Telemedicine in the NHS for the millennium and beyond

Simon Wallace, Jeremy Wyatt, Paul Taylor

The world has entered the ‘information age’. This has been described as being as significant as the industrial revolution. This revolution, led by the computer and telecommunications industry, will have a profound effect on the way medicine is practised and healthcare is delivered. One area in which this will be particularly apparent is the field of telemedicine.

As we enter the next millennium, all health professionals working in community, primary, secondary and tertiary care will be exposed to the possibilities offered by telemedicine. Politicians, chairmen, chief executives and managers of both trusts and health authorities are beginning to explore its potential in a burgeoning and complex health service. Enthusiasts claim that telemedicine will do for healthcare what the personal computer has done for the office. Opponents claim that it represents a threat to the doctor-patient relationship and is an intrinsically unsafe way of practising medicine.

What is telemedicine?

Telemedicine is not a new concept. As early as 1897, the telephone was used to help diagnose a case in a child. Almost 50 years ago, X-ray transmission along a telephone line was described. However, attempts to establish telemedicine services in the late 1960s and 1970s failed, principally because of the cost of technology, poor image quality, the structure of care services and staff training issues.

Box 1 describes telemedicine in the 1990s. It offers a new way of exchanging health-related information and knowledge in digital form. This can be used to transmit anything from verbal advice, X-rays, pathology slides, electrocardiograms, medical records, or coded commands to a surgical robot.

The role of telemedicine has been acknowledged in the recent Department of Health white paper that states that the NHS will harness the enormous benefits of information technology to support quality and efficiency by "developing telemedicine to ensure specialist skills are available to all parts of the country".

Modalities of telemedicine

Telemedicine can employ a number of modalities (table 1). In its broadest sense, as well as videoconferencing and digital image transmission, telemedicine also includes the telephone and its modern accessories: voice mail, e-mail, fax and paging services. Two categories of application can be distinguished, real-time systems and store-and-forward systems.

REAL-TIME SYSTEMS

Real time systems involve two or more parties (eg, general practitioner, patient and hospital specialist) in a live consultation using videoconferencing techniques. The system allows direct consultation and provides an immediate opinion and a recommendation for management. However, the patient, referring doctor and specialist must be available at the same time.

Table 1 Modalities of telemedicine

<table>
<thead>
<tr>
<th>Modality</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice only</td>
<td>Conventional telephone conversation</td>
</tr>
<tr>
<td>Data only</td>
<td>e-mail/bulletin board</td>
</tr>
<tr>
<td>Voice and data</td>
<td>Computer/telephone integration</td>
</tr>
<tr>
<td>Voice, data, non-real-time image</td>
<td>Store and forward using electronic patient board</td>
</tr>
<tr>
<td>Voice and real-time data</td>
<td>Telemonitoring and telecare</td>
</tr>
<tr>
<td>Voice, data and real-time image</td>
<td>Videoconferencing or 'virtual consultation'</td>
</tr>
</tbody>
</table>

Box 1

What is telemedicine?

- Telemedicine combines computer and telecommunications technology with medical expertise to enable health professionals to send and receive information and provide medical diagnostic and consulting services from locations distant from patients and their attending doctors.
- Telemedicine allows a whole range of medical activities, including treatment and education, to be provided at a distance.
- Telemedicine will promote a new form of healthcare delivery that shifts medical expertise closer to the patient and requires a significant change from traditional practice.
Examples of applications in telemedicine

- teleradiology: distant interpretation of radiological images
- telepathology: distant interpretation of pathology specimens
- distant consultation in clinical specialties, eg. dermatology, oncology, cardiology
- telesurgery: advice between an operating theatre and a remote expert during a surgical operation
- telerobotics: computer-assisted surgery and clinical applications of virtual reality

Box 2

STORE-AND-FORWARD SYSTEMS

Store-and-forward systems consist of electronic medical files of audio, text, video clips, X-ray or pathology slide images that are transmitted to a remote data storage device (a server), from which they are accessible for review and consultation. This non-interactive system is more convenient for all parties concerned, is readily accessible and involves lower transmission costs due to reduced digital bandwidth requirements. Store-and-forward systems have been used in teleradiology and telepathology. However, their role in patient consultation has also become apparent, since it avoids the need for three different parties to be available at the same time. For it to work effectively, the referrer must provide all the necessary clinical information.

Specialties suitable for telemedicine

Telemedicine will be more appropriate for clinical specialties and healthcare areas where there is an image component involved with the consultation. Box 2 lists some examples of how it can be used to provide an alternative platform for healthcare delivery between different sectors of the NHS (community (eg, home) and/or primary and/or secondary and/or tertiary care).

In box 2, the applications are patient-related. Other areas where electronic telecommunication can play a role include education, shared medical records and pharmaceutical trials. The figure summarises how real-time and store-and-forward telemedicine can function in each of these settings.

Services can be offered within a local geographic area ('the natural referral community') consisting of local general practices, trusts (acute and community) and a tertiary centre of expertise. If a local service is unavailable, of poor quality or has long waiting times, it can be offered from a geographically distant location.

Telemedicine can also centralise provision of services that would otherwise involve clinicians and/or patients travelling to a number of different hospitals, offering all health professionals and patients access to high quality clinical support. This applies to urban and rural settings, and to potentially hazardous environments (eg, prisons, battlefields) and inaccessible places (eg, aircraft, submarines, mountain tops).\textsuperscript{1-6}

Evidence for telemedicine

Research in telemedicine is rather heterogeneous. Taylor\textsuperscript{7} has proposed a research agenda for studies of telemedicine systems. A useful starting point is to distinguish between research carried out to test the intrinsic safety and efficacy of telemedicine systems and research which attempts to demonstrate the impact value or utility of healthcare services delivered via telemedicine.\textsuperscript{8}

ASSESSMENTS OF TELEMEDICINE SYSTEMS

There has been a great variety in the extent to which practitioners of telemedicine have perceived a need to test the safety of the technology they use. In an article describing the use of a telemedicine system to perform 138 dermatological consultations, it was noted that 'relatively little has been done to assess the diagnostic accuracy of telemedicine' and that 'diagnostic accuracy was not formally assessed in this evaluation'.\textsuperscript{9} The area attracting most attention is radiology, perhaps because it already has a tradition of the rigorous assessment of imaging technology.

Teleradiology

The particular question that has been addressed most frequently is whether digital images of radiographs contain as much information as conventional film. These tests appear to suggest that even very high resolution displays compare unfavourably to conventional film for some classes of abnormality.\textsuperscript{10-12} However, other studies looking at the disagreement between diagnoses made using telemedicine and those made conventionally, show that in real life situations, this has very little impact on diagnosis and the effect may even be negligible given normal inter-observer variation.\textsuperscript{13,14} It is difficult in these circumstances to establish an acceptable minimum standard for the specification of digital image display devices, and even more so given that technology is continually improving.

Telepathology

Tests of telepathology systems suggest that reasonably standard hardware (1028 pixel displays) is sufficient but that the transmission of static images of selected fields is problematic.\textsuperscript{15}
Telemedicine in clinical practice

Telemedicine in clinical practice 723

Figure Applications of telemedicine (Jeremy Wyatt, 1998)

Telecare

Patient

Clinical data

Advice

Clinician

Telepathology, teleradiology

Patient

Local clinician

Advice

Clinical data, Image

Remote expert

Local pathologist, radiologist

Teleconsultation by store and forward

Patient

Local clinician

Advice

Clinical data, Image

Remote expert

Teleconsultation

Patient

Local clinician

Advice

Clinical data, Image

Remote clinician

Real-time teleconsultation

Patient

Local clinician

Advice

Clinical data, Image

Remote clinician

Real-time teleconsultation

Patient

Local clinician

Advice

Clinical data, Image

Remote clinician

Real-time teleconsultation

Patient

Local clinician

Advice

Clinical data, Image

Remote clinician

Key to arrows

Interactive

Store and forward

Either

Teledermatology

There have been only a few assessments of teledermatology\textsuperscript{15-18} and the results are difficult to interpret, often due to the small numbers of observations. Studies are still required to establish the minimum acceptable specification for cameras and display devices.

Other teleconsultations

There has been relatively little work on the diagnostic accuracy of consultations carried out across video-links\textsuperscript{19-21} and further investigation of the validity of teleconsultations seems desirable.

HEALTHCARE SERVICES

The assessments described in the previous section aim to prove that using telemedicine does not impair a clinician’s performance. Such a demonstration does not in itself provide a reason for adopting the technology and requires further evidence that telemedicine leads to some worthwhile benefit. However, introducing a telemedicine service is a complex intervention and one that is difficult to assess. Telemedicine can be used to provide new kinds of service, the introduction of which represents a change to the structure of healthcare delivery and alters the process by which patients are cared for. There is, currently, very little work on the impact of telemedicine on the structure and process of care. It would be interesting to know more about the effect introducing telemedicine has
Advantages of telemedicine

**Known**
- equitable access to care in remote settings
- provision of home care for elderly patients
- facilitates cost effective care: reduced clinician travel and unnecessary patient transfers
- new models of care: nurse-led clinics and home-monitoring services
- links doctors with centres of excellence: educational benefits, more appropriate referrals and reduced professional isolation

**Potential**
- facilitates continuing professional development: dissemination of knowledge between general practitioners and hospital specialists
- earlier treatment and diagnosis: improved outcomes
- facilitates improved use of resources: outpatient waiting times
- integrated community-based health service

---

Disadvantages of telemedicine

**Known**
- incomplete or inaccurate clinical information
- increased demands on clinician time – videoconferencing
- patient and user dissatisfaction in rural areas
- costs of equipment and telecommunications – although these continue to fall
- equipment failure at critical moments – videoconferencing (the use of store and forward services to replace consultations needs further research since they are potentially more efficient)

**Potential**
- possible increase in waiting lists because of ease of access by telemedicine
- security of equipment
- confidentiality of patient data

Box 3

---

on, for example, referral rates. In nearly all the research that has been done, one of three outcomes is measured: user satisfaction, patient health and financial cost.

**User satisfaction**
Surveys of user satisfaction have found that patients and practitioners are both able and willing to take advantage of telemedicine where they perceive it to have benefits. Some studies also show that some patients do not like it and that some doctors do not use it. Patients may not want technology to dominate their encounter with their general practitioner but they do like the idea that their doctor is up-to-date with the best available technology. Equally it seems probable that the clinicians who participate in telemedicine studies are more likely to be disposed towards it than those who do not, and that positive conclusions about satisfaction based on early research may exaggerate the degree of acceptance that a routine service would enjoy.

**Patient outcome**
There are only a few studies examining patient outcome from a telemedicine service. One good example is the transmission of brain scans of patients with intracranial injuries to neurological departments, which can significantly reduce the number of unnecessary inter-hospital transfers. It is worth noting that many of the studies which have shown significant improvements are, in telemedicine terms, relative low-tech. Reviewing trials of various forms of electronic communication with patients, Balas found possible outcome, improved performance or significant benefits in 50 out of 80 eligible trials. One such study showed that patients with hypertension have improved adherence to programmes of medication and lower blood pressure if given access to a simple telephone monitoring service.

**Financial benefit**
Some studies of outcome have also suggested that telemedicine can reduce costs and other studies have tried to show that teleradiology can provide a cheaper service than the conventional alternative. One of the best known is that of Halvorsen and Kristianson, who showed that teleradiology would not save money in a rural setting. In contrast, Bergmo appeared to show that it could. There are many difficulties with such studies, one of which is that comparing the existing service to the telemedicine alternative ignores other, cheaper possibilities. Teleradiology may be cheaper than sending radiologists to perform one clinic a week at a remote hospital, but not cheaper than having the films sent to the radiologists' usual place of work.

A review of the work that has been carried out to date suggests that a great deal remains to be done in demonstrating that telemedicine is safe, establishing how telemedicine can best be performed and examining under what circumstances it is acceptable, medically justified, and an appropriate use of public funds.

ADVANTAGES AND DISADVANTAGES OF TELEMEDICINE IN THE NHS
The known and potential advantages and disadvantages of telemedicine are listed in boxes 3 and 4.

Tested in the new NHS

Over recent years, a number of pressures have combined to require the reappraisal of the traditional model of care provision across the community, primary, secondary and tertiary care sectors. This had led to an increase in interest in telemedicine applications. These are summarised in box 5.

New approaches to healthcare delivery are needed if the NHS is to continue providing a free, quality service. The concept of a more community-based NHS suggests that more of a patient's care will be managed outside hospital and in the community setting. The white paper suggests that primary care teams should be better equipped and able to take on an increased role for a wider range of conditions in both acute and chronic care. This will require increased professional training and improvements in primary care and community-based accommodation. To support this, easy access to expert opinion from specialists will be necessary and telemedicine could be one way of offering this link.

If such a service were to be carefully developed and implemented, it could reduce the need for patients to attend out-patient clinics or be admitted to an acute hospital, yet still provide quality healthcare based upon the latest evidence and guidelines. Telemedicine could also offer improved communication and patient management between secondary and tertiary care providers. In oncology, for example, the service is being restructured into cancer units and...
cancer centres. A telemedicine service could allow a shared multimedia electronic record for referral to confirm diagnosis and advice with management.

**A possible scenario for telemedicine in the millennium and beyond**

Consider the following. Telemedicine will initially become commonplace within geographically based, local healthcare networks. All general practices within these 'natural communities' will have telemedicine systems that allow them to interact with their local provider hospitals, which in turn have a similar link to a number of tertiary centres providing a range of medical expertise. These developments will have complemented the creation of Primary Care Groups and allowed healthcare to be provided closer to the patient.

Following the implementation of the Department of Health's revised Information Management and Technology Strategy, all general practices will have been supplied with a fast ISDN line and powerful computers allowing the potential of NHSNet to be realised. Aspects of healthcare delivery will have changed. All clinical specialties will have incorporated into their routine one or more telemedicine outpatient sessions, either live videoconferencing or store and forward. The referral process between secondary and tertiary care will use telemedicine to improve speed of access and opinion, avoid needless travel by both doctors and patients, and could prevent unnecessary duplication of medical records and investigations.

As the benefits of implementing a telemedicine service become apparent, the geographical barriers of the natural community will fade, perhaps because of dissatisfaction with the local service or the increased speed of referral to distant centres.

Telemedicine will become an integral part of the overall information technology strategy developed for the NHS, so that one piece of hardware can offer telemedicine, electronic patient records, clinical decision support, patient information and administrative functions, i.e., a networked integrated clinical workstation.

As clinical management and care is increasingly transferred from hospital to the primary care setting, the clinical workstation will be used for seeking remote expert opinions. Community diagnostic centres, nurse-run clinics and home care monitoring services will become more popular and will replace a significant amount of activity that once took place in hospital.

**Assessing where telemedicine can help NHS local services**

For the above scenario to become reality, it is important to have a thorough understanding of how services are presently provided, the route a patient takes from initial contact to final outcome, and the improvements that would be gained if a telemedicine system were available. For example, the criteria for judging if an application of telemedicine in dermatology is appropriate will be different from those for judging the monitoring of patients with heart disease in the community.

Table 2 demonstrates how this approach can help understand the role of telemedicine in transferring foetal ultrasound images from remote areas to a tertiary referral centre. When considering whole specialties or healthcare areas, issues such as manpower, case-mix, volume flows, cost and the type of telemedicine service must be taken into account. An analysis reviewing how this new approach

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Potential role of a telemedicine service in neonatal care</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Question</strong></td>
<td><strong>Comment</strong></td>
</tr>
<tr>
<td>What is the system to achieve?</td>
<td>Improving access to expert advice</td>
</tr>
<tr>
<td>What currently happens without the system?</td>
<td>Detecting problems early</td>
</tr>
<tr>
<td></td>
<td>Reducing the need for widespread specialist foetal medicine service</td>
</tr>
<tr>
<td></td>
<td>Ultrasound is undertaken at local site</td>
</tr>
<tr>
<td></td>
<td>Suspicious cases are dealt with by post or patient referral to a tertiary centre</td>
</tr>
<tr>
<td></td>
<td>&quot;x&quot; tertiary centres are available</td>
</tr>
<tr>
<td></td>
<td>Most pregnancies are routine</td>
</tr>
<tr>
<td></td>
<td>&quot;y&quot;% need expert opinion (derivable from public health records)</td>
</tr>
<tr>
<td></td>
<td>&quot;z&quot;% have no ready access to expert opinion (derivable from demographic/geographic sources)</td>
</tr>
<tr>
<td>If the system were in place, how often would it be used?</td>
<td>Reduced probability of adverse pregnancy outcome (estimable)</td>
</tr>
<tr>
<td></td>
<td>Reduced travel costs (estimable)</td>
</tr>
<tr>
<td></td>
<td>Reassurance (difficult to quantify)</td>
</tr>
<tr>
<td></td>
<td>Restructuring of tertiary referral system</td>
</tr>
<tr>
<td></td>
<td>Changing role of specialist consultation</td>
</tr>
<tr>
<td>For each person (patient/health professional) using the system, what are the benefits?</td>
<td></td>
</tr>
<tr>
<td>What are the longer term consequences?</td>
<td></td>
</tr>
</tbody>
</table>

Adapted from: *Telemedicine - evaluation or stagnation*. M O’Rourke, S Gallivan. Clinical Operational Research Unit, University College London, London WC1E 6BT.
to healthcare delivery would affect different players (eg, clinicians, general practitioners, other health professionals, the trust, the health authority and the patient) will highlight the benefits and opportunities, as well as the disadvantages and threats. Once these questions have been answered, then health professionals will have a much clearer idea about how such a service could be delivered in their particular setting.

**Barriers to implementing a telemedicine service**

**TECHNOLOGY MATCHING HEALTH NEEDS**

The medical profession has often been criticised for allowing new technologies and fancy gadgets to drive changes in patient care. Lock highlighted the low priority accorded to the evaluation of computer projects in NHS hospitals and the *British Medical Journal* recently bemoaned the poor quality of published information about information technology. Although using the right technology is important; improvement in healthcare process and patient outcomes are key. The computer and telecommunications technology required to implement a successful, quality telemedicine service is available today. As telemedicine is another kind of medical technology, the same principles of rigorous evaluation of costs and benefits should apply. Finally, telemedicine software will need to be compatible with a wide range of NHS systems, which themselves are a legacy of a lack of standards and system of accreditation.

**PROFESSIONAL RESISTANCE**

The greatest barrier may come from health professionals themselves, in particular the medical profession. Some doctors may worry that the advantages of telemedicine highlighted earlier will be outweighed by a threat to the doctor–patient relationship, the role of the clinical examination and the initial costs involved.

However, studies do suggest that once health professionals become familiar with the concept and understand its application, they find it acceptable as a method of healthcare delivery. This implies that a significant programme of education will be required to help telemedicine become an accepted method of healthcare delivery.

One area needing careful consideration is the effect on the infrastructure of a specialty within which a telemedicine service is offered. If for example, less travelling is involved and more output achieved by the same doctor, there will be a redistribution of manpower resources that could act as a real threat to job security.

**PATIENT RESISTANCE**

Some patients may dislike the apparent impersonal nature of telemedicine. However, evidence suggests that patients are often in favour of and satisfied with the care offered using telemedicine. As with all new initiatives involving change, both health professionals and patients will be less resistant to the concept of a telemedicine service if it can be demonstrated how the technology can improve the quality of care and meet clinical needs.

**NHS MANAGEMENT**

As well as the medical profession, chairmen, chief executives, directors and managers of trusts, health authorities/boards and politicians will need to understand the advantages and implications of teledicine as a new component to healthcare delivery. Although management in the NHS is often reactive and dominated by the need to 'balance the books', this group will need to develop forward-looking strategies for telemedicine. Managers must consider how a telemedicine service will fit into the new NHS environment set out in the white paper. The resultant charging mechanism, risk management and staff contracts will need to be discussed. The development of standards and use of guidelines will also need to be addressed.

**MEDICO-LEGAL IMPLICATIONS**

The medico-legal implications of telemedicine have not yet been tested in the courts, services remain unclear and need careful consideration. Since there is no body of legal judgement upon which to determine precedent, current advice is based upon conjecture. It seems unlikely that telemedicine raises any new issues of principle distinct from the use of the telephone, fax, mail, or e-mail for consulting. However, potential consequences of loss of data from compression techniques, incomplete transmission, technical failure and resolution of the monitoring equipment will need to be addressed from a medico-legal standpoint.
A comprehensive review has been undertaken, which addresses confidentiality, data protection, security, telemedicine malpractice, standards adopted by the General Medical Council and Royal Colleges, and intellectual property rights and competition law.

CONFIDENTIALITY AND DATA SECURITY
A patient's paper records are generally available at one location, whereas electronic patient data is available from terminals where multiple approved users have access. Although a paper record may be read by numerous people during one patient episode, the extended range of access offered by centralised computer records, increases the potential for data impropriety and breaches of security.

The possible abuse or loss of confidential clinical data arises from three sources:

- threat from health-related employees
- threat from viruses, hackers, private detectives and professional information seekers
- threat of communications breakdown from natural disasters, vandalism and sabotage.

Each of these exist now and proposed solutions, such as password-protected access, encryption and electronic signatures, will have to be developed and implemented, whether or not telemedicine services are considered.

Irrespective of the advantages, disadvantages and barriers, the most important factor determining the success of telemedicine will be a clear understanding of user requirements. It is essential that the development of telemedicine is driven by the needs of clinicians, health professionals and patients rather than the possibilities of technology.

Implications of telemedicine for the NHS
Telemedicine could offer the NHS a new approach to healthcare delivery, improve patient management throughout the health service and shift medical expertise and skills closer to the patient in the community and primary care setting. Therefore, all chairmen, chief executives and managers of both trusts and health authorities, doctors, health professionals and politicians need to ask themselves the question: "What role does telemedicine have to play in the effective delivery of quality healthcare in my organisation?"

To answer this, they will need to understand the principles of telemedicine outlined in this review. When we adopt this new form of healthcare delivery, it should not be superimposed on the NHS as an additional burden. Instead, it must be fully integrated into existing services, to help the NHS meet the challenges of changing demographics, improved clinical practice, evidence-based medicine, increasing cost and patient's expectations.

With an increasing amount of commercial activity in the field of telemedicine, it is important that stakeholders from both private and public sectors work together to develop and implement services that meet the needs of both patients and health professionals. The establishment of a "Virtual National Institute of Health Informatics" under the aegis of the Department of Trade and Industry's Foresight Technology initiative could provide a platform for this.

The following recommendations could assist this process:

- to establish a national working party to advise the NHS about the role of telemedicine
- to provide doctors with information and guidance about the role of telemedicine at the community, primary, secondary and tertiary care level
- to support R&D funding for randomised trials to answer questions about the costs of telemedicine and its impact on clinical decisions, actions, patient outcomes and resultant cost-benefit
- literature about telemedicine should focus on lessons learnt (both positive and negative) in order to guide others about the practical implications in clinical practice
- telemedicine should be driven by the health needs of patients and health professionals and not the possibilities of the technology.

Conclusion
Telecommunications and the practice of medicine have both changed dramatically over the last hundred years. As we approach the 21st century, the development of information technology has created an opportunity to improve both the quality and delivery of healthcare in the UK. Everyone involved with health should consider the role of telemedicine in their organisation, not tomorrow but today.

The authors wish to thank Jeremy Holland for allowing them to adapt his work to produce table 1.
29 Wyatt J. Teledermatology trials: clinical pull or technology push (commentary)? BMJ 1996;313:1380-1.
34 Brench RM, Gray CL, Peterson C, Youngblood B. The University of Texas Medical Branch.
Telemedicine in the NHS for the millennium and beyond.

S. Wallace, J. Wyatt and P. Taylor

*Postgrad Med J* 1998 74: 721-728
doi: 10.1136/pgmj.74.878.721

Updated information and services can be found at:
[http://pmj.bmj.com/content/74/878/721](http://pmj.bmj.com/content/74/878/721)

These include:

**Email alerting service**

Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

Notes

To request permissions go to:
[http://group.bmj.com/group/rights-licensing/permissions](http://group.bmj.com/group/rights-licensing/permissions)

To order reprints go to:
[http://journals.bmj.com/cgi/reprintform](http://journals.bmj.com/cgi/reprintform)

To subscribe to BMJ go to:
[http://group.bmj.com/subscribe/](http://group.bmj.com/subscribe/)