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Review Paper

Communication in Health Care

Abstract: For routine communication, care providers still rely on paper documents and paper mail. At present, new technologies are emerging that have considerable potential for improving communication in health care. This paper reviews existing communication problems, and discusses electronic communication techniques that are gradually replacing paper-based communication.

Keywords: Communication, Telemedicine, Networking, HL-7, EDI, EDIFACT, PACS

1. Introduction

The quality of communication between medical-care providers highly influences the quality of care. Communication is essential for those patients who are under the shared care of several physicians. Inefficient communication between these care providers may have undesired effects such as conflicting therapies or duplication of diagnostic tests, thereby wasting financial resources and negatively influencing quality of care.

At present, letters are the most common and in most cases the only means of communication between care providers. Previous research indicates that this communication is too slow for a progress follow-up, and often does not satisfy the information needs of the parties involved. Long and Atkins report that communication between GPs and consultants occurred in only 3% of the hospitalized patients, although 58% of the GPs and 67% of the consultants acknowledged the need for communication [1]. Penney found that of 104 hospitalized patients 26 (25%) discharge summaries never arrived: for the remaining 78 the average delay was 25.3 days, 20.8 days of this delay was taken by typing the summaries in the hospital [2].

Not only the content of a letter determines its usefulness. Tuloch et al. report that GPs preferred structured and well-designed summaries to narrative reports. They also found that the presentation style of the information, using headings, underlining, and capitals, added to the accessibility of the letter [3]. In a recent study, Newton et al. report that, although there exists a high degree of consensus among British clinicians about the content of referral communications, standardization of communication still is not widely accepted: when writing letters, physicians prefer to use their own phrasing [4].

Communication does not necessarily have to occur between physicians only. For example, Inada et al. [5] describe a system for home-care support which can measure, collect, and record biological information of patients at home, and subsequently send this information to hospital-based specialists for remote monitoring of these patients.

Nowadays, several new possibilities for supporting communication have become available: the most well-known are the Facsimile (Fax), the smart card, electronic mail (E-mail) and Electronic Data Interchange (EDI). In this review article, we give an overview of the current techniques used for communication in health care. For each of the techniques the possibilities, limitations and developments are described.

2. Communication methods

In this section we briefly review the different communication techniques used in health care. We also give examples of projects that make use of these techniques.

2.1 Fax

With the Fax it is possible to send documents via the telephone line to the receiver, thus speeding up communication considerably. The Fax has penetrated a large number of business areas, and is widely used by medical professionals. A large number of publications on Fax communication projects are available in MedLine. Harrison and Hall [6] report on an experiment in which the Fax was used for transmission of referral letters from a general practice to a dermatology department. Terae et al. [7] describe a project in which CT images were transmitted, using electronic communication, from a town hospital to a university hospital. At the university hospital, these CT images were judged by experts and the written report was sent back to the hospital, using the Fax. Van Casteren and Leurquin report on a European sentinel network, in which all the participating national coordinators used the Fax for reporting to the central facility in Brussels, where all national data were gathered and compiled [8]. Yasnoff [9] describes the so-called US HealthLink system, which offers online diagnostic decision support, information about drug interactions, and literature references. Fax delivery of this information is one of the options of the system.

The Fax is an easy-to-install and easy-to-use communication tool, relatively cheap and fits smoothly into organizational habits. Existing Fax communication protocols have been widely accepted. Disadvantages of the Fax are the low quality of the printouts and, although Fax speeds up communication, it remains merely a sheet of paper: the data cannot be used directly in computer applications.

2.2 Electronic Mail

When compared to the Fax, E-mail is a relatively old procedure. For example, the Telex has been used for many years. The use of E-mail in health care, however, is still not very widespread. We define E-mail as the delivery of mail in electronic form: this means that, when using E-mail, the sender composes a message on his computer, e.g., using a word processor, and sends it via a communication network (e.g., the telephone system) to the computer of the receiver. This can be done directly, from computer to computer, or indirectly via a so-called E-mail postbox. The receiver can read, print or edit the message because, unlike the Fax, the message is still in electronic form.

Several E-mail projects in health care have been implemented during the late Eighties. Buckingham [10] describes an experiment in the UK, using the so-called Merlin business system (British Telecom). Each user had a terminal, connected to the public telephone system via a modem. For every message the sending terminal established a point-to-point telephone connection with the receiving terminal. Buckingham concludes that, for the system to be comprehensive, terminals need to be located in all health-care facilities, such as hospitals, health centers and general practices. Grundner and Garrett [11] describe an E-mail system, based on a computer-based postbox system. This system was originally designed to facilitate fast communication between care providers, located in five clinical units and scattered throughout the Cleveland metropolitan area (USA). Within a few weeks, however, members of the public found out about the project and began putting medical questions to the system. The authors describe how they adapted the technical and organizational structure of the system, in order to meet this unexpected demand. They conclude that telematics is a feasible option for the delivery of health care information. A similar system was also implemented by Vance Esler [12]. Cowie [13] reports on the implementation of an E-mail system for transmitting laboratory data between two hospital departments. Laboratory test reports were transmitted from a laboratory computer, via the telephone network and an E-mail system, to a laboratory computer in another hospital. Cowie reports that the system worked reliably, saved secretarial time, and eliminated transcription errors. In a project described by Gaunt, the Prestel Mailbox service was used for transmitting microbiology reports to GPs [14]. Gaunt reports a reduction in distribution delay of one to four days.

Working with E-mail offers fast message exchange. In addition, the receiver can edit and store the message in a computer-based database, because the message is in electronic form. To be able to work with E-mail, users obviously need to invest in a computer system. Furthermore, working with E-mail is often more complicated for the user than using a Fax machine. Also, E-mail messages are usually in free-text format. This impedes automated processing of data at the receiving computer system, for which standardization of messages is essential.

2.3 Electronic Data Interchange

A special form of electronic mail is known as Electronic Data Interchange. EDI can be defined as "*the replacement of paper documents by standard electronic messages conveyed from one computer to another without manual intervention*" [15]. The central, most important aspect of EDI is the use of widely supported message standards. These standards should describe syntax and semantics of the message. When standardized messages are used for transmitting data, this data exchange is system- and application-independent, thus reducing the costs of building interfaces between different computer systems. EDI reduces the amount of paper documents, it enables automatic handling of data, and consequently reduces the number of errors in data processing. Data, once entered into a system, do not have to be re-entered manually into another.

Outside health care, EDI has already been used for many years in several business areas, such as shipping, customs, and transportation. In health care, EDI is also in use, especially for financial, administrative and logistic activities. In an article by Sedor [16] it is stated that half of the hospitals in the USA are using EDI. Shafarman et al. [17] describe the experiences with implementing an EDI-based system for transmitting laboratory test reports from a laboratory system to a clinical database. Cahill et al. [18] report that the use of EDI proved to be beneficial because of shortening interface design efforts and providing common messages between various computer systems. Branger et al. [19] showed that the use of standardized letters, together with the use of E-mail, improved the speed of communication, decreased workload, and increased the general practitioner's understanding of the care delivered by other health care workers.

Similar to E-mail, EDI offers fast exchange of data, but in addition it facilitates fully integrated data exchange between computer systems. Sophisticated computer hardware and software, and a well-organized, national message standardization body are necessary. Initial investments, therefore, are higher than for Fax or E-mail. Another problem is the shift in costs that occur using E-mail and EDI. Using paper mail, the sender pays all, while using EDI the receiver is also charged. Especially organizations that have a considerable amount of outgoing mail (e.g., hospitals) might benefit from the use of EDI. General practitioners, on the other hand, receive more mail than they send out. This unbalanced situation will not stimulate the use of EDI, unless some ways are found to even the score.

2.4 Smart Cards

As health care becomes more complex, the question arises whether patients should carry their own medical record. Several options exist [20]. One of the possibilities is the use of a so-called Smart Card. A Smart Card is a card the size of a credit card, containing a microprocessor and a memory on a microchip. The Smart Card is essentially a compact, patient-held medical record. In order to inspect data on the card or add data to the card, a special card-reading device is needed. This card reader is connected to a computer. In France, several projects are investigating the use of Smart Cards in health care [21]. In two separate papers, Benson [22] and Hopkins [23] report on the British Exeter Care Card project. In this project, family physicians, pharmacies and hospitals participate: around 8500 patients were issued a Care Card. Data are stored using the Read Clinical Classification [24]. The Care Card is protected by a code, only known to the patient. When a patient visits a physician, the card will reveal its content only after the patient has typed in his code on a terminal. In this way the patient can choose freely which physician to visit, without the risk of loss of information, or the need to tell his medical history all over again. The patient can inspect his own card if he wishes to. The authors state that the use of the Care Card offers physicians an up-to-date, accurate patient history (including test results and medication). They report a reduction of time needed by the GP for gathering information and in carrying out investigations [25]. The average percentage of cards carried by the patients in the Exeter trial was over 80%. Not everyone is convinced of the potentials of smart cards. Smith [26] argues that the Exeter Care Card project failed, because of imprecise aims and bad luck.

Ideally, the smart card offers a patient-held medical record so that patients, wherever they go for medical treatment, always carry their relevant data with them. There are, however, drawbacks to the use of smart cards. Apart from the fact that the use of smart cards is expensive, and that their storage capacity is still limited, patients may lose the card so that a backup will always be needed. And if this backup exists, why not simply link up the systems that contain the data [27]? Furthermore, Regan [28] argues that the heralded sovereignty of the patient over his own medical data is very questionable: refusing access to the data to some organization will probably rule out receipt of the service required. Regan also expects physicians to be reluctant to add information to the card, because of the unknown future audience that will be inspecting his entries. The question whether HIV-infected patients should carry an identity card suggests that Regan has touched a very important issue: as stated in a collection of letters by Srivastava et al. [29], "Medical gossip is more transmissible than any infection yet known in nature".

2.5 ISDN

ISDN stands for Integrated Services Digital Network. The main principle of ISDN is to provide the user with a single interface to the existing telephone network to utilize the switching services of the network to establish multi-channel digital links [30,31]. A pre-requisite is the digitalization of the public telephone network, which is underway worldwide.

ISDN connections can be used for all kinds of digital data, such as voice, text, data, signals and pictures. An ISDN link contains several logical channels. The CCITT (Comité Consultatif International pour le Télégraphe et le Téléphonie) has specified two different interfaces [30]:

- Basic Rate Interface (BRI). This contains two information bearing channels (B-channels) of 64 kb/s. each, and one signal channel (D-channel) for network control information. The data channel is used for network signalling and control (e.g., dialing, status, flow control, error control etc.). It uses small data packages instead of dialing tones. The total bandwidth of 64 kb/s. is not needed for control, so it can also be used for a packet-switch type of data transfer. Each channel is designed for full duplex communication. All logical channels are time-multiplexed onto the same physical information carrier, which is for the short distance a pair of copper wires. Total maximum potential is 144 kb/s.
- The Primary Rate Interface (PRI) is intended for larger numbers of channels. In the USA and Japan, 23 B-channels and one D-channel of 64 kb/s. each are used. In Europe, 30 B-channels, one D-channel, and a framing channel of 64 kb/s. each are used, which allow for 30 logical communication channels. The framing channel is needed because the D-channel is not sufficient for all the signal information of 30 B-channels. The total maximum transfer rate is 1.4 Mbytes/s.

3. Communication Applications in Health Care

The availability of the communication methods mentioned above has led to a large number of projects in which data collection and data communication is being done using computer systems. In this section we will give examples of such projects: we have divided these projects by subject. This division is not always definite; a number of projects could easily be appointed to other (related) subjects, dependent on the weight given to certain aspects of the project.

3.1 Telemedicine

It is not always possible that patients and medical specialists are at the same location. Medical data such as ECG tracings or radiographs are usually obtained by trained technicians. Especially in rural areas, centers can be equipped with data acquisition equipment, but the data will then have to be transmitted to a medical center where specialists are available to interpret the data. This situation, where patient and physician are at a different location, medical data are exchanged between the two locations and interpreted by physicians elsewhere, is called *Telemedicine*.

Lear et al. [32] studied the possibility of using an ISDN network for the transmission of radiological images. The authors state that the limited usage of tele-radiology was caused mainly by the slow transmission rates of telephone-based systems, while the faster satellite communication systems were still too expensive. Banifatemi [33] describes a system where French physicians in rural areas can obtain diagnostic support from university hospital physicians for the interpretation of endoscopic and radiologic images. McDaniel et al. [34] underscore the need for a Wide Area Network (WAN) in rural areas in Canada to allow for communication between physicians.

3.2 Population Surveillance

From a public health point of view, it is beneficial to have insight in prevalence and incidence of diseases, and the spread of diseases over different regional or global areas. Therefore, projects have been started in a number of countries, involving networks of physicians gathering disease data, which are compiled in a central database. These data are used for epidemiological studies, and for monitoring of, e.g., the spreading of an influenza epidemic.

Gathering data using paper-based documents may lead to transcription errors, thus endangering the validity of the database. Another problem, observed by Bean et al. [35], is that paper-based reporting is too slow for monitoring trends. The Centers for Disease Control, therefore, use a PC-based electronic reporting system for entering data locally, and E-mail for sending the data to regional or national offices. This has led to a faster availability of disease data and a reduction in paper handling. Salamon et al. [36] describe a similar telematics network, located in France. This network uses data, entered by GPs, for epidemiological surveillance. Another project, the French National Communicable Diseases Network, explored the possibility to detect and predict certain epidemics, such as influenza [37]. The authors conclude that monitoring of communicable diseases using telematics worked better than the original paper-based approach. The participating physicians especially liked the possibility to receive a quick feedback about the development of epidemics, and were probably more eager to participate than with the paper based method, which did not supply this feedback.

3.3 Cost Control

In business environments, one of the reasons for using telecommunication is cost control. When delivering care to individual patients, it is difficult to measure financial effects of improved communication. Several researchers, however, have argued that improved communication can decrease expenses in the fields of logistics and the handling of mail. Parker [38] estimates that the use of the Fax in his surgical unit (six surgeons) would result in a net saving of UK£ 19,900 (US$ 30,000) over a period of ten years. Neal et al. [39] describe the use of EDI for controlling a hospital pharmacy inventory. The use of EDI reduced the amount of time spent on placing daily orders to the wholesaler from 3 h to 1.5 h. Also, the drug turnover rate showed an increase from 10.8 to 12.5 in the first half year after the introduction of EDI. The authors conclude that EDI provides an efficient and effective way to control pharmacy inventory. Mahoney [40] describes the reorganization of pharmacy services in a 719-bed teaching hospital in Rhode Island, USA, by which substantial savings were established. The number of pharmacy dispensing offices were reduced from 12 to 2. Fax machines were installed for the transmission of medication orders.

3.4 Imaging and Picture Archiving Systems

The use of Picture Archiving and Communication Systems (PACS), also known as Image Management and Communication Systems (IMACS), opens the possibility to use a computer network to transport, store and use image information together with patient information. An IMACS system can be within one hospital but may also cover several hospitals. The connection of varied imaging modalities and patient information systems require communication between the systems. A well-defined protocol, communication speed, and accuracy are the most important issues to be considered. Currently, the image information originates from a variety of imaging systems such as CTs, MRIs, and radiographs. Advantages of using IMACS are:

- a case can be viewed simultaneously at different locations,
- possibility of post-processing of images (e.g., possibility to compensate for incorrect exposure which will reduce the number of retakes),
- reduction of the number of images lost or misplaced.

Lear et al. [32] state that, depending on the imaging modality 0.2 - 2 Mbyte is required per image. On normal telephone lines the capacity is limited to 10 kbits/s, resulting in transmission times ranging from 3 to 30 minutes. Satellite communication would be faster: channels are available that can operate up to 400-kbits/sec but ground stations are expensive ($50.000) and charges for transmission costs are on average $1 per image.

At Hokkaido University, Japan, a 9600 bps modem on normal telephone lines was used to transmit CT images from the Nakashibetsu Town Hospital to the university hospital (420 km away) for diagnostic interpretation [7]. Twelve CT images on film were digitized, compressed by a ratio of 5 - 10 and then sent to the university. The interpretation was returned as a written report using Fax. The transfer of the film took 7 to 20 min (7 min with the highest compression factor and with no re-transmissions). The 12 CT images were stored on a 14 x 17 inch film (4 rows x 3 columns) and digitized in a 2000 x 2000 matrix which resulted in 512 x 512 pixels per CT image.

According to Levine et al. [41] the requirement for the matrix size of the images and the number of colors or grey-levels for IMACS can vary from 512x512 to 2048x2560 with 10-12 bits for the grey-levels. Lear et al. [32] reported that it was possible to transmit radiographs that were digitized into 1024x1024 pixels and non-destructively compressed by a factor of 2:1 in less than 2 min using only one B-channel of an ISDN link. They found that only in 7% of the cases a re-transmission was required.

Paakkala et al. used a 512x512 matrix with 8-bit grey-scale radiographs [42]. These images were transmitted from rural areas, where no radiologist was available, to Tampere University for diagnostic interpretation. A 64 kbits/sec digital transmission line was used to transmit the images (2 min per image). Two radiologists evaluated the quality of the images and recorded all pathological findings independently. Three months later the original radiographs were interpreted by the same radiologists and compared with the results of the transmitted images. Questionable cases were reviewed by a panel. The image quality was considered satisfactory in 73% of the transmitted cases and in 90% of the original films. The sensitivity for diagnostic findings was about 5% better in the original films.

Meyer-Ebrecht [43] states that the wish for a digital alternative to the radiography filing room was the stimulus for PACS systems. Digital image archives, however, go hand in hand with the installation of digital communication systems. In case of a digital archive before a physician can view and evaluate images, he first has to retrieve them from the archive, via a communication link. At the Aachen university hospital, Meyer-Ebrecht measured the time needed by radiologists for interpreting radiographic images. He found that the time needed to analyze a set of 2 to 12 X-rays was 0.5-2 min, and for a sequence of 20 to 40 CT or MRI images 1-5 min. He estimated the size of an X-ray at 10 Mbyte, a CT at 0.39 Mbyte and an MRI at 0.1 Mbyte per image. This means for a reporting session, when images have to be retrieved from a digital archive to the computer system of the radiologist, an average data transfer rate of 3 Mb/s and in extreme situations up to 10 Mb/s. Radiologists judge that the latency time for retrieving an image should not exceed 2 seconds. This means that the required data transfer capacity should be between 57 and 335 Mb/s. At present, most hospital networks do not meet these requirements.

4. Standardization

4.1 What should be standardized

In medical informatics, communication is no longer restricted to dedicated point-to-point connections within one department or institution. Health care providers in different organizations and different locations exchange messages in either textual format or as special types of data, such as images, ECG signals, etc. This requires standardization on different levels, of which Mattheus [44] distinguished three:

(1) Health-care Specific

Most communication deals with patient-related information. Health care providers have to agree on the protocols used for 'shared care'. This is a standardization activity that primarily belongs to the medical field, but the medical informatics discipline should provide the framework. The Medical Data Interchange standard (MEDIX standard P1157 of IEEE) [45] aims at developing models for the health care environment. The same subject is being studied by the AIM-project TRILOGY [46]. Within CEN (European Standardization Committee), Technical Committee 251 (TC-251) is working on standards for health care terminology and medical concepts (semantics). Working Group 2 of TC-251 is concerned with health care terminology, semantics and knowledge bases.

(2) Information Technology Related

Standardization of, for example, information models, data models, and EDI messages, is needed to create an *Open Architecture for Medical Information Systems*. Within TC-251 three Working Groups (WGs) are responsible for this task:

- WG1 : Health-care Information Modelling and Medical Records,
- WG3 : Health-care Communications and Messages,
- WG4 : Medical Imaging and Multimedia.

(3) Telecommunication Related Standards

Medical Informatics should not reinvent the wheel but make as much as possible use of existing standards.

4.2 Standardization Activities

The EC has many activities going on in this field [47]. The latest one is the AIM project A2055 'TRILOGY' [46]. The mission of this project is *To establish an Open European Framework for the provision and exploitation of Health care Telematics Services derived from and validated against the practical results of Operational Trials, building on the work of key AIM main phase projects.* The project will provide a framework for the implementation of Health-care Telematics Services, and the implementation of already developed telematics services, rather than carry out new research and will guide and monitor practical implementations based on some 15 regions in 5 domains.

Harrington et al. [48] describe the framework model for Health care IT as developed by the Medical Data Interchange (MEDIX) Committee of the IEEE as project P1157. This model has been reviewed and accepted by the HISCC (Health care Information Standards Coordinating Committee). P1157 also distinguishes three levels:

- Actual Health-care Environment,
- Information Model,
- Computational/Communication Model.

P1157 defines a common reference information model and a computational/communication model. The long-term scope of the IEEE P1157 effort is medical data interchange for the entire field of health care. The initial phase emphasizes medical data interchange at the departmental level within the hospital setting. Standardization of the model is restricted to those aspects of the overall environment which are shared between multiple applications, and related to instances of information exchange between heterogeneous systems.

The HL7 Working Group is now working in cooperation with the IEEE P1157 in developing MEDIX [49]. HL7 stands for Health Level 7, which relates to level 7 of the OSI model (Open Systems Interconnect) of the International Standards Organization. Level 7 is the applications level, while levels 1 through 6 deal with hardware, levels, data packages, networking, etc. The HL7 group started its work in 1987 and has developed standards for transmission and communication control structures as well as protocol formats for certain domains. HL7 defines transaction sets, which are specifications of data flows corresponding with so-called triggering events. Triggering events are, for example, admitting a patient, or ordering a laboratory test. For each transaction set the initiating messages and response messages are defined. A message is defined as consisting of a set of data segments in a specific sequence. A message segment consists of a structured group of related data elements. The standard also defines the structure of the message and the field delimiters used. HL assumes the presence of a network capable of exchanging the messages as described by HL7.

Closely related to HL7 is the EDIFACT standard [50]. EDIFACT stands for Electronic Data Interchange For Administration, Commerce and Transport. It defines the syntactical rules for the messages in a similar way as HL7. The European standardization Committee for Medical Informatics CEN/TC 251 has selected EDIFACT as one of the possible Interchange Formats (IF).

The standards activities described so far all relate to the health care sector as a whole. Standards relating to communication are also defined for special domains in health care.

4.3 Standards in Image Processing

Transport of images is needed for remote consultation of radiologists and in a hospital environment when the archiving of film images is replaced by a digital archive. In the first case, public communication facilities have to be used, while in the latter dedicated high-speed data links can be used. The acceptable latency time in transferring images is in the latter case significantly lower than in the first case. The requirements of the PACS systems exceed the capacity of existing networks. Meyer-Ebrecht [43] reports that Ethernet gave an effective transfer rate of 3 Mb/s (disk-to-disk), while a 100 Mb/s FDDI (Fiber Distributed Data Interface) resulted in 14.4 Mb/s. Therefore, he concluded that it will be unavoidable to develop networks specifically tailored to a PACS environment.

The generation, processing and management of information is achieved by distributed devices. In a PACS environment all these heterogeneous components have to exchange messages and data. The DICOM (Digital Image COMmunication) standard describes the logical and functional relations between images and non-image information by its data structures and protocol definitions. The DICOM standard is being developed by the American College of Radiology (ACR) and the National Electronics Manufacturing Association (NEMA) [51]. The DICOM standard describes the structure of the data sets in such a way that the data set itself describes the formats of its content. The content of a data set is contained in data elements which can be grouped in chains of data of the same type. Groups and data elements have a header describing the content format. For image data, the header contains information about, e.g., matrix size, encoding scheme, or exposure data. The DICOM protocol exchanges information by means of DICOM messages. A message is composed of the DICOM data set preceded by the command group. The command group controls the transmission of a data set and initiates the execution of PACS-specific functions by the addressed devices.

European standardization activities concerned with the specification of structures for medical images and related data created the CEN*MEDICOM* proposal which attempts conformity with ISO/IEC CD 12 087 IPI (Image Processing and Interchange), DICOM and other standard and pre-standards.

4.4 Standards in Laboratory Systems

The ASTM E1238 standard specifies the transfer of laboratory test requests and laboratory test reports, and care provider observations [52]. The EUCLIDES standard describes message syntax, transfer mechanism, and the coding systems used within the message [53].

5. Concluding Remarks

Communication between health care providers attracts much attention, as is shown by the many articles published on the subject. The American College of Emergency Physicians even states that *use of facsimile (FAX) and electronic data transfer should be available to each emergency department* [54]. Several researchers have argued that replacing current paper-based communication with electronic communication holds potential benefits, both from a financial and a medical point of view. It is obvious, however, that investments and organizational changes may be needed to achieve these benefits.

Because of its easy operation and low cost, Fax technology has earned itself a place throughout society. It provides fast transmission of documents, and is especially suited for situations in which processing and interpretation of the documents by the receiver is not different from handling paper mail. This makes the Fax the ideal choice for a fast and uncomplicated implementation in medical practice. Examples of such situations are physicians working in rural areas, who can use the Fax to transmit, e.g., fetal heart rate recordings to hospital-based experts for treatment advice [55].

Another situation arises when more than just an increased speed of communication is desired. For a number of health problems, for example, shared care protocols have been developed, involving division of tasks between health care providers from different disciplines [56]. Optimal communication is considered to be a vital aspect of shared care, both from medical and cost effectiveness points of view [57], but physicians often lack the time to comply with the protocol. The use of computer-based medical records and electronic communication can facilitate shared care, by assisting physicians in maintaining high quality communication by automatically generating messages for co-treating physicians. Under these circumstances, more is required of the data transmission: in many information systems, the data are stored in a structured manner. Composing a message, based on the data in such a system, and subsequently sending it to the receiver using a free text format, would lead to a reduction of information. Using EDI, the information can be transferred in such a manner that structured storage in the receiving system is possible. To do so, standardization of messages is necessary, not only with respect to the syntax of messages, but also the semantics [58], and medical procedures. Defining, implementing, and maintaining standardized messages requires much more organizational effort than using Fax technology.

Patient-held medical records (such as smart cards) may be a good choice when patients tend to visit different physicians, without one physician acting as coordinator of the delivered care. Using a smart card, the patient carries all his important medical data with him, so the physician will always have a clear overview of the patient's medical situation. Problems arise, however, when the patient forgets to bring the card with him or, worse, when the card gets damaged or lost. A backup system, therefore, will always be necessary. From an organizational point of view, the use of smart cards poses the same problems as EDI: standards are necessary.

Protection of privacy of both patient and physician is an important issue in health care, not only in relation to information technology. From our own observations, however, we conclude that people tend to demand more preventive actions when information technology is involved, than with the original, paper-based storage and transmission of medical data. We believe, however, that protective measures (for example passwords and encryption) guarantee privacy of patients at least as good as is the case with paper-based mail.

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