Review Article

Information Technology for Healthcare

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ABSTRACT

The article produced below hopes to focus on the use of information technology solutions for improving healthcare delivery systems. It explains evolution of IT-Enhanced healthcare from Telemedicine to e-health, including definition and requirements of telemedical systems. It also traces the evolution of contemporary telemedical systems and the challenges faced by future technologies including legal and formal aspects of telemedicine as well as its acceptance among users. It overviews access to telecommunication technologies, with basic requirements for such communications. It also presents the requirements and architectures of Internet-based medical systems, with focus on Internet telemedical services, Web services and portal technologies. The next-generation point-of-care information systems are also discussed. This article also covers security and safety of telemedical systems in context of legal acts affecting the security of e-medical systems. Wireless hospital and telecare applications with requirements for mobile access from PDA devices to medical database are also considered. Electronic health records describe the progress in constructing a common set of data structures contained in medical records and reports on the main standardization efforts. Decision support systems in medicine covers knowledge based and expert systems which support physicians in making medical decisions by providing interactive tools, Since e-health network services are available over the Internet it covers the requirements and architecture of telematics networks and the organizational models for such networks.

INTRODUCTION;

The use of IT has been a catalyst in the transformation of healthcare services in information age. Information technologies along with medical services open up vast possibilities in the areas of continuing care, chronic disease treatment, home monitoring of elderly people etc. Understanding the nature of this accelerated healthcare with IT is the main factor in improving medical standards and reducing costs. Excellent IT and high quality health care are closely linked. Hospitals with good information systems have several common threads. These are:-

a) All provide near and immediate access to a wide array of information including nearly all clinical results

b) Are highly integrated

c) Provide clinical decision support

d) Have both inpatient and outpatient data with differing views for each

e) Facilitate measurement

f) The availability of enormous information stored can also be made available for future research.

The fundamental changes in existing models of care delivery and system performance can be transformed by application of information technologies to healthcare, including reduction of costs associated with:

a) Medication errors

b) Communication and documentation of clinical care and test results

c) Staffing and paper storage

d) Processing of information

e) Improved quality of care

f) More accurate and complete medical documentation

g) More accurate capture of codes and charges

h) Improved communications among providers that enabled them to respond more quickly to patients' need.

Despite considerable progress in communication technology, the transmission of medical data is still a challenge due to security requirements, required quality of service and vast volumes of medical data.

Telemedicine Development

Telemedicine has been defined as the use of telecommunications to provide medical information and services. This transfer of medical data may utilize a variety of telecommunications technology, including, but not limited to:-

a) Ordinary telephone lines,

b) ISDN,

c) Fractional to full T-1's,

d) ATM ,

e) The Internet,

f) Intranets and Satellites.

This system should fulfill a unique set of requirements, which in many respects distinguishes it from a standard teleconferencing system. The requirements for modern telemedical systems could be grouped according to three categories: telemedical workstation, communication network and human perception of media.

a. Telemedicine workstation Telemedical system requires programmable video, audio, image handling and compression to support application ranging from typical video teleconferencing to that providing "diagnostic-quality" video, audio and medical images in an interactive way. It should usually provide use of the following standards and formats: MPEG (for a high quality audio/video compression), JPEG (for still image compression), and H.324 (for videoconferencing over POTS). Support for data acquisition from peripheral medical devices, e.g. electronic stethoscope as well as images from medical

imaging equipment and high-resolution cameras is also critical.

b. Communication network: It should adapt to a wide variety of bandwidths (e.g., from 28 kbps to 155 Mbps), depending on the clinical application, the available telecommunication channels (ISDN lines, land based fiber optic cable, satellite link) and the desired interaction level in order to achieve optimum utilization of available transmission medium while providing the best quality video and audio.

c. Human perception of media: The latency of communication should be minimized in order to support an effective interaction within the telemedical system. It has been reported that lead/lag between the audio and video playback should be less than 80 m/sec to be perceived as synchronized by human observers. In case of full duplex communication, both audio and video should arrive no later than 80 m/sec, which is not easy to achieve. These requirements call for network connections that feature guaranteed bandwidth and maximum delays at a given bit rate such as ATM.

Types of Technologies. Two different kinds of technologies make up most of the telemedicine applications in use today. The first one is called store and forward and second one is called real – time systems.

a. Store-and-Forward Telemedicine Technology: This is commonly used for transferring digital images from one location to another. Images are captured with digital cameras or still video and sent to another location. This is typically used for non-emergent situations, when a diagnosis or consultation may be made in the next 24 – 48 hours and sent back. There is no limit to the geographical distance between origin and destination of the image.

b. Real-Time Video Linking or two-way interactive television (IATV). This approach is used when a "face-to-face" consultation is necessary. The scenario may encompass a session between a patient and the assisting health

professional in one location and a specialist in another location or a session between health professionals on both sides. In some specific applications, a patient may be the sole participant in the session. Videoconferencing equipments at both locations allow a 'real-time' consultation to take place.

Health Information Network. This network provides the means for electronically sharing information needed to support the health care financing and delivery process. It can offer a number of benefits to participating organizations, including reduced administrative overhead and better access to clinical and financial information. This area is far more attractive for investors than traditional telemedicine. It is underlined that development of these services is usually propelled by the desire to achieve financial profits. Healthcare organizations today are searching for ways to gain competitive advantage, and to do so three fundamental strategies are used. A Health Information Network can benefit by supporting these strategies.

a) **Increase the quality and efficiency of health care delivery**: A health information network can make a broad range of current and historical information available to caregivers. Timely access to a broad range of information enables care teams to provide more effective care to their patients.

b) **Reduce the number of unnecessary procedures and test for quicker initiation of therapy**: By providing access to a broad range of information, a health information network can support efforts to reduce the number of unnecessary tests. Care givers who have access to the information they need are better able to make informed decisions and provide more effective and efficient care.

c) **Reduce administrative overheads**: A primary mission of a health information network is to reduce administrative overheads and human error associated with moving information between organizations and

individuals. Currently a significant amount of repetitive information is moved between organizations. Costs are incurred as staff at each organization individually handles documents and other items as they are routed to their final destinations. Fully standardizing information and moving it electronically, significantly reduces the need for frequent human intervention and reduces the costs associated with errors and no value-added activities.

The Impact on Relations in Healthcare. A common example of the new quality in relations between patient and physician is that of a patient suffering from specific symptoms or diseases presenting at a physician's office with many printouts from websites offering health-related content. For many health professionals this situation is "awkward" as he or she is immediately confronted with the information load absorbed by the patient over the course of days or even weeks. A health consumer who is aware of his or her health status and medical problem is the ideal option for the most successful care strategies developed nowadays. The important advantages of the e-health environment supporting the self managed role of the health consumer encompass easy access, empowerment of the patient/consumer, availability of feedback channels as well as considerable elasticity. Health professionals tend to put more attention on the risks resulting from access to unreliable health related information by patients. The information on the Internet is highly appreciated by the patients and their families. The limited time that a physician spends with his patients makes Internet-related resources even more attractive. Access and alignment go hand in hand. The intent of alignment is to facilitate patients' access to your services. However, what is needed by the patient is someone who:-

a) Is readily accessible

b) Understands the patient's needs

c) Can help the patient clarify needs

d) Can help the patient learn how to take full advantage of technology

Legal Aspects. The addition of telemedicine technology to healthcare delivery has had positive effects on the practice of medicine, particularly for proving access to specialty health care to geographically or otherwise isolated patients. Yet, it is telemedicine's effect on medical liability that requires some examination if its eventual assimilation is to be ubiquitous or just a footnote to modern healthcare. According to many national regulations the relationship between health professionals and patients should rely on direct, face-to-face contacts. This requirement has potentially limiting effect on the growth of e-health and telemedicine applications with focused clinical context. Such situation stems from traditional concepts of medical care delivery and is not necessarily in line with progress occurring in information and communication technologies. A systematic approach to evidence studies showing the safety and adequacy of technical solutions would be of great help in overcoming formal barriers to e-health growth. The security and confidentiality of patient data are important aspects of implementation of e-health system. The Health Insurance Portability targeted the protection of medical information and Accountability Act (HIPPA) accepted in the USA in 1996. This law creates the framework for achieving the standards related to security of medical records, integrity and authentication. Generally, the main players in the healthcare domain focus them on electronic transmission of electronic data.

The issue of delivery of healthcare services within the e-health environment and specifically telemedical activities was not addressed adequately in all countries facing the growth of this field. Existing situation of many local approaches to legal regulation of the issues of security and confidentiality, reimbursement and reliability was addressed within G8 project ENABLE established in order to identify and overcome obstacles on the way to healthcare services in information society crossing borders.

Reimbursement Policies: The issue of reimbursement for services offered through telemedical systems is still open. Generally, health maintaining organizations do not seem to be enthusiastic about payment for care delivered through telemedicine, even if potential benefits and savings may be impressive. The risks related to the use of telemedical systems, which could hamper the quality of the service, are related to technology dependent factor or human factors. However, the approach to reimbursement for telemedicine type activities underwent changes in recent years, at least in some countries.

Networks in Medical System

Networks are the glue that provides the ability to connect systems. Health care information systems are evolving into networks of thousands of devices. The demand on these networks has been significant and this trend will continue. Combining medical sciences with technologies associated with the Internet results in an incredibly wide spectrum of new applications under the umbrella term telemedicine. It appears more and more frequently in everyday life. The most important factors, which propel its expansion, include the need to reduce healthcare costs as well as the perceived improvement of patient care through easier dissemination of expert knowledge through medical portals telecom salutations and telesurgery tools. The main requirements for medical institutions when sharing information are dissemination and telecom salutations between different users. Networks themselves are being moved out into the community, state, and country. Users now need, over wide area networks (WAN), the same level of application and device service they previously received inside an institution through local area networks (LAN). There are many such networks and there are many IP-like devices, and also this method is inexpensive. But not very many

hospitals can afford having a permanent connection to the Internet, and a basic dial-up connection does not give data transmission of satisfying quality. So using ISDN networks is a good alternative with good data transmission rate, almost permanent connection and relatively low prices. There are many different techniques used to access medical resources, such as:

a) Telephone networks (PSTN)

b) ISDN network

c) Private or corporate network LAN/WAN

d) Leased-line (channel 2 Mb/s)

e) XDSL Lines

f) Cellular Networks (GSM, UMTS)

g) Satellite Links

Some of the features for deciding whether the access technique is important or not is related to the cost, availability and penetration of the service. For this reason, some of the above-mentioned techniques are not currently in application.

Requirements of Medical Systems in the Internet Environment: Internet technologies offer a wide range of facilities for medical systems including video and audio medical conferencing, virtually ubiquitous access to medical data, convenient user interfaces, and many others. Following are the most crucial demands to be fulfilled by medical systems implemented in the Internet environment:

a) **Privacy and Security**: The most important factors in this environment, due to the confidential character of the data processed by medical systems and the relative ease of violating privacy on the Internet. The level of security of medical system could be compared with that of a banking system.

b) **Reliability and Availability:** These two correlated factors are very important prerequisites, guaranteeing user confidence in services and comfort of usage. Both play a pivotal role in constant monitoring systems when reaction to an emergency situation must not be delayed.

c) **Quality of Network Service**: Interaction with the system relies on Internet links; quality of network service in term of throughput, delay, etc. is also significant. This requirement mostly concerns such applications as telesurgery systems and telecom salutation tools, which require diagnostic quality of transferred images and real time interaction between remote sites.

d) **Data Integrity:** The growing popularity of Internet based medical services calls for maintaining integrity of patient data; otherwise, they would dissolve into tangled fragments of health records, hardly improving overall patient care.

There are many functional requirements, which depend mainly on the system application and include, among others:

a) **Audio and Video Streaming**: In telecom salutation and telesurgery systems there is a need to effectively transfer multimedia data between two or more participants.

b) **Consultation Organization:** Besides transferring multimedia, organization of telemidical sessions in a virtual hospital environment is also a very important point

c) **Conformance to DICOM Standard**: This standard facilitates interoperability of medical devices by defining communication protocols as well as by providing vendor independent data formats.

d) **Means of Digitalization of Existing Data**: Currently, many medical institutions do not fulfill requirements related to a paperless or filmless organization; hence, system should allow for integration of existing non-digital medical documentation by providing open interfaces supporting various types of data.

e) **Diversity of User Interfaces:** Systems should offer many different and convenient user interfaces depending on the client terminal used for access.

Internet Medical System Design: Proper design of a medical system is a very serious issue and should be preceded by detailed analysis and supported with knowledge and experience in the

area of medical data representation, distributed systems, and computer networks. The role of this segment of healthcare is significant as it is the first point of contact between patients and the medical community, and thus by offering a variety of information, provides with a sense of security and comfort. Another area of applications involves streamlining of healthcare operations. Internet-capable applications are able to deliver medical reports, claims submissions, referrals, eligibility verifications, lab reports, prescriptions and other clinical and administrative data electronically.

Security and Safety of Telemedical Systems: Agencies and standards bodies within governments of several nations have developed evaluation criteria for computing technology security. The need of the healthcare industry to reliably and confidentially exchange patient healthcare information in support of the portability of healthcare insurance and patients between employees, insurance companies and healthcare providers has resulted in creating a document called "The Health Insurance Portability and Accountability Act of 1996" (HIPAA). To support the confidential maintenance and exchange of electronic healthcare information, the Department of Health and Human Services in the US has developed regulations that support and enforce HIPAA privacy and security. These regulations prescribe care in handling paper records, as well as care in handling electronic records for protected health information. This information that is stored in e-medical information systems is subject to inappropriate access or modification, also known as an attack. HIPPA security mandates the following rules:

a) Guarantee health insurance coverage of employees.
b) Reduce healthcare frauds and abuse.
c) Introduce/ implement administrative simplifications in order to augment effectiveness and efficiency of the system.
d) Protect the health information of individuals against access without consent or authorization.

Device and software vendors are not responsible for the organizational policies and procedures of their customers. Their own policies and procedures must protect the confidentiality of information. HIPAA specify critical security policies and technologies, including:

a) Unique Ids for authorized users.
b) Automatic logoff.
c) Audit trail for access to specific type of protected information.
d) Encryption.
e) Digital signatures.
f) Virus checking procedures.
g) Backup/restore plans.
h) Disaster recovery plans.
i) Compliance auditing.
j) Testing programs.
k) Training programs.

If the Security solutions to be effective require training, physical security; appropriate best practices-derived security policies and proper configuration of operating systems and applications.

Wireless Systems in e-Health: The application of wireless system in the e-health domain is very promising, although it is at the same time a very challenging task. There are several factors motivating the move towards wireless technology. Increasing mobility of network users is one of them, while another is the need to have universal access to applications and information. When considering a medical application, it is easy to observe that even if the available bandwidth is sufficient to download large medical data sets (e.g. radiological images) in a timely manner, the level of security offered by the networks sometimes prevents the medical institutions from providing such a remote access service to their workers.

Wireless technology includes many different components, including networks, service providers, protocols, devices and tools for network management and development of applications.

There are three classes of wireless network as defined by their range:

a) **Personal Area Networks: (PANs)** span very limited areas (the radius is 10 meters) and operate at 1 Mbps. These cable replacement networks serve as frequency-hopping radio links between wireless devices. The Bluetooth standard is considered the most important representative of PANs. Most cell phones and headsets come with a Bluetooth interface for wireless communication.

b) **Wireless Local-Area Networks**: (WLANs) are popular alternative to wired LAN. The coverage of a single WLAN is measured in hundreds of meters. The 802.11b standard is the most widely used, and sustains data rates of up to 11Mbps. However, its frequency is susceptible to interference from cordless phones, microwaves, etc. The 802.11a standard provides a faster data rate (up to 54 Mbps), but requires a hardware upgrade since it operates on a different frequency band.

c) **Wireless wide area networks**: (WWANs) span a relatively large geographical area and operate many different networks at many different speeds. Cellular telephony operators frequently provide Service. Most of WWAN data rate ranges anywhere from 9.6 kbps to 2 Mbps.

Support for all major networking protocols is not the only factor which should influence the selection of a handheld device. Processing power, battery life, screen size, and keypads are all key factors to contemplate when developing a wireless application. There are three main types of mobiles and wireless are:

a) **Cell phones**: They have poor user interfaces – such as small displays, no support for cookies and Java scripting, as well as URL length limitations.

b) **Personal digital assistants (PDAs):** They are more powerful. Some of them are fitted with Bluetooth interface and WLAN. It is also equipped with expansion slots, which can be used to attach extension cards such as a GPRS modem.

c) A smart phone is basically a cell phone merged with a PDA.

Applying latest wireless communication technologies can turn the vision of mobile e-health services into reality. Each mobility category imposes some requirements on applied telemedical solutions. These may be divided into functional and technical group. The most important functional requirements are as follows:

a) Access to patient's personal e-health environment on-line anytime and anywhere.

b) Ability to recognize medical conditions and patient's state and to notify a care centre.

c) Localization of patient and selection of nearby medical services.

d) Transparent authorization and synchronization of patient's personal medical e-health environment with medical equipment.

e) On-demand access to a patient E H R at home or from a medical centre.

f) Access to medical data from mobile devices.

Technical requirements are related to the process of making telemedical applications mobile. There are certain challenges which we have to overcome, which include:

a) Determining the architectural approach.

b) Dealing with the current application environment.

c) Securing connected networks.

d) Managing user sessions.

e) Ensuring scalability of runtime environment.

f) Managing diverse content.

g) Handling and managing client devices.

h) Networking technologies diversity.

Relevance of Terminological Standards and Services in Telemedicine: Knowledge about patient centered clinical data and medical information is required for effective and efficient delivery of healthcare. The use of medical language is useful but with drawbacks. The data has to be analyzed using linguistic algorithms or the data has to be entered in a structured and standardized way. Both approaches are dependent

on the availability of terminological systems. The need for supporting the capturing of data either by free text or by structured data entry and perhaps free text generation afterwards, for safe communication between humans a terminological standardization is needed. Standardized terminology is important for searching and selecting the data at different stages of patient care. The vocabularies should be as expressive as possible, to allow for generating arbitrary views and aggregations. For example the integrated linkage to online available literature or guidelines or the integration of knowledge-based systems is only possible if the patient data is based on standards, e.g. for a decision rule concerning antibiotics, if the patient uses a medication called "penicillin" there is a need for knowing that "penicillin is an antibiotic". Furthermore, terminological standards are used for defining payment system. Specialist terminology has always been used in the medical field for communication between professionals. In early days it was Greek and Latin based and not to be understood by others, especially the patient. Coding was used for the analysis and description of diseases and the healthcare system. Based on classifications structured documentation for better communication and easy data entry has been a step forward in exchanging clinical data between professionals.

Electronic Health Records: Clinical care requires healthcare professionals to access patient record information that may be distributed across multiple sites, held in a variety of paper and electronic formats, and represented as mixtures of narrative, structured, coded and multimedia entries. There are many challenges and cultural changes facing the safe and effective delivery of healthcare services. These are listed below:-

a) The requirement to limit healthcare costs and to optimize resource utilization.
b) The shift of care from specialist centers to community settings.
c) The requirement to deliver evidence based and quality assured care.
d) The growth of consumerism and patient active participation in healthcare.
e) Equity of access and public involvement in priority setting.
f) An increasing complexity of healthcare provision.
g) An increasingly distributed and mobile clinical workforce.
h) Changes in working patterns and accountability of healthcare professionals.
i) The growth of medical knowledge.
j) A critical reliance upon patient records.
k) Increasing concerns about the confidentiality of patient records.

The application of information technology to modernize health services has become a key issue. In his 1997 State of the Union address, President Clinton declared "we should connect every hospital to the internet, so that doctors can instantly share data about their patients with best specialists in the field".

Challenges Facing Clinical Care: The delivery of safe and effective healthcare is a challenge for all clinicians, particularly as the extent of medical errors is becoming apparent. Healthcare professionals need to share healthcare information with a growing range of professional colleagues, often on multiple sites. Patients are often under the care of more than one team. Patients nowadays also require access to their own Electronic Health Record (EHR) to an extent that permits them to play an active role in their health management. These requirements are becoming more urgent as the focus of healthcare delivery shifts from specialist centers to community settings and to the patient's personal environment. The medico legal nature and accountability of healthcare delivery places additional requirements on the rigor with which health record entries are attributed represented and managed. The ability to communicate this information in a comprehensible way is crucial to achieving progress towards shared care, improved quality care and effective resource management.

Visions of a Comprehensive E H R. There are many benefits of using E H R systems to acquire organize and view health record data. Duplicate data entry can be avoided if information is captured, maintained and communicated securely and consistently, in line with clinical needs. The same information can be displayed and viewed in a variety of ways. The E H R needs to represent responsibilities and intentions within the shared care process in order to support effective clinical workflow and to recognize the differing culture of nurses and doctors in the way information is used.

Characteristics of a Good E H R: Good health records are just not scattered accumulation of health related data about individuals. Entries are made as formal contributions to a growing and evolving story. A comprehensive E H R system must enable statements to be grouped together under headings and sub-headings in a clinically meaningful way. Aspects of certainty, severity and the absence of findings must be capable of rigorous and unambiguous representation. The medical records need to be faithful, which implies that it needs to be:-

a) Attributable.
b) Permanent (entries can be logically deleted or linked to a corrective comment, but never erased).
c) Authentic.

Joining up diverse and sometimes discipline specific and culturally specific kinds of clinical information to compose a whole person E H R that can safely, legally and useable replace paper records is a complex challenge. The delivery of high quality clinical care depends upon a well-recognized triad of information services: health records, medical knowledge and protocols of care.

Newer Application of Telemedicine

A variety of technologies are being considered to achieve cost and quality goals. Many of them involve heroic life-saving or life-extending support systems for the very young and the very old.. Others are in some way or other aimed at diagnosing and treating the patient in the lowest cost setting. In 1992 outpatient surgical procedures exceeded inpatient surgical procedures for the first time and the gap continues to widen.

Telesurgery Telesurgery is the provision of surgical care over a distance, with direct, real-time visualization of the operative field. It may be categorized as follows:

a) **Telepresence surgery**: Uses a computerized interface to transmit the surgeons actions at a surgical workstation to the operative site at the remote surgical unit, with haptic (force feedback) input to transmit to the surgeon, the tactile environment of the operative field.

b) **Telerobotics**: Remote control with robotic arm, usually in conjunction with a laparoscope, without haptic feedback.

c) **Telementoring**: An experienced surgeon acts as a preceptor for a remote inexperienced surgeon by observing the surgeon via interactive video.

d) **Teleproctoring**: This is an extension of telementoring, referring to documentation of performance for privileging purposes.

CONCLUSION

The use of electronics communication for delivery of care to patients is a real challenge, but technical barriers do not seem to be the main problem. Healthcare managers are well aware that the main obstacles are linked to political, legal and organizational aspects. If e-health environment is to be shaped the threats related to Internet are to be addressed efficiently. The benefits related to the use of such applications include improved data entry, better communication, over the clock access to the information and decision supporting tools. Digital communication platform offers a more flexible solution for the provision of explanations by health professionals. Internet technologies enable individualized education and training processes. The technologies profiled in this article support emerging trends and growing needs in the health care marketplace. Today's plans should no longer focus solely on individual departments but on the entire health system.

The real advantage of e-health applications may be fully explored in the areas having widespread access to the Internet. Populations with low Internet penetration can be monitored with a computerized, telephone-linked communication system. Electronic systems supporting long-term monitoring and treatment of patients suffering from chronic conditions may follow several patterns of usage. They may differ according to the communication with health professionals as well as decision support options offered to patients and physicians.

However, even if the benefits from the use of Internet-based solutions for care delivery are indisputable today, significant limitation for their use exists. The reliability of health-related information on the Internet is frequently questioned. We should also remember that Internet-based applications designed to bring new quality into long term care must respect legal issues. The benefits related to e-health include time saving, convenience, improved knowledge about healthy lifestyle and behaviors. It must be emphasized that a new model of care based on the effective use of e-health solutions cannot be implemented without adherence to legal, ethical and psycho sociological requirements existing in the healthcare environment. In addition health care organizations can no longer afford to view information technology as simply a support function. Technology must be applied in a strategic manner providing the products and services. Applying technology in this type of strategic manner will greatly leverage potential benefits and provide the competitive advantage needed to survive in the rapidly changing market place.

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