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► Introduction to the practice of telemedicine

John Craig* and Victor Patterson*[†]

*Department of Neurology, Royal Victoria Hospital, Belfast, UK; [†]Centre for Online Health, University of Queensland, Brisbane, Australia

Summary

Telemedicine is the delivery of health care and the exchange of health-care information across distances. It is not a technology or a separate or new branch of medicine. Telemedicine episodes may be classified on the basis of: (1) the interaction between the client and the expert (i.e. realtime or prerecorded), and (2) the type of information being transmitted (e.g. text, audio, video). Much of the telemedicine which is now practised is performed in industrialized countries, such as the USA, but there is increasing interest in the use of telemedicine in developing countries. There are basically two conditions under which telemedicine should be considered: (1) when there is no alternative (e.g. in emergencies in remote environments), and (2) when it is better than existing conventional services (e.g. teleradiology for rural hospitals). For example, telemedicine can be expected to improve equity of access to health care, the quality of that care, and the efficiency by which it is delivered. Research in telemedicine increased steadily in the late 1990s, although the quality of the research could be improved – there have been few randomized controlled trials to date.

Introduction

One of the great challenges facing humankind in the 21st century is to make high-quality health care available to all. Such a vision has been expressed by the World Health Organization (WHO) in its health-for-all strategy in the 21st century.¹ Realizing this vision will be difficult, perhaps impossible, because of the burdens imposed on a growing world population by old and new diseases, rising expectations for health, and socioeconomic conditions that have, if anything, increased disparities in health status between and within countries.

Traditionally, part of the difficulty in achieving equitable access to health care has been that the provider and the recipient must be present in the same place and at the same time. Recent advances in information and communication technologies, however, have created unprecedented opportunities for overcoming this by increasing the number of ways that health care can be delivered. This applies both to developing countries with weak or unstable economies

and to industrialized countries. The possibilities for using information and communication technologies to improve health-care delivery ('health telematics') are increasingly being recognized. The WHO has stated that with regard to its health-for-all strategy it recommends that the WHO and its member states should:

...integrate the appropriate use of health telematics in the overall policy and strategy for the attainment of health for all in the 21st century, thus fulfilling the vision of a world in which the benefits of science, technology and public health development are made equitably available to all people everywhere.²

Such a commitment to improve health-care delivery, by utilizing information and telecommunications technologies, is also being considered by those with the financial means to do so, for example, the participants in various European Commission projects. At the national and subnational level, there is also evidence of governmental interest in the benefits that these technologies might bring to health care. For example, in the UK, information technology including telemedicine is at the heart of the government's strategy to modernize and improve the NHS.³ Telemedicine, the area where medicine and information and telecommunications technology meet, is probably the part of this revolution that could have the greatest impact on health-care delivery.

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Correspondence: John Craig, Level 7C Outpatients, Royal Victoria Hospital, Belfast BT12 6BA, UK
(Fax: +44 28 9023 5258; Email: john.craig@royalhospitals.n-i.nhs.uk)

What is telemedicine?

Telemedicine is the delivery of health care and the exchange of health-care information across distances. The prefix ‘tele’ derives from the Greek for ‘at a distance’; hence, more simply, telemedicine is medicine at a distance. As such, it encompasses the whole range of medical activities including diagnosis, treatment and prevention of disease, continuing education of health-care providers and consumers, and research and evaluation.

Telecare is a related term and refers to the provision, at a distance, of nursing and community support to a patient. Similarly, telehealth refers to public health services delivered at a distance, to people who are not necessarily unwell, but who wish to remain well and independent. In effect, however, despite repeated discussions about what constitutes telemedicine, telecare and telehealth and what their differences are, all involve the transfer of information about health-related issues between one or more sites, so that the health of individuals and their communities can be advanced. In other words, the information is moved, not the providers or the recipients of health care. Nowadays, the transfer of information is generally facilitated by the use of some kind of telecommunications network. An umbrella term encompassing all health-related activities carried out over a distance by such information and communication technologies is ‘health telematics’. With this in mind, telemedicine, as an integral part of health telematics, might be defined as:

Rapid access to shared and remote medical expertise by means of telecommunications and information technologies, no matter where the patient or the relevant information is located.⁴

What telemedicine is not

Telemedicine is not a technology or a separate or new branch of medicine, or for that matter even new. It is also not the panacea that will cure all of the world’s health-related problems or a means by which health-care workers can be replaced. It is also not an activity for antiquarians or Luddites, who range from those who are simply not at ease with the use of electronic machinery, right through to those who feel that telemedicine threatens the very fabric of the practice of medicine, and as such should be actively opposed. Equally, however, it is not the sole territory of ‘computer nerds’ or ‘technophiles’. In fact, the tendency of these individuals to concentrate on the technical rather than the practical when discussing

telemedicine may explain the antipathy of some clinicians towards practising medicine this way. Sensible, practical presentations by those who have actual experience of telemedicine have the potential to change the minds of those health-care workers who feel that telemedicine is not for them, either because it is ‘gimmicky’, industry-driven and therefore ‘less than respectable’, or unfathomable. Finally, and probably most important, for the most part telemedicine is far from being a mature discipline, and much work remains to be done to establish its place in health-care delivery.

Types of telemedicine

The common thread for all telemedicine applications is that a client of some kind (e.g. patient or health-care worker) obtains an opinion from someone with more expertise in the relevant field, when the parties are separated in space, in time or both. Telemedicine episodes may be classified on the basis of:

- the interaction between the client and the expert and
- the type of information being transmitted.

The *type of interaction* is usually classified as either prerecorded (also called store-and-forward) or realtime (also called synchronous). In the former, information is acquired and stored in some format, before being sent, by an appropriate means, for expert interpretation at some later time. Email is a common method of store-and-forward interaction. In contrast, in realtime interactions, there is no appreciable delay between the information being collected, transmitted and displayed. Interactive communication between individuals at the sites is therefore possible. Videoconferencing is a common method of realtime interaction.

The *information transmitted* between the two sites can take many forms, including data and text, audio, still images and video pictures. Combining the type of interaction and the type of information to be transmitted allows telemedicine episodes to be classified as in Figure 1. In certain applications, such as teleradiology, a technique that involves the transmission of digital radiographs between institutions, it is possible for the interaction to be either prerecorded or realtime; the latter requires that the expert be available to give an opinion as the image is taken and transmitted.

History of telemedicine

Most telemedicine has clearly occurred in the last 20–30 years, concomitant with advances in

Interaction	Information transmitted		
		Still images	Moving images (video)
	Real-time		e.g. telepsychiatry
	Pre-recorded	e.g. teleradiology	

Figure 1 Classification system for telemedicine episodes

information technology. If, however, telemedicine is considered to be any medical activity performed at a distance, irrespective of how the information is transmitted, its history is much older. An early example of medicine at a distance, be it one of the first public health surveillance networks, was in the Middle Ages, when information about bubonic plague was transmitted across Europe by such means as bonfires. With developments in national postal services in the mid-19th century, the means by which more personal health-care delivery at a distance could be performed was facilitated, and the practice of physicians providing diagnosis, and directions for a cure, was established.

In the mid-19th century, telegraphy – signalling by wires – also began and was quickly deployed by those providing and planning for medical care. This included its use in the American Civil War to transmit casualty lists and order medical supplies, with later technological developments permitting X-ray images to be transmitted. In much of Europe and the USA, the telegraph was rapidly superseded by the telephone as a general means of communication, but in Australia it survived for much longer because of the enormous distances involved.

The telephone has been used for delivering health services since its invention in the late 19th century, and for 50 or so years remained the mainstay of communication for such purposes. However, it was realized as early as 1910 that the telephone could be used for purposes other than voice communication; amplified sounds from a stethoscope were transmitted through the telephone network and similar devices are still used today. Other uses for the ordinary telephone network have since been realized and include the transmission of electrocardiograms (ECGs) and electroencephalograms (EEGs).

The next development of widespread significance was at the end of the 19th century when communication by radio became possible. This was done initially by Morse code and later by voice. Use of the radio to provide medical advice for seafarers was recognized very quickly, and in 1920 the Seaman's Church Institute of New York became one of the first

organizations to provide medical care using the radio, with at least another five maritime nations establishing radio medical services by 1938. One of these was the International Radio Medical Centre (CIRM), whose headquarters are in Rome, Italy. It was set up in 1935 and in its first 60 years assisted with over 42,000 patients, making it the largest single organization in the world to use telemedicine to provide health care to seafarers.⁵ Radio medical advice for passengers on long-distance air journeys has also been provided more recently. For in-flight medical incidents that require professional assistance, and which occur at a rate of about 1 in 50,000 passengers carried, assistance can be obtained from on-call health-care workers on the ground.

The birth of modern telemedicine

The recent development of telemedicine has been facilitated on two fronts. First, there are the advances in electronic methods of communication. Initially, analogue methods were used, but now modern digital communication techniques are the mainstay. Second, telemedicine has developed because of the pioneering efforts of a few organizations and individuals. The former generally represented the interest of high-tech ventures, such as the manned space-flight programme of the National Aeronautics and Space Administration (NASA) in the USA. While these were no doubt of great importance in fostering the development of telemedicine and telecommunications generally, the efforts of a few individuals using readily-available commercial equipment have arguably been just as important for the development of telemedicine. It is interesting to note that in the 40 or so years since these individuals initiated their ventures things have changed relatively little, as far as who is doing research of practical value, and how it is being done.

A major influence on the development of telemedicine was the introduction of television. By the late 1950s, developments in closed-circuit television and video communications were made use of by medical personnel, who began to employ them in clinical situations. As early as 1964, a two-way closed-circuit television system was set up between the Nebraska Psychiatric Institute in Omaha and the state mental hospital in Norfolk, 112 miles (180 km) away.⁶ The system permitted interactive consultations between specialists and general practitioners, and facilitated education and training at the distant site. Another early example of television linking doctors and patients was at the Massachusetts General Hospital/Logan International Airport Medical Station, which was established in 1967.⁷ This used a two-way audiovisual

microwave circuit and permitted care to be provided to passengers and airport employees 24 h a day by nurses, supplemented by physician expertise using the audiovisual link. In an early report of the feasibility of this method of delivering health care, the observations of 1000 episodes were documented. It is noteworthy that few reports of telemedicine projects since have contained such numbers of episodes performed. More recently, there has been a major growth in realtime telemedicine with the wide availability of video-conferencing. This has been made possible because of improvements in digital communications and the introduction of low-cost computing, many of the videoconferencing systems now being based on PCs.

The recent developments of mobile phones and satellite communications have allowed mobile telemedicine. Early examples of such programmes were the Alaska ATS-6 Satellite Biomedical Demonstration from 1971 to 1975, which assessed the viability of improving village health care in Alaska using satellite-mediated video consultation,⁸ and the Memorial University of Newfoundland programme established in 1977, initially to provide distance education as well as medical care to Canadians.⁹

Where is telemedicine being done?

Today, telemedicine represents the experiences, opinions, perceptions and interests of a vast number of individuals and organizations. Most operational telemedicine services, of which the majority concern diagnosis and clinical management at a distance, are in industrialized countries, especially the USA, Canada, Australia and the UK. Telemedicine also includes tele-education, and distance treatment, e.g. telesurgery. The latter area remains the subject of media interest, but there is little practical experience. Teleradiology is the branch of telemedicine which has been integrated best into the fabric of clinical practice. So well integrated is it that figures on its use are impossible to come by.

A recent survey of teleconsultation activity (excluding teleradiology) in the USA found that over 85,000 teleconsultations were done in 2002, performed by more than 200 programmes, in over 30 specialties.¹⁰ Mental health, paediatrics, dermatology, cardiology and orthopaedics accounted for almost 60% of these teleconsultations, with approximately 50% using interactive video, the rest prerecorded or non-video technology (Figure 2).

This survey also identified 52 telemedicine programmes outside the USA, with Canada (10), Australia (9) and the UK (9) being the major contributors. Elsewhere in Europe, Norway has a

National Centre for Telemedicine based at Tromsø and both Finland and Russia have functioning telemedicine programmes. Hong Kong has established programmes in the rehabilitation of older people,¹¹ and there is a telemedicine service for burns patients in Australia.¹² In South America, Argentina has seen its telemedicine applications collapse.¹³

Despite most telemedical services being concentrated in industrialized countries, there are several lines of

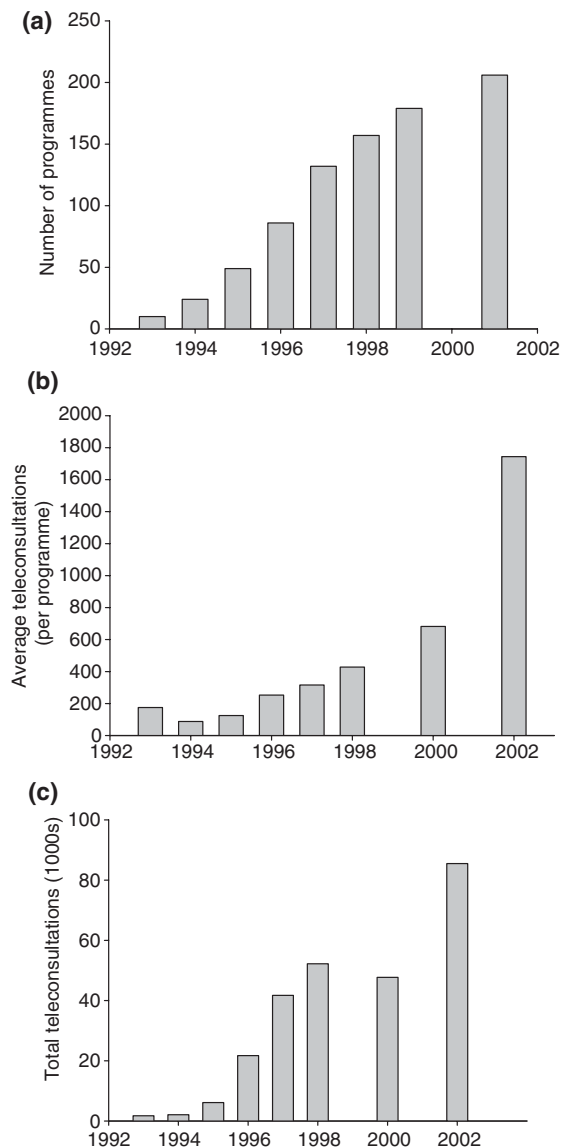


Figure 2 Teleconsultation activity (excluding teleradiology) in the USA. (a) Number of telemedicine programmes; (b) average number of teleconsultations per programme; (c) total number of teleconsultations in the USA each year. Data from Grigsby¹⁰

evidence to suggest their adoption globally, including within developing countries. The first of these is witnessed in the number of conferences and meetings that are occurring with increasing frequency throughout the world, and the diversity of nations that are represented at them. Africa epitomizes the paradox of telemedicine, that the areas that would benefit most from it do not have the resources to utilize it. There are functioning networks in South Africa and in Mali,¹⁴ the latter linked to a hospital in Geneva. There are several other telemedicine networks linking the industrialized and developing worlds; including those run by the Swinfen Charitable Trust¹⁵ and the Medical Missions for Children.¹⁶ This is an area that is likely to grow in the future.

Research

The output of papers on telemedicine-related subjects as indexed on MEDLINE has been fairly constant at about 1000 papers annually over the last five years.^{17,18} Prior to that, there had been a period of rapid growth in annual output from about 100 in 1994. Although almost 50% of recent papers originate in the USA, Finland and Norway produce the greatest number of publications per head of population (Figure 3). One specialist journal, *Journal of Telemedicine and Telecare*, published 13% of all papers but, encouragingly, over 50% of MEDLINE-indexed journals have published at least one article on telemedicine.¹⁷ There has been an increasing number of randomized controlled trials published^{19,20} and also some systematic reviews. The results of the latter are rather critical of much of the telemedicine literature, and one even suggests that much of it should not have passed the peer-review process.²¹ The correspondence subsequent to this review did question the relevance of such academically rigorous analyses to telemedicine, the aim of which is not to replace face-to-face medicine and take over the world, but more usually to improve people's health in certain well defined situations. Telemedicine has a number of separate attributes – feasibility, acceptability, cost, effectiveness, safety, sustainability – and the importance of studying each of these systematically will vary from application to application. For example, to use telemedicine to support an Antarctic expedition requires only that feasibility be demonstrated, since acceptability and cost are less relevant. In contrast, using telemedicine for a single specialty in a large region needs considerably more attributes to be studied. The paradox here is that if research is tightly controlled to meet the strict requirements of the writers of systematic reviews, it may become less relevant to

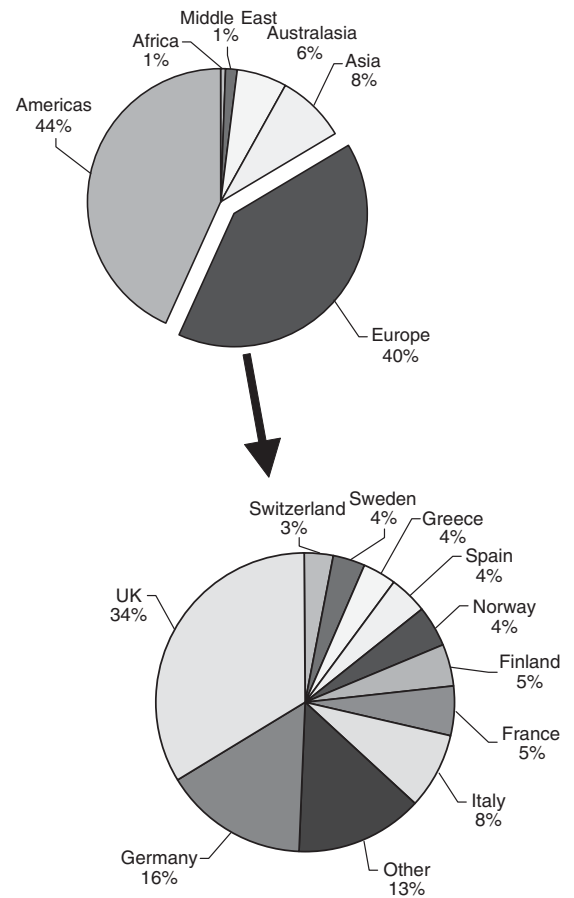


Figure 3 Primary telemedicine research – origin of the research papers published in the two specialist telemedicine journals (*Telemedicine Journal and e-Health* and *Journal of Telemedicine and Telecare*) from 1998–2003 ($n = 2952$)

real-life situations and therefore less likely to be introduced into clinical practice.

Why is telemedicine being done?

The frequent references to telemedicine in the medical and lay literature and the increasing number of politicians who appear to be interested in its use are very noticeable. McLaren and Ball have argued that the reason for such interest is that 'Technology has the power to mesmerise. It is for this reason that telemedicine has a high profile'.²² While there is no doubt that for some this is true, there are basically two reasons why telemedicine should be used:

- there is no alternative to telemedicine;
- telemedicine is better than existing conventional services.

No alternative to telemedicine

Telemedicine clearly has a role in the case of emergencies in remote environments such as the Antarctic and in ships or aeroplanes, where it may be difficult, if not impossible, to get medical care to the patient in time. In countries with unstable or weak economies, however, where health-care services are often not a priority, telemedicine also permits access to services that would not otherwise be available. An example is the provision of medical services from the city of Arkhangelsk in northwest Russia to other parts of the region and exchange of knowledge and experience between the University Hospital of Tromsø, in northern Norway, and northwest Russia.²³

Telemedicine is better

Telemedicine has obvious advantages in remote or rural areas where it improves access to health services, obviating the need for patients and health-care workers to travel. Even in urban areas, however, telemedicine can improve access to health services and to information. Telemedicine has also been shown to improve the consistency and quality of health care.²⁴ It may sometimes also be cheaper than conventional practice, although, as previously mentioned, scientifically sound economic appraisals of telemedicine applications are only just beginning to appear.

Other reasons why telemedicine is being done

Telemedicine is occasionally accused of being an 'industry' driven by commercial rather than consumer interests. Certainly, of the numerous experimental and operational telemedicine systems in use, or at the drawing-board stage, some would appear to have been set up primarily to produce financial benefits for the providers (individuals or organizations) of the service, rather than health benefits for the consumers. Telemedicine principally practised for financial gain is not confined to the manufacturers of equipment, but includes health-care workers (real or fraudulent), telecommunications networks and other organizations. The technological advances that have been necessary to develop telemedicine to its current state, or which are likely to occur in the future, are driven mainly by market forces; hence, there is a concern that the reputation of telemedicine as a whole could be damaged by the actions of those aiming to make their fortune. This is especially likely if operational services are set up without prior establishment of the need for a particular application in a certain setting, and evidence that the service as established is effective and cost-effective. If there was ever an

argument for the need for research for all telemedicine applications prior to widespread adoption, this is surely it.

Effects of telemedicine

In broad terms, telemedicine can be expected to improve equity of access to health care, the quality of that care and the efficiency by which it is delivered, by enhancing communication up and down the health-care pyramid. Widespread adoption of telemedicine would permit decentralization; work previously done in the secondary sector, for example, could be performed in primary care and work previously done in the primary care sector could be devolved to the community level (Figure 4). Such changes, if implemented in the developing world, could potentially have the greatest effect, allowing underserved people to benefit from a greatly improved standard of health care. In all remote or rural areas, however, telemedicine could have a great impact, permitting among other opportunities, better diagnostic and therapeutic services, faster and easier access to medical knowledge, and enhanced communication between health-care workers.

Conclusion

There is no doubt that telemedicine is effective in certain situations. The transition to a world where telemedicine is employed to the maximum will not be realized, however, if governments and health-care organizations do not produce strategies to encourage its development. Wootton has summarized the critical issues that will need to be addressed in such strategies as part of a fourfold commitment: to encourage and provide funding for telemedicine

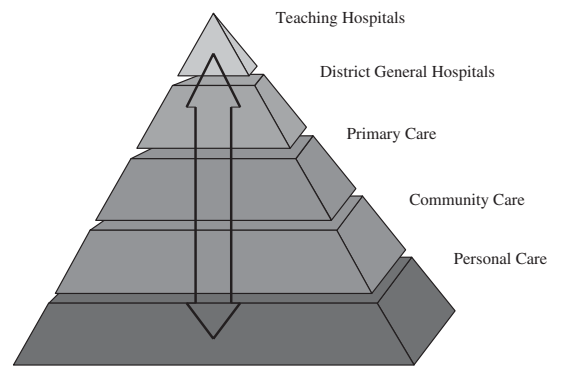


Figure 4 Telemedicine as a means for improving communication up and down the health-care pyramid

research; to develop a plan for implementation (once clinical effectiveness and cost-effectiveness have been demonstrated); to assess the major structural changes required within organizations to incorporate this method of delivering health care; to develop a process for training, formulation of practice guidelines, quality control and continuing audit.²⁵ Other issues that will need to be addressed include ethical and medicolegal concerns, human and cultural factors, such as resistance to change, lack of infrastructure, linguistic differences and illiteracy, and technical and organizational factors. None of these should be insurmountable.

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