallel as possible, of the whole skull.

Digital radiographic systems

One particular type of digital system uses a Memory Phosphor Plate (a.k.a. PSP—Photostimulable Phosphor) in place of the film. After X-ray exposure the plate (sheet) is placed in a special scanner where the latent formed image is retrieved point by point and digitized, using laser light scanning. The digitized images are stored and displayed on the computer screen. This method is halfway between old film-based technology and current direct digital imaging technology. It is similar to the film process because it involves the same image support handling but differs because the chemical development process is replaced by the scanning process. This is not much faster than film processing and the resolution and sensitivity performances are contested. However, it has the clear advantage to be able to fit within any pre-existing equipment without modification because it replaces just the existing film.

Also, sometimes the term "Digital X-rays" is used to designate the scanned film documents which are handled by further computer processing.

Other types of digital imaging technologies use electronic sensors. A majority of them first convert the X-rays into visible light (using a GdO_2S or CsI layer), which is further captured using a CCD or a CMOS image sensor. Some of them use a hybrid arrangement which first converts the X-rays into electricity (using a CdTe layer) and then captures this electricity as an image with a reading section based on CMOS technology.

Historical milestones for Digital Intraoral Sensors

1987 - RVG (*radiovisiography*), Trophy Radiology (France) introduced the world's first intraoral X-rays imaging sensor. Trophy Radiology patented it under the restricted name *radiovisiography* (other companies use the phrase *digital radiography*) and continues to produce intraoral sensors today using the Kodak name which is used under license by Carestream (Canada).
1992 - Sens-a-Ray of *Regam Medical System AB* (Sundsvall, Sweden) is offered. They closed the business and their technology is currently owned by Dent-X (USA).
1993 - VisualX of *Gendex*-Italy (subsidiary of USA company).
1994 - CDR of [*Schick Technologies*] (USA). Also Schick Technologies introduced last year a wireless CDR version being the only supplier offering such feature. This company is owned actually by Sirona (Germany).
1995 - SIDEXIS of *Sirona*, **DEXIS** of *ProVison Dental Systems, Inc.* (renamed DEXIS, LLC following its acquisition by Danaher Corp.), **DIGORA** (PSP solution) of *Soredex* (Finland)
Today there are many other products available under a lot of different names (rebranding is quite usual for this type of product)

The manufacturers claim the resolution is between 12 to 25 LP/mm. A useful precise comparison is difficult because depends on many parameters including the post processing or imaging software.

Historical milestones for Digital Panoramic Systems

- **1995 - DXIS**, the world wide first dental digital panoramic X-rays system available on the market, introduced by *Signet* (France). DXIS targets to retrofit all the panoramic models.
- **1997 - SIDEXIS**, of *Siemens* (currently Sirona, Germany) offered for Ortophos Plus panoramic unit, **DigiPan** of *Trophy Radiology* (France) offered for the OP100 panoramic made by Instrumentarium (Finland).
- **1998-2004** - many panoramic manufacturers offered their own digital system.
- **2005 - SCAN300FP**, of **'Ajat'** (Finland) is the latest innovation offered. It shows the feature to acquire many hundreds of mega bytes of image information at high frame rate and to reconstruct the panoramic layer by intensive post acquisition computing like a computed tomography. The main advantage is the ability to reconstruct focused differently. The drawback is the low signal/noise ratio of primary information which involves much software work for correction. Also the ability to reconstruct various layers raises the importance of the geometrical

distortions already high in dental panoramic radiography. Since **2008** the SCAN300FP system is available in **Ajat ART PLUS** and **ART PLUS C** system.

Currently there are several digital systems for panoramic digital radiology. Some of them are rebranded. Examples: SCAN300FP of Ajat was or is sold as SuniPan or RetroPan or Panoramic Corporation pan, DXIS of Signet was or is sold also as of LightYear, Sigma Biomedics, Panoramic Corporation, AFP Digital or Bluex, iPan of Schick was or is sold as of Bluex or Panoramic Corporation, I-MAX of Owandy sold as of Villa, etc.