

eHEALTH IN ANTARCTICA: A MODEL READY TO BE TRANSFERRED TO EVERY-DAY LIFE

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ABSTRACT

Antarctic expeditions are an important testing area for technology and procedures, such as telemedicine, with analogies for space and other extreme, isolated and remote environments. Telemedicine has also implications in reducing risks and costs related to accidents and health-care in general in Antarctica (1).

During the last 14 years, since the very beginning of Italian Antarctic activities, we have tested many different technological solutions, and set up a link between one of the largest Italian hospitals, San Camillo in Rome, and the principal Italian Antarctic Base at Terra Nova Bay (2). In this paper, we discuss the road we have travelled in a field with many fast technological changes, and reflect on procedures and protocols. Once we had Health, today we have eHealth. (*Int J Circumpolar Health* 2004;63(4):436-442)

Key words: telemedicine, Antarctic, maritime satellites

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MATERIALS AND METHODS

When the Italian Antarctic expedition programme started in 1987, we gave a company the task of developing the first experimental telemedicine system. After 3 years, we had developed enough skills and understanding of the needs, and "off the shelf" technology had become sufficiently sophisticated to allow us to continue the development of the system ourselves.

The first step was to assess the capability to transmit medical data between Terra Nova Bay and a laboratory in Rome, with a dedicated instrument and system using INMARSAT (International Maritime Satellites). Having achieved satisfactory results, in the second year we set up an automatic unattended station and, in the third year, tested the transmission of images and many other types of data to the Italian National Research Council in Rome (CNR-IMS, Institute of Experimental Medicine).

We then started the "medical" development of the system, connecting to X-ray equipment, digital images, digital medical devices (ECG, Doppler CW, Duplex Scanner, EEG, BP) and transmitting the data to San Camillo hospital, in Rome.

More recently, in order to reduce costs, we have focused on procedures and process management, ending the experimental phase and starting the "telemedicine service".

RESULTS

During the 1987-88 expeditionary campaign, we made the first medical digital transmission from Terra Nova Bay and transmitted Doppler waveforms from the expeditions support ship to Italy. It was the first success, using technology built together with an Italian company, Biotronix, our technical partner during the earliest stages of the research.

In 1990, the first images were transmitted, and it was a great success. The first landing of a C-130 aircraft on the ice at Terra Nova Bay was photographed and, within an hour, the image was successfully transmitted to Italy. The image capture system was developed from work by Dr Luciano Alessio (3) from CNR-IMS, and was the first step of a long cooperation between San Camillo hospital and CNR-IMS.

During the 1993-94 summer campaign, prototype experimentation with the telemedical system was ended, and a functional facility at our Terra Nova Bay base was started. Two accidents were discussed by telemedicine, sending the x-rays to Italy, where a radiologist and an orthopedic surgeon were available for diagnosis and to suggest treatment.

A general-purpose e-mail system connected to the internet was also inaugurated, with the capability of sending images and any medical data through the internet attached to messages, using the UUCP (Unix to Unix copy protocol).

The system in Italy could receive e-mail from Antarctica and convert the messages automatically to fax format, allowing to forward transmissions to anywhere in the world, without the high cost of an INMARSAT connection for fax messages. The overall cost of both systems, in Antarctica and in Italy was around 7.000 \$US for hardware, and 1.500 \$ for purchased software, although it also uses some software solutions which we developed ourselves (4).

During the summer campaign of the following year, 1994-95, we started to study a new release of the telemedicine system, planning and testing a direct internet connection using PPP (point to point protocol) to bridge the Terra Nova Bay Medical Network with San Camillo Hospital Network, again using an INMARSAT connection.

The SLIP (Serial Line IP Protocol) and PPP connection were tested and some points were focused. We also tested, with Dr Alessio, new methods of image compression, such as the fractal technique, demonstrating how this algorithm could work well with x-rays and with biological images in general (3).

We thus arrived at the stage where we had a system that could be used routinely. Medical and technical procedures had to be well-defined, in order to set up a system that uses the "normal" hospital standard allowing information transmitted by telemedicine to be interpreted in Italy. The system itself should work without the need for medical supervision in acquiring and sending the data. The next step, therefore, was the organization of the system and experimental testing with real clinical cases taken from our emergency room, in order to assess the capability of the system to provide a low-cost, standard telemedical system applicable to any remote region.

In the summer of 1999-2000, some of our medical events were solved using the telemedicine system. We had an ophthalmic specialist consultation, as well as orthopedic and radiological consultations.

During this time, we took the opportunity to define the technical standards, quality standards and procedures, and to write a manual for teleconsultation, both on-line and off-line.

The system has now become a mainstay of medical practice in the Italian Antarctic Programme, transmitting many different types of medical data via both point-to-point and internet connections, using a high-resolution digital camera, a scanner and a video capture card. Once received in Italy, alert messages are automatically sent to cellular phones to inform the appropriate respondents. The data is stored in a Web-based mail system, in a standard format, and can therefore be retrieved and the questions answered using any Web browser with appropriate security settings in place to protect confidentiality.

Answers are made within 1 hour for an emergency call, using the on-line system, within two to four hours for an urgent enquiry not needing an immediate response, both on- and off-line, and in less than 24 hours for routine questions, using the off-line system.

We designed a reporting form to enable an accurate recording of events and defined some procedures to use when asking for a telemedicine meeting. In this, we tried to adhere closely to the same system as that used in Italian hospitals to ask for an examination, and a similar format for reporting the answer, simply converted to conform with telemedicine systems.

For routine use, the off-line system has to be considered best, as it is very cost-effective in terms of both manpower and transmission costs. The on-line system is essentially reserved for really urgent problems, as it is very time-consuming, taking, in our experience, not less than 40 minutes and involving doctors and technicians at both ends of the connection (Table I). We have systems in place to facilitate telemedicine conferences between technicians and doctors, between primary care doctors on the base and specialists in Italy and, when necessary, between specialists. All the specialists in San Camillo Hospital are involved and, as this is one of the largest hospitals in Italy, the range of expertise is extensive, covering virtually all medical specialisations.

Table I. Comparison of on-line and off-line techniques by response times and costs.

	1 hour	3-5 hours	24 hours	COSTS-TIME
ON-LINE	OK	OK		High
OFF-LINE		OK	OK	Low

During the last year, we have organized a training course in telemedicine at CNR-IMS and all the lessons were also transmitted live and off-line on the internet, to allow distance learning in remote areas.

One of the research interests is in vascular medicine and surgery, and, in the year 2000, we extensively explored the use of telemedicine in the transmission of echo-colour doppler, using the system to assess whether videoconferencing is usable to permit remote specialist interpretation and diagnosis of these complex images.

Today

Today we have a full telemedicine system (5), which seems very well-adapted to the requirements of remote health-care. From a technical point of view, this is essentially a video conference system between Terra Nova Bay and San Camillo Hospital, connected through the internet in a VPN (Virtual Private Network) for security reasons, with some peripherals connected to the video and audio mixer.

Video comes from video camera, x-ray monitor, echo-duplex scanner, or video microscope setups, or from any combination of such systems. Audio comes from a microphone, an electronic stethoscope, or a duplex scanner. This allows a full on-line teleconsultation.

For off-line teleconsultations, we have an asymmetric encryption e-mail system, PGP (pretty good privacy), capable of using some digital data capturing devices (5.4 megapixel digital camera, flatbed scanner, DICOM x-ray device).

Our experience has allowed the design and delivery of a Master's degree from the University of Camerino. This is, as far as we are aware, the first University Master's in eHealth in Europe. This year, one of the students will also travel to, and work in, Antarctica and, during his period in Terra Nova Bay, he will have access to coursework and learning materials for the Master's, allowing 90% to be undertaken by e-learning. Details of the course can be found on <http://www.unicam.it/health> (9).

The Future: from telemedicine to eHealth (6-8)

We are joining our system to the mainstream, every-day life, Italian health-care system, transferring to Antarctica a software used exten-

sively in Italy for the triage and management of patients in emergency departments. This was developed in a project supported by the MIUR ("Ministero per l'Università e la Ricerca Scientifica"). The software is called GIPSE (Gestione Informazioni Pronto Soccorso ed Emergenza, stands for "Emergency and E.R. Information management") and has all the procedures, codes and databases necessary for handling emergency medicine work, but it is also a system which is open for use for teleconsultation and remote evaluation. As a result, Terra Nova Bay will be just another part of our NHS, only some thousands of miles away.

DISCUSSION

When we started our programme, simply achieving satisfactory and reliable transmission was, in itself, a great success. In a remarkably short time-scale, technology has given us the internet, and data transmission has become a standard part of our medical lives. Telemedicine is no longer a technical problem, but it is a management problem and much must be done to improve the efficiency of the organisational and procedural systems.

There are some important questions which must be considered from the point of view of health-care. These include:

- Who is in charge of telemedicine; the emergency departments, the specialists, or a unique unit? Convincing arguments and many reasons can be given for any of these, and different solutions will be applicable to different systems.
- When is telemedicine most useful, in remote areas, in several very specific fields?
- Is it most useful in small hospitals in the developed world, in Antarctica and other hostile, isolated and confined environments, in Africa and third world areas, for ambulance services, or emergency departments? The list is almost endless!
- What kind of equipment and materials are useful and, equally important, which are expensive and never used?
- Who will pay for telemedicine services, and how much are they prepared to invest in these technologies?

Some costs are still unclear, but the benefits are clear. However, quality assurance methods and clinical governance need to be carefully ad-

vanced, and there may be some legal problems yet to be defined. Remote expeditions still represent good laboratory settings for testing systems applicable to hospital organization, but we are now ready to transfer the experience already gained into the health services, and use telemedicine to expand the scope of health-care in remote areas to provide a true, worldwide e-health environment.

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