RADIOLOGY AS A PART OF A COMPREHENSIVE TELEMEDICINE AND eHEALTH NETWORK IN NORTHERN FINLAND

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ABSTRACT

Oulu University Hospital is the northernmost tertiary hospital in Finland and its responsibility area is the largest in the country, covering nearly half of the Finnish territory, also including the arctic regions. Because of vast distances and a sparse population, Oulu has been a forerunner in developing telemedicine and eHealth services in the country. The development started in 1990 and has resulted in the establishment of teleradiology and televideoconferencing services, distance education and a multimedia medical record with remote access capabilities. Wireless technology has been a special focus area, as has the development of an efficient communication between primary care and secondary care. This review highlights some of the key success elements. *(Int J Circumpolar Health 2004;63(4):429-435)*

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Teleradiology

Teleradiology is one of the most widely utilised telehealth applications. The history of teleradiology in Oulu dates back to 1969, when radiological images were transmitted between Helsinki and Oulu using the broadcasting network of Finnish national television. Even though the pilot project showed the technological possibilities, it was too expensive and unpractical for clinical work. Modern teleradiology started in 1990, first using videoconferencing and, since 1991, digital data connections.

The teleradiology programme consists of three major areas: teleradiology for primary health-care, teleradiology for secondary care (hospitals) and the development of mobile teleradiology. In the development phase, all of the projects have been subjected to health technology assessment. The Finnish national criteria for technology assessment within the field of telemedicine were developed in 1996 (1) by Oulu University Hospital and the Finnish Office for Health Technology Assessment (FinOHTA).

Teleradiology serving primary health-care started in 1991, using ISDN lines and low-cost scanners and microcomputers. The first target was to develop the technical backbone and a business model (2). During the last few years, the technology has seen an evolution to broadband connections and direct DICOM (Digital Imaging and Communication in Medicine standard) compatible interfaces between sending and receiving sites. Work-flow and work practice studies have shown how technology affects co-operation between different institutions (3). The hospital network between various hospitals in Northern Finland was built during 1992 – 1996. The network serves for secondary opinion and emergency coverage between Oulu University Hospital and all the central, regional and local hospitals. Assessment studies have shown that teleradiology is cost-effective and influences both patient transportation and treatment (4).

As part of the secondary opinion network, an international teleradiology network connection was established, as early as in 1993, between the university hospitals of Oulu (Finland), Reykjavik (Iceland) and Tromsoe (Norway). This was made possible by the Nordic University Network "Nordunet", which was a precursor of the public Internet. To our knowledge, this was one of the first international teleradiology connections in the world (5).

Electronic patient record as an eHealth platform

Oulu University Hospital started a web-based multimedia medical record project in 1995. One purpose of this development was the creation

of regional eHealth services. Currently, the system, called ESKO, is used in all of the departments with over 250000 registered patient folders. The information can be retrieved via text terminals, web-browsers and mobile communicator devices. The patient record is a virtual record retrieved from various hospital databases according to the users‘ requests. The system is technically divided into three layers: 1) user interfaces using a standard www-browser, 2) a middle-ware taking care of the query/retrieval processes, and 3) modular databases.

Currently, the multimedia content of the medical record combines narrative texts, laboratory results, radiological information system (RIS) information, scanned graphics and DICOM format radiological images, such as computed tomography (CT) and computerised radiology (CR), and ultrasound (US) and magnetic resonance imaging (MRI) scans. Together with a structured nursing care record system, there are over 3000 professional users. With the system provided, users are able to use a familiar interface, the web-based electronic patient record (EPR), to display almost all of the clinical data they need in the university hospital environment. Current developments include installations in three other central hospitals in Finland and secure connections to remote primary health-care centres for teleconsultations and electronic referrals.

The modern medical record is a portal which can deliver information to the point of care. The integration of medical imaging should be seamless. In our hospital, the users can access all the images in DICOM archives through the EPR interface and this approach, developed in the RUBIS project funded by the European Union, has been successful (6). New components of the medical records can be added according to user needs and connected using standard interfaces. National and regional guidelines are also available for the professionals through the same interface. This enforces the use of evidence-based medicine. The portal type medical record is also a platform for mobile services for citizens and professionals. Our patients can, for example, receive health information via their GSM mobile phones, using the SMS service.

Electronic communication between primary and secondary care

Today, all the primary health-care centres in Northern Finland area are equipped with fully operational, paperless, electronic patient records. This means that electronic referrals and discharge letters are key tools in sharing multidisciplinary patient information between primary and

secondary care. In order to be effective in a major health-care service network, e-referrals should be connected to local electronic patient record systems and patient databases. In 1999, the first e-referral services between electronic patient record (EPR) systems at the university hospital and primary care centres in the region were started (7). This supplements the current network of e-consultation tools, such as teleradiology, videoconsultation services in surgery and psychiatry, and e-learning opportunities for professionals (8, 9).

There are two different ways to use our e-referral and discharge letter services: either in the form of a standardized XML language message between the EPRs, or as a secure Web link. The current XML message for e-referrals, e-consultations and discharge letters has been adopted by all of the major EPR suppliers in Finland. The primary care physician can use his own EPR to type in the e-referral and patient consent, and can also attach additional information in the form of PDF files. After the message is sent, the physicians at the university hospital can read the information using their own web-browser EPR. An e-referral can be turned into an e-consultation, sent further to another department, or returned to the sender. After the treatment, the referring physician receives an electronic discharge letter into his, or her, own system, provided the patient has allowed that.

The alternative Web link interface gives the primary care physician extended access to patient information in the hospital information system. If the patient has given his permission, the physician can read all of the multimedia information relating to a particular hospital visit. All narratives, laboratory results and full-resolution radiological images are available on-line. The web-link also makes it possible to follow the referral work-flow and waiting time. All of the connections are protected from intruders. The primary health-care centres are connected to the university hospital over either a virtual local-area network (VLAN), or a virtual private network (VPN).

At present, 12 of the 17 different university clinics provide e-referral services (emergency department, internal medicine, paediatrics, radiology, ophthalmology, neurology, gynaecology, radiation therapy, anaesthetics, medical genetics, physical medicine/rehabilitation (physiatry) and dermatology). The target is to include all of the clinics as service providers before the end of 2004. There are currently 13 municipalities using the services for their primary health-care centres, and more will be joining the team during the following

months. According to users, electronic consultation is a major modification in the patient care process and has required a careful roll-out process (10).

Wireless teleradiology

Some clinical specialities, such as neurosurgery, are dependent upon image information before they can give their advise. Similarly, during on-call hours, radiology residents need to consult their seniors, who may be absent from the hospital. Our mobile teleradiology development started in 1993 with a portable wireless Nokia data phone and a laptop computer. The system showed the technical feasibility, but weighed over 10 kilograms, so it was not taken into clinical use. In 1995, the first feasibility studies were made with suitcase systems and, in 1997, the first smart-phone application was brought into use. Our early experiences showed that wireless devices are capable of receiving diagnostic image information (11, 12).

During the years 1998 – 2000, the European Union (EU) provided financial support for the MOMEDA (Mobile Medical Data) project, which, according to our knowledge, produced the first pocket-size multimedia patient record terminal for physicians. The new concept of mobile medicine means sending information to the point-of-expertise, or fetching information to the point-of-care, even outside of the hospital. According to the concept, a MOMEDA server was established in the hospital intranet. In case of consultation, the server receives the DICOM images and sends them, together with relevant narratives retrieved form the hospital electronic patient record system, to the mobile device. The package is then forwarded to the mobile client using a GSM data pathway. Data connection is established with a secure call-back method and connections are authenticated with double security verification. The client software is running in a Nokia communicator device, which is a pocket-sized PDA (Personal Digital Assistant) with an integrated GSM phone. The developed client image viewer software is a lightweight version of diagnostic image workstation viewer software, which is capable of full diagnostic manipulation of the data. Additional information requests can be made from the hospital EPR system using a WWW-browser. Finally, a consultation phone call can be made to the hospital with a hands-free phone, while simultaneously reading the images (13).

The concept was evaluated in a real clinical setting by a team of neuroradiologists and neurosurgeons. The diagnostic quality was adequate and user acceptance for specific emergency tasks was high. Our demonstrator showed that it is medically sensible to use pocket-sized teleradiology terminals for consultation purposes in radiology and neurosurgery. This meant that the final product was adopted for clinical use by the neurosurgeons of the Oulu University Hospital in June 2000.

During the years 2002 – 2004, the EU supported the PROMODAS (Professional Mobile Data Systems) project, which further developed the ideas to 2.5 generation wireless networks and platforms. The development of mobile internet protocol (IP) networks with GPRS (General Packet Radio System) technology made it possible to stay connected with less costs than previously. New portable terminal devices with faster processors enabled a more efficient processing and display of patient information. In practice, the PROMODAS terminal has already replaced the earlier generation in clinical use.

DISCUSSION

It is seen that Internet technology is a glue for system integration and gives us a useful user interface when we have to access several systems simultaneously. Development work requires continuous effort, with technical developers and users working closely together in order to find new solutions. Teleradiology services and electronic referrals can be utilized to their full potential only if they are integrated with electronic patient record systems. The standardization of information contents and formats is needed for data exchange between institutions. The Finnish National Project on securing the future of health care places special emphasis on developing standards and recommendations for more secure and efficient communications. The target is inter-operability between the various electronic patient record systems before the end of 2007. Another emerging trend is the creation of regional archives for medical image data and laboratory results. This means that several hospitals can store their data in one single archive. This data is then available over secure and fast networks to authorized persons involved in patient care. The patient is the final winner when medical professionals can access information in the most practical way.

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