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Telemedicine and Fictional views of the e-laboratory for better care decisions

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Telemedicine has been defined in the past in broad terms as the delivery of healthcare and sharing of medical knowledge over a distance using telecommunications systems.

Former definition: "Delivery of healthcare and sharing of medical knowledge over a distance using telecommunication systems"

- 1960s - interactive television
- 1970s - telemetry of medical data in space programmes
- 1990s - digital telecommunication revolution

Most of the early attempts to transmit data were based on land telephone lines, and were limited in the speed and quality of transmission, and by the limited techniques available to digitalise analogue signals such as retransmitting slide wires that some of you will recall were fitted on chart recorders. Later, remote interviews and consultations were tried with television, but the issues of image quality and speed of transmission were similar. Physiological monitoring of astronauts led to sensor miniaturisation and digital processing, but it was really in the 1990s that the widespread use of digital telecommunications triggered the explosive growth in telemedicine that we see today.

Definition

The growth in telecommunications is worldwide, and telemedicine projects are supported by national governments and by the European Union. The European Union defined telemedicine as a "fast access to distributed medical knowledge using telemedicine and information technologies regardless of actual location of a patient or relevant information".

This definition adds three new concepts to telemedicine:

- Fast access: essentially aimed at real-time interactions
- Telemedicine and information technologies: there may be some specific telemedicine technologies
- The patient and the relevant information can both be at a distance from the operator of the telemedicine system, and this could be on a multistate or international level.

Factors driving developments

The specific technologies driving the use of telemedicine include high speed digital modems and digital telephony, able to transmit 128 kbit/second, the increasing use of fibre-optic networks that can handle enormous numbers of simultaneous connections, and cost less than the dedicated telephone mines such as the Transpac system that were used in the 1980s, high density television and television formats that are compatible between Japan, Europe, and the USA, and the world-wide web. In remote areas that have no telephone lines, radio-satellite communication can be achieved with easily transported equipment, widely used by journalists today.

Much of telemedicine is based on the analysis of images: X-rays, scans, etc., and these involve large data files that require vast amounts of computer memory to store. Data compression algorithms can reduce this, but there are many questions still to be answered on the loss of fine resolution that can lead to misinterpretation of the image when it is decompressed, or if the number of colours is limited to 256 from 16 million, or more. Many of these questions are also found in non-medical multimedia applications, and there are a number of reports of pathology images being stored in JPEG, which most PCs can handle easily. A second obstacle that is also being overcome by non-medical applications concerns the confidentiality of the data that is transmitted to protect medical secrets and prevent unauthorised modifications.

Technology is not the only driving force. In fact telecommunications can be useful in developing countries where a trained person at a home base or district hospital can guide local helpers through a diagnostic or therapeutic problem. In developed countries, telemedicine is one approach to harmonising the access to care between rural and urban areas, and improving quality by standardising patient management.

Macroeconomic Significance of Telemedicine

The reasons why telemedicine has become such an issue for national and European governments are probably related to the macroeconomics: there are tax revenue and employment benefits from the commercial activities. There are savings to be made, both direct and indirect, from not having to transport patients to specialist services, and by not having excess manpower capacity where it is under-utilised.

Telemedicine Applications

The escalating interest in telemedicine and publications about success of some telemedicine projects suggest that during this decade, the market for this technology will increase, as will the number of available programs. However many programs have failed to continue past the pilot-project stage. Although a significant proportion of telemedicine current applications are non-clinical (e.g., administrative functions, continuing medical education). Clinical applications now cover many specialities, including: radiology, nuclear medicine, dermatology, psychiatry, emergency medicine, home healthcare, cardiology, pulmonary function, obstetric ultrasound, ophthalmology, oncology endoscopy, guiding surgical, and clinical procedures.

In the USA, the Federal Telemedicine Gateway is a list of Federally funded telemedicine projects, jointly funded by the Department of Defence, the Rural Utilities Service, the National Telecommunications and Information Administration, the Agency for Healthcare Policy and Research, the FDA, the Office of International and Refugee Help, the Indian Health Service, and others. The types of project are listed include the remote interpretation of radiological and nuclear medicine images. Many of the devices use direct digitalisation from phosphors and not film, so that transmission of data is rapid. TV cameras and microscopes with TV cameras can transmit images captured from skin, the cornea, the retina, cameras can be fixed to fibre optic endoscopes.

Examples include:

- Teleradiology (reading still and full motion radiographic images),
- Telepathology (analysis of tissue histology samples).
- Electronic transmission of pathologic or Histopathologic slides and thereby analysis of a tissue sample from one location to another,
- Telementoring (guiding surgical and other clinical procedures from a remote location), • Telemedicine & Teledermatology (actual physical examination of a patient).

What these applications have in common is: remote acquisition of raw data from patient, lower skill level for data acquisition than interpretation, central interpretation real-time e.g. for remote consultation with the possibility of computer-assisted interpretation by pattern recognition or artificial intelligence. This is also similar to the applications of telemedicine to the clinical laboratory.

Laboratory Medicine Applications

Telepathology has been in development, especially in Europe, since the 1980s, initially with an emphasis on diagnostic coding and standardisation of the signal processing. The two principle approaches are the transmission of a selection of static images at random from a slide, and having a robotic workstation where the reviewer at a distance manipulates the slide under the stage. The are several examples of telepathology systems, and which have been evaluated for diagnostic efficiency vs. glass slide review. These include The Resintel network in Dijon, the commercial Roche RIAS, the TELE.INFO.MED.LAB project in Greece, to mention only a few. The Lab Eye Innovative system is used in Sweden for remote pathology conferences, and there is a 10-year experience of remote interpretation of frozen section slides in real time (3-45 minutes) for breast and thyroid surgery. Both Norway and Sweden have developed telepathology services, particularly appropriate to the distributed population density. Many other examples can be found in the literature of locally developed telepathology devices and their application to routine work, including cervical cytology, which has some special requirements for clear, relatively high magnification images. Microbiological microscopy can also be performed with remote interpretation of gram stains and simple preparations for flagellates, which can be done by a nurse or technician.

In principle, the same could be done for blood films in haematology, and indeed, when automated differential counting was performed by pattern recognition systems, there were several specialised labs offering central image review, but this is no longer the case. Some attempts have been made for transmission of microscope images of thick films for malaria.

Although cells isolated and prepared by flow cytometry could also be subjected to remote review, there is little experience other than for research applications. There appears to be limited use of telehaematology for human medicine, although there are reports of veterinary applications, particularly in the USA.

Telemedicine applications in biochemistry are also rare. The most developed approaches involve remote interrogation of QC and calibration parameters on blood gas instruments. It is possible to link the instruments to AI systems such as VALAB to have a clinical plausibility of the result, and we have some experience of this in France for release of results of tests performed at night or in the absence of a qualified pathologist. A special case, more common in the UK and in the USA than elsewhere is the transmission of hCG and oestriol results together with patient information, for the determination of trisomy-21 risk by algorithms which are not in the public domain.

Both of these demonstrate the feasibility of transmission of data, either test requests or results, in order to have an optimised pattern of investigation or interpretation of the results.

However there are still problems to be overcome. A task force on diagnostic cytology has identified these problems, but the findings apply to all telebiological tests. Economic factors will impose on us commercial equipment and software. As professionals, clinical chemists have to define how we will use these to serve and protect our patients better, including the development of procedures and checks that ensure the accurate transmission and interpretation of the results and information. The laboratory professionals have to develop the technical standards by themselves, in collaboration with manufacturers and national authorities. They need to be able to validate and maintain the systems for teletransmission and interpretation. Where someone who is not in charge of the patient or by a diagnostic algorithm makes interpretation at a distance, they need to have clear definitions of responsibility, and of professional liability.

As with any healthcare program, the most important element required for a successful telemedicine and telebiology practice is a defined clinical need, for example, the need to increase the access to and the quality of care, to improve patients' outcomes, or to decrease the cost of care without sacrificing quality. Many programmes are acquired technology first and searched for applications later. This strategy is often unsuccessful because the choice of the technology and the infrastructure required depends greatly on the clinical applications. Without a clear clinical need, even the most cutting-edge technology is unlikely to improve healthcare delivery or patient outcome. The needs analysis should result in a business plan oriented toward addressing the defined clinical need. This analysis should include a cost justification for implementing the technology and an evaluation of the telemedicine program. A medical staff champions most successful programs. To be successful, the laboratory scientist champion should be easy with the technology, in order to incorporate telemedicine and telebiology into his/her own practice, to have the time to devote to promoting telemedicine and telebiology, to teach effectively, and to be willing to serve for little or no compensation.