THE ROYAL SOCIETY

# Digital healthcare: the impact of information and communication technologies on health and healthcare

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## Contents

# Summary

Information and communication technologies (ICTs) have the potential to transform radically the delivery of healthcare and to address future health challenges. Whether they actually do so will depend on the design and implementation processes sufficiently accounting for the users' needs, and the provision of adequate support and training after their introduction.

ICTs provide tools both to improve current practices and to help develop new ways of working over the next 10–15 years, which is the subject of our study. These technologies may be used on a variety of scales, from pieces of equipment for individual healthcare professionals, patients or carers, to nationwide systems. For example, patients may be able to monitor chronic conditions such as asthma and diabetes in their own homes using modified mobile 'phones to access and process their data, which may give greater convenience and better management of their conditions and reduce the need to visit their local health centre. Electronic health records should allow healthcare professionals access to patients' data wherever they are in the country and potentially worldwide. This should allow the many different healthcare professionals with whom an individual interacts during their treatment (who are often in different locations) to share information and make better informed healthcare decisions.

The patients, carers and healthcare professionals whom we consulted as part of our study had a very wide range of expectations of what ICTs could deliver, some of which were unrealistic and certain not to be met. It is also not possible to say that all healthcare ICTs will bring cost savings: some will, some will not.

The complexity and nature of the healthcare environment present several major barriers to realising the great potential of healthcare ICTs. Publicly funded healthcare systems have finite resources to deal with an unlimited problem, which results in strong cost constraints. Any new technology has to bring clear improvements to the delivery of healthcare to justify its introduction. The enormous scale and complexity of the National Health Service (NHS) with its various local, regional and national Trusts and Agencies is another complicating factor. The NHS has been slow to adopt existing technologies, such as personal computers and mobile 'phones, which have the potential to benefit patients and healthcare professionals. The poor track record of successfully introducing large-scale public sector information technology (IT) systems has generated resistance and scepticism about whether new complex systems will ever work and if they are good use of public money.

New healthcare ICTs will improve the delivery of healthcare only if they are properly designed and integrated in the healthcare system. Healthcare often involves people when they are at their most vulnerable, which needs to be accounted for in the design of new technologies. Exploiting the introduction of healthcare ICTs needs to be seen as one way of achieving the targets that the health service aims to meet. Spending on appropriate healthcare ICTs has the potential directly to improve healthcare: it is not a diversion of funding away from patient care as is sometimes suggested. However, the benefits of new healthcare ICTs take some time to be realised, particularly large and complex systems such as the English National Programme for Information Technology (NPfIT) currently being delivered by Connecting for Health. Existing and new technologies need to be monitored constantly, locally and nationally, so that those with net benefits to healthcare can be effectively deployed. Learned and professional societies, such as the British Computer Society, the Institution of Engineering and Technology and the medical Royal Colleges, are a valuable source of independent advice to the Government in identifying new and existing technologies that might benefit healthcare.

The single most important factor in realising the potential of healthcare ICTs is the people who use them. The end users of any new technology must be involved at all stages of the design, development and implementation, taking into account how people work together and how patients, carers and healthcare professionals interact.

All healthcare professionals need to recognise the potential value that healthcare ICTs can bring to their work. Their managers must ensure sufficient time for healthcare professionals to be involved properly in the design, development and implementation of new technologies. This includes local and national health authorities ensuring that funding and time are allocated for initial training and ongoing support when new systems are introduced. Higher education institutions and professional bodies must ensure that both basic training and continuing professional development include the use and understanding of ICTs as an integral part of healthcare professionals' everyday role. Healthcare ICTs will change the roles of patients, carers and healthcare professionals in the delivery of healthcare. For example, more healthcare-related material is available now for patients via the worldwide web, leading to a new role for healthcare professionals in guiding patients through the various information sources. Continued research into the socio-cultural impact of healthcare ICTs is required.

Access to data is a complex and controversial issue. It is currently technically possible to establish systems that allow different levels of access to an individual's electronic health records. However, it is not clear what a sensible

access policy would be because there is an unresolved conflict between privacy and sharing healthcare data for both individual and public benefit. To help resolve this conflict there needs to be further engagement with patients, carers and the wider public to determine where a workable balance lies between privacy issues and data sharing. Future Government health policy needs to be informed by the findings of this engagement.

To deal with the complexities of the healthcare environment we strongly advocate an incremental and iterative approach to the design, implementation and evaluation of healthcare ICTs. This involves engaging the end users at all appropriate stages from determining the specifications through to training and ongoing support once the system is introduced. Experimentation is a major part of this approach to design and development as it allows the good and bad elements of systems to be determined and developed or dropped as appropriate. This approach is especially important for large and complex systems, such as the components of NPfIT, where the public sector has a poor record of successful implementation. Future health policy needs to be informed by an assessment of the different approaches to the deployment of healthcare ICTs in the four countries of the UK to determine the successful and unsuccessful elements. We believe that specific attention should be paid to the impact of the speed and scale of the different programmes and the varying levels of user-engagement. It is also essential to establish criteria for evaluation of the technical and financial performance and the user-satisfaction at the start of the development process. However, we note that there is a lack of methods to evaluate the social and economic costs of healthcare ICTs: the development of new methodologies is urgently required.

Local, regional, national and international systems must be able to operate together and share information, which requires national and international standards. We encourage the Government to build on its ongoing work to achieve connectivity as quickly as possible between the different national and international standards being developed. It will not be possible to establish fully interoperable systems until these standards are agreed. There is an essential objective for the national programmes for healthcare IT in ensuring that all stages of the development of new healthcare ICTs are undertaken within centrally set standards to ensure interoperability.

# Recommendations

R1: We recommend that all stakeholders consider how ICTs might be able to assist in delivering better healthcare. For example the potential contribution of healthcare ICTs should be considered by Government health Departments while formulating policy and by healthcare professionals and managers in determining how best to meet performance targets.

R2: We recommend that existing technologies and developments in new technologies are continuously monitored so that those with net benefits to health and healthcare can be assessed and then effectively deployed.

a At a local level we recommend that this is undertaken by Chief Executives of local healthcare trusts as well as by healthcare professionals.

b At a national level we recommend that the Government health Departments undertake this, assisted and advised by the newly established NHS National Innovation Centre as well as the Purchasing and Supply Agency (PASA), the Medicines and Healthcare products Regulatory Agency (MHRA) and the National Institute for Health and Clinical Excellence (NICE).

c We recommend that Government health Departments recognise the value of independent contributions from learned and professional societies (such as British Computer Society and Institution of Engineering and Technology) and the medical Royal Colleges in identifying new and existing technologies that might benefit healthcare.

R3: We recommend that the Government health Departments and their associated national IT programmes adopt an iterative and incremental approach in the design, implementation and evaluation when introducing new healthcare ICTs. We make several additional recommendations to support such an incremental approach:

a We recommend that healthcare professionals and their professional bodies seek to be involved in the design, implementation and evaluation of healthcare ICTs.

b We recommend that healthcare managers ensure that sufficient time is made available for healthcare professionals to contribute effectively at all stages of design, implementation and evaluation of healthcare ICTs.

c We recommend that the Research Councils fund underpinning work on new assessment and evaluation methods while Government health Departments and medical charities and the private health sector should fund applied research such as the assessment of efficacy.

d We recommend that the Research Councils fund work to develop prototypes, new methodologies and experimental systems for new healthcare ICTs.

e We recommend that industry and the Department of Trade and Industry fund the commercialisation of new healthcare ICTs.

f We recommend that the national IT programmes ensure that all stages of the development are undertaken within standards to ensure interoperability.

R4: We recommend that future policy developed by the UK Health Ministers is informed by an evaluation of the effectiveness of the different approaches to deployment of ICTs in the four UK countries. We recommend particular attention is paid to evaluations of the effects of the different speeds and scales and the levels of user-engagement of the national programmes. We also recommend that the Government health Departments and their national IT programmes monitor overseas developments to learn lessons from different approaches, taking into account the different healthcare system structures.

R5: We recommend that the Government health Departments build on their ongoing work to achieve convergence as quickly as possible between the different national and international standards being developed through further collaboration with industry and standards bodies such as BSI (on a national level) and SNOMED-CT, CEN, ISO, DICOM, HL7 and the EU (internationally).

R6: We recommend that Government health policy is informed by evidence derived from engagement with patients, carers and the wider public on confidentiality and sharing of personal data.

R7: We recommend that the ESRC and the Department of Health continue to fund investigations into the socio-cultural impact of ICTs in healthcare, looking at the changing roles and responsibilities for healthcare professionals (including the effects on work processes and the organisation of care) and the impact on patients. We also recommend that Government policy is informed by the evidence derived from these investigations.

R8: We recommend that the higher education institutions and professional bodies (such as the medical Royal

Colleges) responsible for the different disciplines adapt their curricula to integrate the use and understanding of healthcare ICTs into the basic training and continuing professional development of healthcare professionals.

R9: We recommend that local and national health authorities ensure that sufficient funding and time are allocated to provide initial training and ongoing support for healthcare professionals.

# 1 Introduction

## 1.1 Background and aims

The field of information and communication technologies (ICTs) is developing rapidly, including increasingly pervasive communication networks, increasing processing power and the ability to transfer more information faster through both wired and wireless systems. Developments also include increased ability to search, filter and share data and information.

This report discusses the different ways in which new technologies could be used to help address the challenges facing health and healthcare in the next 10–15 years. It also highlights where ICTs can act as an enabler or a driver of change in health and healthcare.

Such technologies can clearly have huge benefits to health and healthcare. These technologies have a potential to affect positively and negatively patients, carers and healthcare professionals. For example ICTs could help to facilitate the drive towards treating patients nearer (or in) their homes. They also raise questions about how any information generated is used, how it is analysed, who owns it and who should have access to the data. These technologies will generate an ever-increasing amount of health-related data. It is important to ensure that these data are made available to appropriate groups, kept away from inappropriate groups and processed to yield useful information.

Given the opportunities and concerns associated with these potential technological developments, the Society decided to undertake a study to investigate the impact of ICTs on health and healthcare. The terms of reference of the study were to investigate the developments in ICTs relating to health and healthcare in the next 10–15 years and to assess the potential impacts and implications of these technological developments.

The predicted changes to health and healthcare in the next 10–15 years are described in chapter 2. This is followed by an overview of future technology developments in chapter 3. How to manage the introduction of ICTs is addressed in chapter 4. The changing roles and responsibilities that might result from the use of ICTs are discussed in chapter 5. Evaluations of ICTs used in health and healthcare are considered in chapter 6. Conclusions are drawn and focused recommendations are made in chapter 7.

This report is primarily aimed at academics, Government policy makers, healthcare professionals and provider organisations, industry, informal carers and patients. Although the report focuses on the UK, we expect that it will be of interest in other countries.

## 1.2 Definitions and exclusions

The following definitions of ICTs, health and healthcare will be used throughout the report. **Information and communication technologies (ICTs)** are a range of technologies for gathering, storing, retrieving, processing, analysing, transmitting and receiving information. These include radio, television, mobile phones, computer and network hardware and software, as well as the various services and applications associated with them, such as videoconferencing and distance learning. **Healthcare** is the prevention, treatment and management of illness through the services offered by the medical, nursing and allied health professions. In contrast the term **health** refers to a combination of the absence of illness, the ability to cope with everyday activities, physical fitness and high quality of life. We acknowledge that there is an overlap between the terms health and healthcare. However, as will be discussed further in section 2, there is an increasing drive to focus more on health rather than healthcare (Wanless 2002; US Department of Health & Human Services 2000).

The report looks at technologies to be used in a variety of health and healthcare situations, which can be classified as follows.

- ***Home care technologies:*** To be used in people's homes for treating known medical conditions, self-care, detecting and identifying new conditions and/or monitoring/maintaining health. These technologies could be used by the patient, their carers or healthcare professionals (such as health visitors or community nurses).

- ***Primary care technologies:*** To be utilised in primary care by general practitioners, public health specialists, community nurses and staff in health centres and community hospitals. These could relate to education about prevailing health problems and the methods of preventing and controlling them, diagnosis and treatment of common diseases/injuries and provision of essential medicines.

- ***Secondary and tertiary care technologies:*** To be used in hospitals, for the diagnosis and treatment of in- and outpatients with medical conditions that cannot be managed in the community or at home.

Improvements in mobile technology and networks will provide healthcare professionals, carers and patients on the move with improved services across all three of these care areas.

In relation to health information management, the study focussed on the impact of future technologies rather than the handling of healthcare records with current technologies in detail. The study did not investigate the technological aspects of national identity cards or the current electronic patient record, as these issues have been the subject of studies by other organisations (National Audit Office 2006; Academy of Medical Sciences 2006; Council for Science & Technology 2005; House of Commons Home Affairs Committee 2004).

## 1.3 Conduct of the study

A working group chaired by Professor Peter Wells FRS was established to undertake this study. The working group first met in May 2005 and had a further four meetings. The full membership of the working group is given in chapter 9. The Council of the Royal Society has endorsed this report.

We were keen to get views from a wide range of people, so a call for evidence was issued on 14 July 2005 with a closing date of 9 September 2005. Responses were received from individuals and organisations with expertise or interest in this topic such as academics (including scientists, social scientists and economists), civil society groups, Government policy makers, healthcare providers (both professionals and informal carers), healthcare provider organisations, industry (such as ICTs, medical devices and pharmaceutical) and professional bodies. Details of the organisations and individuals who submitted written evidence are listed in section 10, and the evidence is available on the Royal Society website (www.royalsoc.ac.uk).

Three evidence-gathering workshops were held in October and November 2005. The science and technology workshop involved leading experts in the information and communication technology sector, many of whom had experience of working with health and healthcare-related technologies. The participants in the other workshops were healthcare professionals and representatives of patients' groups respectively. These workshops were organised and facilitated by the Office for Public Management Ltd (OPM). Further details about all three workshops can be found in section 10, and reports of these workshops can be found on the Society's website.

This evidence informed the working group's discussions, its conclusions and recommendations. We are grateful to everyone who responded to the call for evidence, participated in the workshops and submitted additional evidence.

## 1.4 Other relevant reports

Our study takes a broad view of the potential impact of ICTs on health and healthcare. There have been many recent reports on particular aspects of ICTs and healthcare that have informed this report. Several reports have been published looking at the current technologies which could be used in healthcare systems (eg House of Commons Health Select Committee 2005; HM Government 2005; President's Information Technology Advisory Committee 2004) and attempting to identify future trends (Institute for Prospective Technological Studies 2004; Foresight 2000; Food & Drug Administration 1998).

Specific uses of ICTs in health and healthcare provision have been investigated, such as in dementia (Woolham & Frisby 2002), health literacy (National Consumer Council 2004a), assistive technology (Audit Commission 2004), telecare (Department of Health 2005a), patient records (US Department of Health & Human Services 2005) and the detection and identification of infectious diseases (Foresight 2006).

The importance of design for patient safety and developing new products has been highlighted (Cox 2005; Design Council / Department of Health 2003). The challenges involved in the successful completion of complex IT projects have also been investigated and are highly relevant to our study (Royal Academy of Engineering 2004). The better integration of engineering and healthcare processes has been investigated for the US healthcare system (National Academy of Engineering & Institute of Medicine 2005). The Organisation for Economic Cooperation and Development (OECD) has examined how decisions are made over a range of health technologies (OECD 2005).

There have been two recent UK reports that are particularly relevant to the handling of personal and medical data (Academy of Medical Sciences 2006; Council for Science and Technology 2005). The Council for Science and Technology (CST) report investigated what beneficial uses could be made of the personal information stored in electronic databases, both now and in the future. It also aimed to determine what needs to change to enable the benefits to be achieved and considered what safeguards need to be in place to mitigate the risks. The CST report looked at all areas of personal data, not just health and healthcare related information. The Academy of Medical Sciences (AMS) report examined the current and likely future UK position about the use of personal data in medical research. It also gave considerable detail of the current legal and governance framework.

# 2 Predicted changes to health and healthcare in next 10–15 years

**Summary**

The healthcare system will evolve continuously over the next 10–15 years. ICTs are likely to be both a driver for change and an enabler of the changes needed to address future challenges and to improve the health service over this period. Healthcare ICTs will have an important part in dealing with the expected increase in patient-focused healthcare, in chronic disease management and in adapting to the ageing population. Healthcare ICTs are currently being deployed differently across the UK; future health policy should be informed by an evaluation of the effectiveness of these contrasting approaches.

## 2.1 Introduction

This chapter outlines the pressures and challenges likely to drive change in healthcare system in the UK over the next 10–15 years. The chapter also describes the regional variation in the deployment of healthcare ICTs and discusses the English National Programme for IT being delivered by Connecting for Health.

The healthcare system in the UK faces further reform now and in the future in terms of the structure of the organisation and the service provided. Our understanding is that there will be four main areas of reform:

- **Increasingly patient-focused healthcare**. NHS provision is increasingly being centred on the needs of the patient, as opposed to the needs of the service providers as it has traditionally been. Increasing patient choice is likely to be a big driver for changes in service provision. This is discussed further in section 2.2 and the impact of ICTs on patients is addressed in section 5.2.

- **Providing treatment as close to the patient's home as possible**. Care is increasingly being moved from the hospital care setting into primary care and the community. This is partly driven by patient preference, economics and the risk of infection in larger institutions. Several of the ICTs described in chapter 3 have the potential to facilitate this shift.

- **The integration of healthcare with other services, particularly social care,** will continue to change the way the NHS operates – presenting further challenges of providing a seamless multi-disciplinary and multi-agency service. For example, the growing demand for social care for the elderly was highlighted in a report by Sir Derek Wanless (Wanless 2006). Sharing data between these services is discussed further in section 4.5.

- **Increasing number of service providers (including private sector organisations)** providing 'free at the point of care' treatment for NHS patients (particularly in England). This presents further challenges for integration and management of patient and information flow. It will also be important for data relating to private-sector treatment to be recorded in an individual's record that can be accessed by both the NHS and private sector. Clinical governance, confidentiality and data protection are discussed further in section 4.4.

The healthcare system will also have to address the continuing changes in the demographics and disease patterns and the shifting burden this will present. This is expected to include:

- Changes in disease patterns are predicted to include an increase in patients suffering from long-term conditions and the emergence of new infectious diseases.

- Increased focus on prevention of disease and maintenance of health and use of ICTs to monitor health and identify disease earlier.

- A shortage of healthcare professionals, in part due to the ageing population (Royal College of Nursing 2004). A similar problem is predicted in the USA (Metropolitan Chicago Healthcare Council 2004). This, combined with the other pressures and drivers of change mentioned, is likely to result in a change in the roles and responsibilities of healthcare professionals.

These changes and drivers were identified and discussed at our evidence-gathering workshops and are described in further detail in the OPM report, which is available on the Society's website.

There are considerable differences between the healthcare systems in the four countries of the UK, including their use of ICTs, as outlined in section 2.5. Consequently, there may be lessons to be learnt from the successful elements of the different approaches adopted in England, Northern Ireland, Scotland and Wales.

## 2.2 Patient-focused healthcare

Giving patients more choice about how, when and where they receive treatment is a major part of the Government's current health strategy (Department of Health 2006a). There is discussion about extending choice to people with long term conditions and mental health needs and into primary care services (Department of

Health 2006b). It is widely expected that patient-led healthcare will have a growing importance in healthcare provision.

As patients have access to more relevant and comprehensive medical information, so the relationship between the healthcare professional and the patient will increasingly involve the discussion of options, costs and benefits. This increased access to information will also lead to higher patient expectations. The potential impact of ICTs on patients and on the relationship between the healthcare professional and patient is discussed further in chapter 5.

There is also a policy drive for patients and their carers to take more responsibility for their health maintenance and to be more involved in self management of long term conditions. ICTs are seen as a means of supporting this shift in responsibility. Examples of personal and home based medical equipment are discussed in section 3.3.2. Such changes may also alter what patients expect and require from health professionals. However, increased choice and responsibility may provide new problems and dilemmas, which are discussed further in section 5.3.

There are concerns about whether the so-called 'digital divide', that is the differences between groups in their abilities to access or use ICTs effectively, will serve to increase health inequalities. Ensuring equity of access is discussed in section 5.6.

Patient-led healthcare is not a new concept as patients already manage to a greater or lesser extent their own care. Patients currently make use of their social care networks to manage their own care and it is possible that ICTs (such as mobile 'phones, e-mail and web forums) would be able to facilitate this.

## 2.3 Changing roles and skills mix of healthcare professionals

The division of labour in healthcare (ie who does what) has changed dramatically during the past decade and the pace of change is accelerating. In particular, nurses and allied health professionals (such as physiotherapists and radiographers) are taking on many tasks that used to be undertaken by doctors. Completely new roles, such as the physician's assistant (who undertakes minor surgery) are also developing (Katikireddi & Rushworth 2004).

The drivers for these changes are both internal (increasing professionalisation of occupations such as nursing and physiotherapy) and external (such as the need to reduce junior doctors' hours as a result of the European Working Time Directive). In this context, ICTs are an enabler for these changes. For example, developments in remote monitoring of physiological measurements and algorithmic decision-support systems (described in sections 3.3.2 and 5.4.2) might enable diagnosis, monitoring or treatment to be undertaken by less skilled professionals or the patient. This has important implications for the education and training of healthcare professionals and for the way in which ICTs are implemented. Training and education needs are discussed further in section 4.3.2.

There will continue to be a move towards the treatment of minor and common complaints and the management of chronic disease by nurses, nurse practitioners and allied health professionals. There is evidence that triage, the rationing of limited medical resources when the number of injured needing care exceeds the resources available to perform care so as to treat the greatest number of patients possible, can be delivered safely by nurse practitioners in the primary care setting (Stewart & Catanzaro 2005; Horrocks, Anderson & Salisbury 2002; Cox 2001).

Introducing ICTs can influence levels of trust in the patient-healthcare professional relationship, with the potential to increase trust if used appropriately (Blumenthal 2002; BMJ 2003). The impacts of ICTs on the patient–professional relationship are discussed further in section 5.3.

IT specialists who have developed their skills in environments other than healthcare will need to learn about and to adapt to the very different culture of the healthcare environment. Already IT specialists in healthcare are beginning to define themselves as a new profession and are establishing their own professional associations and the beginnings of a regulatory framework, such as the UK Council for Health Informatics Professions (www.ukchip.org).

## 2.4 Demographics and changes in disease patterns

### *2.4.1 Ageing Population*

In 2004, the UK population was 59.9 million with a median age of 38.6 years. Several scenarios for the future UK population age distribution can be imagined, depending on fertility rate, migration and life expectancy. Broadly, the population is predicted to increase to 65 million by 2021, when the median age is likely to be between 41 and 42 years. By 2021, the proportion of the population aged over 65 years old is expected to have risen from about 16% to about 18%. Nevertheless, very few people are expected to live to an age of more than 100 years (National Statistics Office 2005).

Thirty-six per cent of the total number of 'finished consultant episodes' (defined as a period of healthcare under one consultant in one hospital) in NHS hospitals (including the NHS component of work in private-sector providers) in England in 2004/05 involved those aged 65 years and over (NHS Health & Social Care Information Centre 2005). In addition, there have been steady increases in the number of years of unhealthy life and this seems to be a trend that will continue over at least the next 15 years (Parliamentary Office of Science & Technology 2006a; National Statistics Office 2004).

This shift in demographics is likely to mean that the health service will be under increased pressure to deal with diseases related to old age and to provide suitable care for elderly people. ICTs and related assistive technologies could provide the means to treat more people (despite a potentially shrinking healthcare workforce) and to enable more elderly people to live independent lives at home, reducing the burden on the NHS. The types of technology that could enable this are discussed in sections 3.3 and 3.6.

The House of Lords Science and Technology Committee investigated the scientific aspects of ageing (House of Lord Science & Technology Committee 2005). The study looked at the biological processes of ageing and how existing technology, and research into new technologies, could be used to improve the quality of life for older people. The Committee was disappointed by the failure to apply existing technologies, which it attributed to a lack of infrastructure and a failure of industry and commerce to recognise the enormous potential of the market that older people represent. In response to this point, the Government stated that making the best of existing technology is largely a matter for industry itself, although the Government acknowledged that it has a part to play, not least in helping to shift cultural attitudes towards ageing (House of Lords Science & Technology Committee 2006). The Government has allocated £80 million over two years from April 2006 for English local Councils to invest in telecare to support individuals in the community as part of its actions to address this (Department of Health 2005b).

### *2.4.2 Chronic disease management*

Currently, over 15 million people in the UK report living with a long-term medical condition, which can be defined as conditions that cannot be cured but can be controlled by medication and other therapies. This figure is set to increase over the coming years for several reasons, which range from changing demographics and ageing population, to increasing prevalence of obesity (Royal Society 2006; Department of Health 2005c) and improved survival because of medical advances. Examples of long-term conditions include coronary artery disease, chronic obstructive pulmonary disease, arthritis and diabetes.

The growing prevalence of these conditions represents an increasing public health burden. New strategies are required to deal with these issues and increased public expectations that are likely to accompany them. ICTs are seen as one important means of dealing with this major health challenge. The development of extensive information systems would help patients to be more responsible for their own health and healthcare. ICTs could be used to improve monitoring of long term conditions, to facilitate early discharge from acute care settings and to support individuals in the community. The types of technology that could become increasingly available are detailed in sections 3.3 and 3.6.

### *2.4.3 New infectious diseases*

The emergence or identification of new diseases and changes in the patterns of distribution and populations suffering from these diseases are likely to drive changes to the healthcare system. There is also an increased emphasis on management of infectious disease and the possibility of terrorist threats involving chemical or biological agents. The potential influenza pandemic, widely reported as both imminent and inevitable, is seen as a more immediate challenge. In response, health services need to be able to respond in a unified way and at speed across organisational boundaries. For example, surveillance and simulation techniques could be developed to monitor and predict spread and control of infectious diseases (Foresight 2006). Supercomputers could also be used to create models, such as those outlined in section 3.5.4, for predicting the spread of infectious diseases and to screen tens of thousands of chemical compounds to help design effective treatments.

### *2.4.4 Disease prevention*

It is widely believed that there will be an increased focus on prevention of disease and leading a healthy life (Department of Health 2004, 2005d; WHO 2005; Wanless 2002, 2004). For example, the Government has launched several initiatives related to diabetes and obesity. It also recently announced the development of NHS 'Life Check' in England, to allow people to assess their own risk of ill health (Department of Health 2006c). The self-assessment stage will be available online as part of Health Direct Online or locally on paper. The online assessments can be stored as part of an individuals' life-long personal health plan, with an option to share their assessment electronically with their general practitioner (GP) or add it to their electronic healthcare record.

The increasing use of 'smart' clothing and smart homes to monitor health and detect early signs of disease, outlined in section 3.3.2, and the greater provision of health-related information should help people live independently for longer. However, this will not necessarily reduce the overall burden on the health service. Consequently, we feel that the importance of preventative measures should not be overstated, as the greatest demands placed on the health service will continue to be due to treating those with diseases.

## 2.5 Effects of regional variation

Since the political devolution in the UK in 1999, health policies, priorities and organisational structures for the delivery of healthcare have markedly diverged in England, Northern Ireland, Scotland and Wales. There may be lessons to be learnt from the successful (and unsuccessful) elements of these different approaches. The approaches of the four countries have been described (Greer 2004) as follows:

- England has emphasised the concept of the *market* that focuses on competition, diversity and consumer choice as the means of improving quality. It draws heavily on American models, such as the Kaiser Permanente Health Maintenance Organization (http://kaiserpermanente.org), where the delivery and financing of services is controlled by the organisation to help control healthcare costs. Greater use is made of private sector providers, while ensuring that the service remains free to patients at the point of use.

- Wales emphasises *localism* with a greater focus on the determinants of health. This involves partnerships with local government and measures such as subsidising school meals and use of sports and exercise facilities for children and elderly people.

- Scotland is building on a strong tradition of *professionalism,* basing its policies and its organisational structures around the professional structure of medicine. For example, local healthcare Trusts have been replaced by the direct provision of services by health boards in contrast to the English approach.

- Northern Ireland, in and out of devolution, has continued to focus on *permissive managerialism*. This approach emphasises keeping services going in tough circumstances and provides stability in difficult conditions, without radical change but allowing local experimentation and variation.

Although the challenges facing the healthcare services (as described in section 2.1) are the same across the UK, each country is exploiting ICTs in a different way. However, there are some common approaches to ICTs across the UK, such as the introduction of an electronic health record which will be available to any health provider at the point of care.

All four countries have National Programmes for the development of ICTs in the NHS. The English programme, which is being delivered by the agency Connecting for Health (CfH), is the largest public-sector IT programme ever attempted. The programme is discussed in section 2.6; further information is also available in the evidence submitted by CfH and on the CfH website (www.connectingforhealth.nhs.uk). The English strategy is to procure systems that will be regionally deployed with a spine database and a strong focus on value for money. The Welsh programme is based on the development of several projects, each of which is clinician led and patient centred. The electronic health records will be different in England and Wales: the English version uses a 'spine' approach, whereas the Welsh version emphasises a summary record, beginning with a minimum data set which will be built up over time. The Scottish programme is called the *National eHealth/IM&T Strategy*: more information can be found on its website (www.ehealth.scot.nhs.uk). In Wales the programme is called *Informing Healthcare*: for more information see the Informing Healthcare website (www.wales.nhs.uk/IHC/home.cfm). A consultation on the Northern Ireland strategy was undertaken in 2002 (Northern Ireland Health & Personal Social Services 2002).

However, it is essential that there is interoperability between the different systems in the four countries. The key issue for interoperability is having minimum international standards, which is discussed further in sections 3.5.1, 4.4 and 4.5.

It should also be noted that healthcare needs to be considered in worldwide as well as regional and national contexts. Severe Acute Respiratory Syndrome (SARS) and avian influenza are just two recent examples that illustrate this point. Overseas developments in the use of ICTs in health and healthcare should be monitored, although the different healthcare structures will need to be taken into account.

## 2.6 Connecting for Health

Connecting for Health (CfH) is the agency of the Department of Health responsible for implementing the English National Programme for Information Technology (NPfIT). NPfIT aims to supply improved healthcare through information technology to hospitals and primary care trusts in England. NPfIT was launched in October 2002 with an initial budget of £6.2 billion. Its scope and complexity is wider than any ongoing or planned healthcare information technology programme in the world and it represents the largest single information technology investment in the UK to date.

NPfIT has four main components, known as the 'Core':

- **NHS Care Records Service:** The aim is to provide a single electronic health record for every patient in England. The benefits for patients are seen as improving quality and convenience of care, as well as allowing greater participation in care decisions via better access to personal health information. For clinicians, the benefits will be improved patient information and access to records. Electronic records are discussed further in section 3.2.2 and the associated patient data management issues are addressed in sections 4.4 and 4.5.

- **Electronic booking service (known as 'Choose and Book'):** This aims to make it easier and faster for hospital appointments to be booked by GPs and other primary care staff. It is expected that this will assist both GPs and patients in choosing suitable times for hospital appointments. Another objective of this part of the programme is to make it possible to choose from several hospitals or healthcare providers (and individual practitioners). The benefits to patients are seen as providing greater choice and the ability to leave the GP's surgery with a hospital appointment having already been made. For clinicians, it is believed that the service will achieve a better use of time and a reduction in non-attendance rates.

- **Electronic transmission of prescriptions:** Given the huge volume of prescriptions, it is unsurprising that medication errors occur: the Association of the British Pharmaceutical Industry (ABPI) estimates that in 2005 more than 825 million prescriptions were dispensed in the UK (ABPI 2006). Under the present system, the information relating to prescriptions is typed three times (by the GP, the pharmacy and the reimbursement agency). The electronic transmission of prescriptions is an area where it is anticipated that ICTs should result in significant improvements.

- **National Network:** This aims to provide a broadband network with a bandwidth of around 5 megabytes (Mb) per second that will link all NHS organisations in England.

There has been considerable media discussion of Connecting for Health, much of which has focused on the total cost and the dates by when various parts of the programme will be completed. The National Audit Office (NAO) estimated that the total spending on the programme will be £12.4 billion over the lifetime of the main contracts (to 2013–14), taking into account several additions to the original programme (NAO 2006). The NAO commented also that it was too early to assess the value for money of the programme. The main aim of NPfIT is to improve services rather than reduce costs. We note that it is not possible yet to evaluate whether the introduction of so many healthcare ICTs will result in any cost savings.

The NAO concluded that substantial progress had been made although some milestones had already been missed by April 2006 (NAO 2006). For example, uptake of the Choose and Book system has been slower than initially planned despite it being available at all relevant locations. However, the NAO noted that successful implementation will depend on three key areas:

- ensuring that the suppliers continue to deliver systems that meet NHS needs to the agreed timescales;

- ensuring that NHS organisations can and do fully play their part in implementing new systems;

- gaining support of NHS staff and the public in making the best use of the systems.

We agree with the NAO that NPfIT has the potential to generate substantial benefits to patients and the NHS. However, it should be noted that attempting to implement so many different components at the same time does not allow for mistakes to be discovered and corrected or for improvements to be implemented. Also, it is vital to ensure that users' needs are incorporated in the design and that users are involved in implementation of any new healthcare ICTs, as highlighted by the NAO report that stressed the importance of gaining support of all levels of NHS staff for NPfIT.

Future health policy should be informed by an evaluation of the effectiveness of the different approaches to deployment of ICTs in the four UK countries. In particular, attention should be paid to the necessity for interoperability across national boundaries, the effects of the different speeds and scales and the levels of user-engagement of the national programmes. The importance of adopting an iterative approach to design and implementation for large and complex systems, such as NPfIT, is discussed further in section 4.2.

# 3 Future technological developments

**Summary**

Technological developments will drive more dispersed, pervasive (anywhere, anytime, 'on-demand') and patient-focused healthcare. They should also provide professionals with access to all necessary information to consult and be consulted wherever they may be. Many of these technologies are not health-specific and are inexpensive and may enable health and healthcare to meet the challenges of the next 10–15 years outlined in chapter 2. Seamless global access to information and knowledge has the potential greatly to enhance healthcare for the patient, carer and healthcare professional. Electronic records are destined to become an important part of the overall information environment for health. ICTs could also enable healthcare professionals to have discussions regarding individual cases while viewing the primary information on a patient, even if the participants are at remote locations. Broadband communications technology will enable a wide range of data, including images, to be available on demand at any time in multiple locations. The development of pervasive person- and object-based communications should enable a patient's state to be monitored both remotely and automatically. ICTs will help to make it possible to obtain data from both the individual and the wider community, leading to more accurate epidemiological studies.

## 3.1 Introduction

This chapter describes the very rapidly developing technologies for communications and data processing that have the potential to have an enormous impact in health and healthcare. The relevant future technological developments are divided into five groups:

- global communications and information infrastructure;
- personal and ubiquitous technologies;
- data capture and imaging;
- high-performance computing;
- autonomous and robotic systems.

If any of the technologies described in this chapter are to be introduced successfully in health and healthcare scenarios, they will need to undergo suitable development and transfer from prototypes to fully functional pieces of equipment or systems. Some of the issues associated with technology development and transfer are discussed in section 3.7. The future availability of ICTs in healthcare is predicted in appendix one. Whether the potential of these technologies can be realised will depend on how their introduction is managed, which is discussed in detail in chapter 4. Consideration will also need to be given to whether spending money on new ICTs is a good use of limited healthcare resources, which is addressed in chapter 6.

## 3.2 Global communications and information infrastructure

There will be continued increase in the speed of communications and of access to information, alongside a growth in the number of users. The increased capacity to transfer data will allow communication and access to images and video. One example is the introduction and growth in the use of third-generation ('3G') mobile 'phones, which offer users high-speed mobile services such as video calling and messaging. This has immediate implications for healthcare, enabling patients to share information, practitioners to share information, global access to information about drugs and treatments, rapid and accurate diagnosis in many locations and remote diagnosis via teleconferencing.

The following four developments in information infrastructure will make the use of ICTs in healthcare widely applicable:

- Wide availability of wired and wireless broadband communications networks.
- Use of internet technology including the web and grid.
- Widespread use of international standards, DICOM, HL7 and XML. Details of the necessary standards are discussed further in the evidence received from the Institution of Engineering and Technology (IET), formerly known as the Institution of Electrical Engineers.
- Ever-increasing availability of more and more powerful PC-type technology at low cost.

In combination with the technologies listed above, much better human-machine interfaces (such as voice recognition) are likely to enhance and accelerate the use of ICTs in healthcare (Suchman 2006; Williams et al 2001; Ehn & Löwgren 1997). For example, the Engineering and Physical Sciences Research Council (EPSRC) is currently supporting 75 projects in the area of user interface technologies and human–computer interaction, at a total cost of £22 million.

### *3.2.1 Communications infrastructure: mobile 'phones, wireless technologies*

Broadband networks offering up to 100 Mb/s (Ethernet) to the home will become more widely available over the next three to five years. These networks will support converged voice, video and data services. An obvious example is Voice over Internet, in which voice telephony is supported via the same devices and networks as are used for data and internet access. New access network technologies should enable much more detailed patient monitoring and diagnosis within the home, enabling a significant amount of healthcare to move from the hospital to the community and the home allowing more effective and convenient care for patients, in line with Government's aims outlined in chapter 2.

In the medium term, wireless local area networking (WLAN) and other high data rate local networking technologies will be standard on mobile 'phones and other cell devices, enabling similar converged voice, video and data services from home, office and street. Indeed, internet technologies (such as wireless fidelity (WiFi) and worldwide interoperability for microwave access (WiMAX)) and cellular technologies, which currently offer complementary coverage, are expected to merge to provide a single wireless connectivity system. This will enable, and will in turn be driven by, the use of motion video for TV, films and educational material. This is an example of where technological development driven by another application (in this case home entertainment) will have potential beneficial applications in health and healthcare.

This will greatly assist the development of common information environments because industry-standard ICTs can be used for healthcare applications, thus reducing the cost and increasing reliability. At present it is possible to support a common information environment within a hospital, but such an environment is based on broadband computer networks, which typically use PCs, Macs and UNIX boxes.

Full motion video is now available on mobile 'phones and personal digital assistants (PDAs) with sufficient speed and resolution to be used in healthcare: video telephony using a mobile 'phone has been used to identify strokes (Vodafone Netherlands 2006). However, in the future there will be an increasing number of healthcare-related applications for this technology as the frame rates and resolution continue to improve. It is highly likely that this range of information will be made available across several different devices, rather than a single device. The full range of information will be available in the same way that mobile 'phones are used for voice and SMS (texting) today, but with much better user interfaces.

The evolution of the internet and its standards will continue into the foreseeable future, offering new capabilities to an increasing number and variety of users. The End-to End Research Group, part of the Internet Research Task Force, published an agenda for ten years' development of the internet (Clark et al. 2005). One of the challenges it set for the research community is that in ten years there should be low-cost local communications architecture that enables the local interconnection of dozens or hundreds of small (eg chip size or slightly larger) devices ranging from very low cost to very high cost and performance.

The next generation of the internet protocol (IPv6) anticipates the rapid growth in the number of devices connected to the internet. Most of today's internet uses IPv4, which is now nearly 20 years old. There is a growing shortage of IPv4 addresses, which are needed by all new machines added to the Internet. IPv6 solves several problems in IPv4, including the limited number of available IPv4 addresses. It also adds many improvements to IPv4 in areas such as routing and network auto-configuration. The accurate labelling of items, such as individual medical devices, reduces ambiguity and could help to reduce clinical risk by (for example) ensuring that the correct device is in the right place at the right time.

### *3.2.2 Electronic records*

Several different electronic records are being used now and being developed, which are described in this section.

The Electronic Patient Record (EPR) is currently used in the UK and is a record of clinical episodes. At the moment within the NHS it is possible for an individual to have several EPRs, for example one at their GP and others at different hospitals as they are not integrated. Today most EPRs contain only information in the form of text and numbers (such as letters, reports or laboratory results). Some of the more advanced EPRs now contain a selection of representative still and moving images.

The Electronic Health Record (EHR) is now beginning to be implemented. It is a much more comprehensive record of a person's life from the cradle to the grave. It will integrate all the EPRs for a single individual, as well as being a record over time of such issues as diet, exercise and general lifestyle. In addition, broader data will be included such as whether other members of the family have a history of arterial disease or there a higher incidence of a particular type of cancer in a given geographical area.

The Picture Archiving and Communications System (PACS) is the high-capacity image and display system currently found mainly in radiology departments, although it is now spreading to other specialties. PACS contains images only with all the ancillary information relating to a patient's images being stored in the Radiological Information System (RIS). For example, when a patient has an 80-image magnetic resonance (MR) scan of the brain, all 80 images will be stored in the PACS with all the ancillary information (text and numbers) in the RIS. The EPR will typically contain one or two representative images from the 80 selected by the radiologist. The Hospital Information System (HIS) contains a wide range of more general information (such as name, address and age) on a particular patient. The aim is to combine all of these different information systems into a common integrated system called a clinical information system where all the data are interrelated and accessible (usually via a web-based system).

Throughout the report we use the term EHR, as we are referring to the cradle-to-grave record that is now being implemented. There are several issues relating to the potential impact of the EHR on privacy, confidentiality and liability that will need to be resolved to gain the benefits of the EHR, which are discussed further in section 4.4.

The EHR has the potential to reduce the duplication of tests and investigations, which happen currently, and decrease the likelihood of treating patients without their notes. Further details of the plan for EHRs in England (referred to as the 'NHS Care Record') can be found in evidence submitted to the study by Connecting for Health on the Society's website.

Mobile computing will allow the record to be available in the patients' homes, on ward rounds and in emergency situations. This mainly involves the development of standard technology, which will be widely used in society, coupled to increased wireless network bandwidth. In healthcare the use of hand-held devices involving the full EHR is probably 5–10 years away. For example, aspects of the summary care record and low resolution scans or X-rays could be delivered to hand-held devices now, although providing this capability for high-resolution diagnostic images could take 3–5 years.

The results of complex investigations including scans and X-rays will be available to all who care for a patient, which has the potential to allow some of the patient's care to be undertaken by general practitioners rather than hospital staff. This is very much a political decision, although such changes will involve the deployment of existing technology (such as scanners or ICTs) in different ways. The use of fixed and mobile scanner technology in primary care centres is now routine in some parts of the world, such as the USA. Within the NHS such changes will probably occur, if new policy is introduced, within the next ten years.

The EHR also has the potential to provide prompts, alerts and watchdog facilities to assist clinicians in ensuring that appropriate interventions are performed at appropriate times. It could undertake trend analysis on the patient's data to observe, for example, if their current state lies within their normal range over some time period. The range may vary as a disease progresses or a patient improves after an operation. This involves automatic analysis of patient data on an ongoing basis, which is a form of advanced monitoring. Simple timing and alerts are already in routine use. More sophisticated systems are likely to be implemented in a matter of years.

Information contained in the EHR can also be coupled to expert support systems for the healthcare professional. An example is the web-based system Map of Medicine, which takes the healthcare professional through a map of symptoms and signs to assist with diagnosis. The system assigns probabilities to a given condition, based on the patient information entered. Such systems are now being implemented around the world and are expected be in general use within the next 5–10 years. Section 5.3 discusses the impacts of ICTs on the patient–professional relationship, including the use of decision support.

There are several secondary uses for the EHR, such as measuring the healthcare outcomes and epidemiological studies, which are discussed further in section 4.5.1. One example is that the EHR has the potential to reduce the effort required for medical audit. With the appropriate software these data could be used for a range of monitoring and management purposes, such as the success of a specific type of intervention in a particular hospital.

### 3.3 Personal and ubiquitous technologies

The rapidly developing area of personal and ubiquitous computing has many applications, from health and home care to environmental monitoring and intelligent transport (Parliamentary Office of Science and Technology 2006b).

#### *3.3.1 Tracking people and objects*

Costs of computing devices will continue to fall. Existing PC capabilities will be available within consumer products (such as TVs), hand-held devices and mobile 'phones at a fraction of their current cost. At the same time, ultra-low-cost (disposable) computing, such as Radio Frequency Identification Device (RFID) technology, will become more widely used. RFID technology enables wireless devices to transmit, receive and store information without line-of-sight to the receiver, working along similar principles to bar codes where data are transferred optically. RFID is expected to be used extensively throughout product distribution networks but can also be used to track people around buildings (National Research Council 2004; Parliamentary Office of Science and Technology 2004). Over the past decade it has come into widespread use, for example being used to time marathon runners. Global positioning systems (GPS), which are rapidly becoming standard in cell 'phones, systems that locate relative to for mobile 'phone base-stations and systems that employ lightweight gyroscopes, could also be used to track people.

Some of these technologies will require ultra-low-power, enabling them to be stand-alone, scavenging power from their environment or using sealed-in batteries that last as long as the product. These open the way to cheap, disposable sensors, distributed in the environment, wearable, suitable for swallowing or even implantable. In addition, low-power short-range wireless communications will enable these devices to be connected to communications networks.

RFID technology will be used increasingly over the next 3–5 years. It is already being implemented for tracking pharmaceuticals and foods to provide usage and batch information. RFID technology could help patients follow their prescribed pharmaceutical routine. For example, where a patient is taking up to 20 or 30 different pills each day, RFID technology could be used in conjunction with home-based monitoring equipment to assist with the taking of medication at the correct time.

RFID technologies could also be used in health-related ways such as the dietary management for individuals and families, where automatic audit of food ingredients can be undertaken. It could also be used in determining when food and pharmaceuticals have passed their use-by dates.

Continuing improvements in RFID technologies will increase their range and decrease their cost and power consumption. Most current systems use passive RFID (without internal power supplies) with a range of a few centimetres; active RFID (with internal power supplies) will become widely available over the next five years and has a greater potential range of a few metres. Active tags also have onboard processing and dynamic memory enabling tagged devices to record information about, for example, the environment through which they have passed.

RFID will also enable the monitoring of equipment usage in hospitals, community clinics and homes providing real-time information relating to its position and use. It is very difficult to assess when the NHS is likely to use RFID, but the timescale will probably be determined by external organisations such as the pharmaceutical companies and regulatory authorities. For example, Birmingham Heartlands Hospital started a pilot project in 2005 using a system to track and identify some of their patients using RFID tags (British Journal of Healthcare Computing and Information Management 2005).

In the longer term, the printing of electronics (including keypads and displays) onto labels, packages and fabrics will facilitate embedding intelligence into more and more low-cost items. For example, smart pill packets could have personalised dynamic prescription guides and automatic transmission of pill use to an online disease management system.

The increasing use of RFID technology has raised concerns among some privacy, civil liberty and consumer groups. The National Consumer Council and National Research Council have both held workshops to address these concerns (National Consumer Council 2004b; National Research Council 2004). These workshops highlighted that more work was needed to achieve a better understanding of the potential and implications of RFID. Privacy and data collection were seen as the major cultural and social questions arising from RFID development and use. These issues are discussed further in section 4.4.

### *3.3.2 Personal and home-based equipment*

Sensor technologies could enable much more effective monitoring of people and patients within their everyday environment. An increasing variety of personal healthcare devices based on low-cost computer technology bought over the counter, or over the internet, are expected. These currently include pedometers, scales, thermometers, heart-rate monitors, blood pressure monitors, body-fat analysers and blood sugar monitors. Many of these can upload data to personal computers; in future it is highly likely they will be networked and may be used continuously.

Pilot 'smart homes' exist already where ICTs are used to help control a variety of functions and to provide communication with the outside world (Barlow Gann & Venables 1999). It is expected that home monitoring will increase with the growing availability of ubiquitous computing and sensing technologies. These could initially be used for routine sensing and control, replacing conventional thermostats and lighting controls. Continuous monitoring of the elderly in relation to their mobility at different times of the day should allow more intelligent detection of falls. Smart toilets may also be a feature that build on currently available technologies. For example, a Japanese company has reportedly produced a toilet that measures sugar level in urine, blood pressure, body fat and weight (CNN 2005). Information on the mobility and diet of the sick and elderly could be automatically compared with normal activity patterns for the individual, and this information could be fed back on a regular basis to a healthcare professional or carer, or stored as part of the EHR.

The reliability of the data from some detectors has been questioned, although this is expected to be resolved relatively soon. The main technical challenge remains being able to monitor and analyse activities of daily living to inform decisions about changes in patterns of activity to bring health benefits. For example, detectors need to be able to differentiate between an individual who is sleeping and one who has fallen down. Research into acceptable, low-cost hardware and software to achieve this is ongoing.

Devices worn on the body could also be networked. Body sensor networks enable networks of sensors to be placed on (or inside) the body to monitor physiological state, as well as other variables such as body position (eg standing, sitting or lying). Some of these technologies will become available in the form of 'smart clothing'. For example Sensatax is currently testing its SmartShirt system that remotely monitors a wearer's movement, heart rate and respiration rate in real-time. This could give healthcare professionals early warning of any abnormalities and help to inform decisions about their patients. These functions can be measured even if the patients are miles away, potentially facilitating treatment of patients as close to their home as possible.

Many of these new technologies can be introduced by minor enhancements of existing technologies, such as wireless technologies, mobile 'phones and PDAs. These will be augmented with integrated body sensors, allowing direct logging and communication of information using existing infrastructure. For example, security systems in the home could be easily modified to incorporate patient and person monitoring.

Evidence submitted to the study by Lionel Tarassenko of the University of Oxford describes the potential use of mobile 'phones to improve the self management of chronic diseases such as diabetes. This involves patients measuring their condition (eg blood glucose level) and using their mobile 'phone enabled with the appropriate software to evaluate the most recent reading in the context of recent trends in their condition. The patient can then decide on the most appropriate action to take. Carers or healthcare professionals can also have full access to the patient's measurements and can provide immediate feedback and targeted support when necessary.

Progressive improvements in display technologies, together with high-speed networking, will make it more practicable to perform remote consultations using videoconferencing and to view medical images in a patient's home. High-definition television (which offers twice the resolution, wider screens, better sound and better colour than the standard format) will become standard over the next 10 years. New high-dynamic range displays are just becoming available, which add a factor of 100 to the ratio between bright and dark parts of an image, providing much more realism.

### *3.3.3 Near patient testing*

Near patient diagnostic systems enable healthcare professionals to provide vital information to their patients 'on the spot' at a clinic, emergency room or in the doctor's office, or enable patients to conduct tests themselves at home. Potential advantages include reducing turnaround time: a patient can be diagnosed within minutes and thus, in theory, be treated more quickly than when centralised testing is used. This has the potential to improve health outcomes, lower costs and increase patient satisfaction. However, the impact of near patient diagnostics on patient care/outcomes is as yet not well documented and further research is needed (Delaney et al. 2000).

Existing products include: kits for pregnancy testing; ovulation prediction; infection screening (eg chlamydia); and monitoring of warfarin therapy via international normalised ratio (INR) monitoring. The list of kits is growing, with plans for those that will screen for: a wider range of infectious agents (eg influenza); illnesses such as appendicitis; and for genetic testing. Polymerase chain reaction (PCR) methods are being used, for example to develop portable ultra-rapid, in-field detection of bio threat agents (Royal Society 2004a).

Increasing research and development work in this sphere includes interest in biomarkers for diagnostics applications. A biomarker is a biological characteristic that can be measured and evaluated. Such markers can potentially be used to differentiate normal from diseased states, measure disease progression, or assess adherence with treatment regimes. Identification of such markers provides the opportunity for medical intervention during both symptomatic and asymptomatic stages of an illness.

### *3.3.4 Personal technology for practitioners*

In the future people might wear an almost invisible wireless headset all day for all their audio communications and applications. It is now possible for a headset to deliver 'phone calls via a belt-worn 'phone when at work and on the move. For example, similar technologies would enable surgeons to record their operations from headset cameras. Such technologies are already being used to train surgeons. Another example is a hands-free communication system introduced in 2006 for staff at the Royal Cornwall Hospitals Trust in Truro, which works through voice-activated, wearable badges based on a wireless local area network (BT 2006).

Adaptive interfaces are user interfaces that change over time, in response to how they are used, to improve the quality of the interaction. Examples with current technology include speech and handwriting recognition systems that improve the accuracy of their recognition as they become familiar with the user's style. Adaptive interfaces should become more intuitive, making use of the context in which the practitioner is working to understand aspects of a user's intent and provide information or options tailored to that intent, without the user having to be explicit.

Authentication and security to control access to databases or to validate the sources of data could use biometric technologies. Also, technologies such as bar codes and RFID could be used to identify patients. For example, bar codes are already used to ensure that the correct medications are given to the right patient.

## 3.4 Data capture and imaging

Imaging technology will become increasingly important. Current imaging within healthcare consists primarily of two-dimensional (2D) and 3D images of anatomy; this will extend to wide use of 4D imaging (ie sequences of 3D images over time) providing quantitative information about physiology and function. Increasing use is being made of computer-aided detection and diagnosis of disease, especially in areas where clinical need outstrips available clinical expertise (eg the detection of microcalcification clusters in mammography). Some predominantly 2D imaging technologies (eg mammography) will soon be 3D (tomosynthesis), facilitating easier integration with other 3D images such as magnetic resonance imaging (MRI) and positron emission tomography (PET). Visualisation systems will enable scanned 3D and 4D image data, such as a beating heart, to be viewed in real time. The volume of data will increase by very many orders of magnitude. Radiological imaging systems (as described in section 3.2.2) are likely to become common with the associated Picture Archiving and Communications Systems (PACS). This will be facilitated by better ICTs, particularly 1 Gbit/s networks capable of transferring large amounts of data quickly.

Healthcare professionals could carry personal ultrasonic imaging devices in their pockets, in a similar way that they currently carry stethoscopes, allowing ultrasound to be used in places where it cannot currently be utilised. This is feasible in the next 5–10 years although this would require additional training for healthcare professionals. Imaging techniques could be increasingly used to guide therapeutic and surgical procedures, which themselves will become less invasive.

Virtual reality could be used in 3D and 4D body imaging. High-resolution CT scans, fluoroscopy, MRI, PET scans and ultrasound can capture and render detailed 3D images of the patient. These images can be helpful in diagnostics, designing a treatment plan and preparation for surgery. Virtual reality's interactivity enables healthcare professionals to program lifelike behaviour into virtual-reality computer models, enabling them to work through simulations of complex procedures and anticipate complications. Current work on the examination of pelvic and abdominal organs is quite advanced (Aggarwal et al. 2006).

In the longer term, virtual reality could be used more widely in healthcare. The addition of systems in which realistic forces are fed back to users in real-time to virtual-reality imaging will greatly increase its effectiveness at simulating real-world situations. Training systems using a simulator and virtual reality, where a system provides doctors with the 'feel' of virtual patients, could be used for surgical training in the future.

Molecular imaging technologies are already available that provide information ***in vivo*** of cellular and molecular processes, but these are mainly used in basic medical science and research laboratories. Examples are optical and electron microscopy techniques, atomic force microscopy, as well as high-throughput gene sequencing technology. Fast protein-sequencing technology is also becoming commercially available. Clinically and pre-clinically, molecular imaging is currently based on nuclear medicine, PET and single photon emission computed tomography (SPECT), though a range of complementary technologies will come into use over the next 5–10 years. At a finer spatial scale, increasing use is being made of protein sequencing and microarray technology: usage will increase rapidly over the next 5–10 years. The rapid developments in molecular biology could move medicine from the traditional approach of working at the systems, organ and tissue levels to a far more integrated approach covering all levels of the biological continuum (ie systems, organs, tissue, cells, proteins and genes). These changes are already occurring, but could produce major changes in the practice of clinical medicine over the next 10–15 years.

These images could also be connected via ICTs into a common information environment, seamlessly integrating different information sources for the healthcare professional. Currently, medical information is stored in a range of systems such as HIS, EHR, PACS and RIS (as described in section 3.2.2). However, only suitably trained professionals will be able to interpret raw data into a usable form. For example, it will not help a health visitor to have access to unanalysed raw laboratory data.

## 3.5 High-performance computing

The use of high performance computers and servers is growing rapidly in many areas of science, engineering and medicine and is spreading into more commercial sectors such as financial analysis and modelling. Costs of this technology will continue to drop and performance will increase. New techniques could support the management of the very large datasets needed in healthcare. It will become practicable to aid diagnosis by automatic analysis of patient data including images. There is the potential for mining large datasets gathered on a global basis over a period of time, enabling major epidemiological studies.

### *3.5.1 Improved data structure and searching*

The semantic web provides a common framework that enables data to be shared and reused across applications, between individuals and organisations. Its development is a collaborative effort led by the World Wide Web Consortium (www.w3.org/2001/sw) with participation from many researchers and industrial partners. It has the potential to enable computers to extract, filter and cross-reference data found on web pages. One of the problems with current web practice and technology is that it only allows data to be viewed and has very limited capability for further manipulation. Work is already underway to use the semantic web as a starting point for the standardisation of health data sets (www.w3.org/2001/sw/hcls). It should be relevant both for richer use of large datasets and for sensors and home devices to ensure that they speak a common language.

The key to interoperability between devices and systems is having minimum international standards, as mentioned in chapter 2. There are currently standards being developed for terminology (eg by SNOMED CT, www.snomed.org), messaging (eg by HL7, www.hl7.org) and the content of healthcare data (eg by ISO and CEN). Several international standards are currently being developed that cover medical information and datasets at the systems, organ and tissue levels. The most widely accepted standard terminology at present is SNOMED CT, which has recently been officially adopted by the NHS. Having a standard terminology and definition of concepts (sometimes referred to as medical ontology) helps remove ambiguity and, hence, reduces clinical risk. Standardisation is discussed further in section 4.5.1.

The rapid growth of the Internet and intranets has created access to a large quantity of information. As the amount of information continues to grow, so does the complexity of finding and retrieving it. There have been many developments in information retrieval tools to address this problem and it is expected that there will continue to be incremental improvements in this area (Levene 2005).

### *3.5.2 Data mining and epidemiology*

ICTs will help to make it possible to obtain data from both the individual and the wider community. In the case of the individual, it will be possible to obtain detailed clinical information at all levels of the human organism (system, organ, tissue, cell, protein and gene). This, coupled to more general medical information within a patient's health record (eg weight, exercise regimes, diet and genetic risk), will enable much better data analysis, leading to far more accurate epidemiological studies.

The European Commission has already begun work on a pan-European EHR that it expects to be operational within 20 years. This would enable very detailed epidemiological studies to be performed, for example with the ability to monitor continually the health status of the nation and the EU and to track the development of epidemics at a very early stage. This could give many benefits, such as more effective development and delivery of vaccines. Using data to reshape health practice is discussed further in section 4.5.1.

There is a trend to make large datasets available and link the databases that hold the data. The benefits and risks associated with data sharing were discussed at a recent Foundation for Science and Technology meeting (Foundation for Science and Technology 2006). Federated networked databases and appropriate data mining tools will be important in healthcare, enabling a patient's genotype, health status and medication to be linked, as well as being linked to epidemiological data. However, concerns have been expressed about data privacy and confidentiality in joined-up databases, as highlighted in the written evidence that we received from the University of Surrey. For example, specific concerns have been voiced on the extent of disclosure of information from accident and emergency departments to the police and social services and its legal and ethical parameters (Hunt & Van der Arend 2002). These issues are discussed further in section 4.4.

### *3.5.3 Personalised drugs and treatments*

More detailed clinical information will increase the ability to design and develop personalised drugs. The major pharmaceutical companies are already devoting significant resources to this topic. The Society recently undertook a study to look at the potential of personalised medicines (Royal Society 2005a). The problem with the current generation of drugs is that at the level of the individual their effects and side-effects vary significantly. The data provided by the advanced medical information systems described above will mean that it should be possible to choose drugs that are particularly suitable for the individual based on their particular genetic make-up.

The impact of genomics on personalised medicine is likely to be in the more distant future. Realistically, the greatest benefits from advances in genomics are unlikely to be realised within the next 10–15 years. Nevertheless, the ICTs established within this timescale need to be capable of coping with the escalating volumes of data and information which will eventually flow from these advances. Genomics is a field that depends on the acquisition, storage and analysis of huge quantities of data. In 20 years (probably not sooner), it may be feasible in terms of cost and speed to sequence the entire genomes of individuals on a routine basis. In the medium term, genetic testing to predict individuals' responses to at least some drugs will become more routine, particularly in the field of oncology.

Pharmacogenetics will become increasingly important in drug discovery. Studies of pharmocogenetic variability will require the analysis of large repositories of clinical data, during and after clinical trials. Acquisition, storage and analysis of pharmocogenetic data will raise particular ethical problems in relation to consent, rights and confidentiality (Royal Society 2005b). Regulatory agencies will need to establish post-market/sales monitoring of pharmacogenetic medicines.

### *3.5.4 Grid technology*

Grid technology uses the resources of many separate computers connected by a network (usually the internet) to solve large-scale computation problems. Grids provide the ability to perform computations on large data sets, by breaking them down into many smaller ones, or provide the ability to perform many more computations at once than would be possible on a single computer.

Developments in grid technology could facilitate the access to large amounts of high performance computing for health and healthcare uses. For example the CancerGrid project (www.cancergrid.org) is a consortium of specialists in oncology and software engineering drawn from UK universities that aims to develop software for clinical cancer informatics. It is looking at modular, distributed software for clinical trial patient entry, randomisation and follow-up, storage and analysis of complex datasets, linking trial and epidemiology data with profiling information.

Another example where grid technology is being applied to eHealth is the University of Oxford's eDiaMoND project (www.ediamond.ox.ac.uk). The project aims to pool and distribute information on breast cancer treatment, enable early screening and diagnosis and provide medical professionals with tools and information to treat the disease. eDiaMoND should give patients, physicians and hospitals fast access to a vast database of digital mammogram images. eDiaMoND also hopes to help reduce the rate of false-positive diagnosis and overcome problems created by inconsistent mammogram image formats and lost X-rays.

Over the next 5–10 years, standards for Grid middleware, such as WebServices, will be agreed and quickly incorporated into every PC, laptop and hand-held device. This will facilitate a wide range of healthcare applications that are currently infeasible because of the need for distributed and intensive computation.

### *3.5.5 Computer modelling*

Developments in high-performance computing will help more advanced healthcare-related computer modelling. There are many areas of healthcare where advanced modelling could bring benefits. Two of the many current examples include using supercomputers to develop simulations of the possible future course of an avian influenza pandemic (Germann et al. 2006) and the World Community Grid's fightAIDS@Home project, which has established a virtual supercomputer to test thousands of human immuno-deficiency virus mutations against tens of thousands of chemical compounds that might be used to treat HIV (http://fightaidsathome.scripps.edu).

### *3.5.6 Security and access*

Developments in consent management and data custodianship will help to support privacy while allowing professional access to appropriate information. For example access control/monitoring and watermarking could be used to keep track of who is accessing what data. Several of the latest EHR and PACS already have sophisticated automatic audit trails where every interaction with the system is logged: this includes which individual has entered or modified individual pieces of information. These technological developments should also help to secure ICTs against cybercrime and hackers.

There are lessons to be learnt from electronic banking. The introduction of electronic banking did not create inherently new risks: rather, it increased and modified some of the traditional risks associated with banking (Basel Committee on Banking Supervision 2003). Banks have developed mechanisms over more than 30 years to deliver ubiquitous access to data with adequate security at reasonable costs.

## 3.6 Autonomous and robotic systems

The availability of inexpensive computing power both in mobile devices and in servers makes it practicable to introduce autonomous systems in healthcare. For example, low-cost mobile and wearable devices could be used to automate drug administration based on continuous sensor data. Information-based sensor and delivery systems for the control of drug administration and anaesthesia may be introduced.

Rapid development of fully robotic systems is expected over the next decade, based on energy-efficient computers, innovative sensing and control techniques, and advanced materials. In combination, these enable robotics that could be used as personal assistants, in toys or in prosthetics. Some of these developments are directly relevant to healthcare: robots could be used in image-guided surgery, in emergency and hazardous situations, in the home for the chronically ill and for the support of the elderly. Rapid development continues in both remote-controlled and autonomous robotic systems.

Assistive robots are in use now and are likely to become increasingly common, particularly where there are repetitive and relatively unskilled jobs to be done. For example, pharmacy robots are in use in some hospitals, undertaking jobs such as filling and labelling vials and delivering prescriptions to wards, allowing qualified staff, who are in short supply, to spend more time with patients. This could help deal with the expected shortage of healthcare professionals, as discussed in section 2.1.

Patients at home, with acute or chronic conditions, could interact with and be supported by robots, including humanoids and mechanical pets. Carebots are in use in the USA and Japan, to help reduce the loneliness of isolated, elderly people. Robotic teddy bears, which have been used for some years in Japan, greet the owner by name, relay voice messages from relatives and remind them when to take medication. Carebots have also been developed which can guide disorientated patients around, as well as monitor health and provide cognitive reminders for patients with mild dementia who have difficulties keeping track of their required daily activities. However, the high cost of the prototypes means that it will be a while before they are on sale and longer still before they are mass produced.

Last year Honda unveiled its 1.3 m tall, bipedal robot Asimo. Using visual, ultrasonic and floor sensors it recognises its environment, and using wrist kinaesthetic sensors it gives and takes objects. Asimo can walk while holding a person's hand and carry objects using a trolley. Honda see it as a potential aid to nurses, taking care of the heavy manual tasks, allowing them to spend more time with the patient.

Image-guided robotic surgery may become more common, although surgery performed by remote experts through the control of robots (telesurgery), which has been undertaken in the USA, is unlikely to be needed in the UK, except, perhaps, in emergency and hazardous situations.

Research to develop powered prostheses is a challenging area, but researchers have demonstrated that non-human primates can learn to reach and grasp virtual objects by controlling a robot arm through a closed-loop brain–machine interface (Carmena et al. 2003). The research may lead to permanent artificial prostheses for those who have lost a limb and might increase the mobility and dexterity of those suffering from spinal cord injuries or nervous system disorders.

### 3.7 Technology development and transfer

If any of the technologies described in this chapter are to be introduced successfully in health and healthcare scenarios, they will need to undergo suitable development and transfer from prototypes to fully functional pieces of equipment or systems. Managing the introduction of ICTs for use in healthcare is discussed in the next chapter. The generic challenges involved in the commercial exploitation of science, engineering and technology developments have been addressed in several reports (eg ETB 2004; Lambert 2003). It was suggested in the evidence received from the EPSRC and the IET that the UK is at the forefront of innovative progress in this area. However, the challenge of implementing these technologies within the health sector was also stressed by the IET.

The House of Commons Health Select Committee noted that the UK medical technology industry consisted of approximately 4800 companies, employing in excess of 55 000 people, with combined annual sales of £6 billion and accounting for £3 billion of export earnings (House of Commons Health Select Committee 2005). These figures give an indication of the large size of the healthcare ICT market.

Specifically relating to healthcare technologies, the Government established the Healthcare Industries Task Force (HITF) in October 2003 in response to Sir Derek Wanless' comments that the NHS was a late and slow adopter of medical technology (Wanless 2002). HITF bought together Government and the healthcare industries to investigate how to facilitate the introduction of beneficial new technologies into the NHS and how health- and social care could present a more attractive market for companies operating in the UK. The final HITF report was published in November 2004, which identified nine specific outputs (Healthcare Industries Task Force 2004). The Government acknowledged that this is a complex issue and that there is no single 'quick fix' solution (HM Government 2005). However, the Government believes that working in partnership with the main stakeholders (including industry, health- and social care professionals, patients and carers) will increasingly have a positive impact on uptake of new technologies, alongside the range of measures being implemented as a result of the HITF report. Although HITF looked at a very wide range of medical devices, its outputs are highly relevant to healthcare ICTs. However, it is currently too early to say whether the measures introduced as a result of the HITF report will have the desired effects. These measures include the following actions:

- From 1 September 2005, what was previously called the Device Evaluation Service (part of the Medicines and Healthcare products Regulatory Agency), became know as the Centre for Evidence-based Purchasing as part of the NHS Purchasing and Supply Agency. This aims to produce more informed procurement decisions, hopefully speeding up the introduction of beneficial technologies.

- NHS Collaborative Procurement Hubs are being developed to include clinicians in purchasing decisions by giving a practitioner's perspective (http://www.scep.nhs.uk/cph/).

- On 1 July 2005 a new National Innovation Centre was established as part of the NHS Institute for Innovation and Improvement. This will aim to create the 'pull' for the introduction of innovation from within the healthcare system to complement the 'push' from healthcare industries.

- HITF suggested the idea of 'Healthcare Technology Co-operatives' to support clinically driven new technologies by bringing together the NHS, academia and industry in collaborative ventures. Work has begun to develop a pilot project.

- Sir Ara Darzi is chairing a working group responsible for providing the strategic lead on training and education to underpin the use of innovation and develop the toolkits for trainers and staff to use.

Another important technology transfer issue is that many healthcare-related ICTs (such as monitoring devices linked to mobile 'phones or cars) are being developed outside the health industry and may be marketed directly to patients and carers. The efficient exploitation and integration of these will be a challenge.

# 4 Managing the introduction of ICTs


**Summary**

Given the complexity and changing nature of the healthcare environment, we advocate an iterative approach to the design, development and implementation of healthcare ICTs. ICTs should be designed with an understanding of the needs of healthcare professionals, patients and carers, particularly if the technology has the potential to reshape the organisation or result in reconfiguration of service delivery. Learning, training and support for healthcare professionals is a vital part of the successful introduction of healthcare ICTs. The conflict between privacy and sharing health data for individual and social benefits is a key issue that will need to be resolved before the full benefits of healthcare ICTs can be realised.


## 4.1 Introduction

This chapter addresses the design, development and implementation of healthcare ICTs and the factors that will help influence the relative success of healthcare ICTs. The potential impacts of ICTs on individual healthcare professionals, patients, carers and the patient-professional relationship are discussed in chapter 5.

Whether the ICTs described in the previous chapter achieve their full potential in healthcare will depend on the roles and relationships between individuals, groups and organisations and also on perspectives of how information should be used. The variety of scales on which these technologies will be utilised, from individuals and small teams through to nationwide systems, will also influence what types of product will be used and in what ways.

ICTs may help to redesign the organisational structure of healthcare and reconfigure how services are developed. This is because ICTs have the potential to:

- help to cope with workforce shortages;
- promote self-care and improved management of chronic conditions;
- expose inconsistencies and inefficiencies;
- facilitate joined-up healthcare provision (social services, different parts of the NHS and by the private sector), for example through use of a standardised electronic health record;
- make service-providers more accountable by increased transparency with increasing availability of data on outcomes.

## 4.2 Design and development

Healthcare is a very challenging environment into which to introduce any new technology, for the following reasons:

- Many healthcare needs are urgent, which causes healthcare professionals and patients to be often under considerable time pressure. Linked to this, there is often an intolerance of system failure.
- Healthcare often requires dealing with vulnerable people when they are most in need.
- Healthcare professionals, patients and carers can often have unrealistic expectations of what healthcare ICTs can deliver. Patient expectations are discussed further in section 5.2.1.
- Publicly provided healthcare systems have limited resources to tackle unlimited demand, which results in serious cost constraints. The importance of economic evaluation is discussed in chapter 6.
- The NHS is a complex organisation and there are likely to be an increasing number of service providers including the private sector, as raised in section 2.1.
- At our evidence-gathering workshop with healthcare professionals, several of the participants commented that they suffered from change fatigue, from being forced to deal with ever-changing management requirements and new ICTs.
- Large-scale public sector IT projects have a poor success rate and there is a tendency for these projects to fail to deliver all of the key features and benefits to time, target cost and specification (Royal Academy of Engineering 2004). There is a poor track record of successfully introducing nationwide IT systems including the following examples: Criminal Records Bureau, Inland Revenue, National Air Traffic Services and the Department for Work and Pensions (POST 2003).

To deal with these challenges we advocate an incremental and iterative approach to the design and development of new ICTs. Healthcare professionals and any other users must be consulted to determine their requirements and be involved in the implementation stages. It is also essential that evaluation is a key part of this process, with milestones agreed from the start. Evaluation and the need for improved methodology are discussed in greater detail in chapter 6.

An iterative process is especially important in the design and delivery of large and complex systems. We hope that Connecting for Health has adopted this approach in delivering the main components of NPfIT. User requirements need to be very clearly identified at the start to prevent the initial scope either being extended or having new components added. Such 'scope creep' is likely to result in cost and time overruns and can result in project failure in the worst cases. The fact that the estimated cost for NPfIT has risen to £12.6 billion over the lifetime of the contracts (NAO 2006) from the initial 2002 estimate of £6.2 billion is due partly to the addition to the original scope of the Quality Management Analysis System, NHSmail, PACS, bowel cancer screening and Payment by Results. Clearly identified user requirements will allow appropriate criteria to be determined that will be used to evaluate the technical, financial, efficacy and user-satisfaction aspects throughout the project. It will be impossible to determine the success of a new system without having such evaluation criteria. The NAO had difficulty assessing the value for money of NPfIT (NAO 2006), which might be because of inadequate or inappropriate financial evaluation criteria being set initially.

ICTs are likely to fail if their design is not based on how people work together. Healthcare professionals know how specific problems in their area of expertise are addressed, what the structure of the overall patient pathway is and how test results are used and communicated throughout the healthcare system. The NAO noted that Connecting for Health concluded the bulk of its procurement before focusing on communicating with and engaging NHS staff (NAO 2006). We hope that adequate user-engagement was undertaken before procurement to take into account how the main users of the future systems work together. Experts in ICTs traditionally come from a different domain and have different skills. It is essential that those involved in developing new ICTs work closely with users (health professionals, patients and carers) and interdisciplinary working should be encouraged.

It is often difficult for users to imagine how future systems will operate. It is much easier for users to respond to systems they see and work with. Therefore emerging ICTs should be designed with a willingness to experiment: try something, see if it works, keep successful aspects and abandon unsuccessful ones, then start again. The experimentation is both with technology and with how people function together. For example, both mobile 'phone features and the way people communicate have evolved in response to each other. It should also be recognised that different users have different needs, which can sometimes be best served by diverse systems working together rather than by a uniform solution.

Evolutionary development needs pioneers at the grass-roots level, immersed in both the needs of health users and skilled with technology. Provision should be made to enable locally developed visionary ICTs to be introduced gradually into the healthcare system. For example, the critical care information management system at the Queen Elizabeth Hospital in Kings Lynn was developed using a prototyping approach to each element. The hospital claims its critical care has improved since introducing the system while keeping its critical care costs among the lowest in the country (Queen Elizabeth Hospital 2005).

Seed money is essential for initial development work to fund small trials of experimental models, develop prototypes and new methodologies. This should be funded by the Research Councils. The results of this work need to feed into health service planning and can help to define user specifications more clearly. Industry and the Department of Trade and Industry need to be involved in the commercialisation of new healthcare ICTs. Funding will be available relating to all stages of the development process from the European Commission via the Framework Programmes for pan-European projects.

This local experimentation needs to be undertaken within centrally set standards to ensure interoperability. A key role for the national IT programmes is ensuring that all stages of the development are undertaken within standards to ensure interoperability.

It is essential that all healthcare professionals and their professional bodies are involved in the design specification, implementation and evaluation of healthcare ICTs, and that healthcare managers ensure that they have sufficient time to do so.

### 4.3 Implementation

The introduction of ICTs can change professional roles and relationships, which is addressed in greater detail in chapter 5, but importantly it can also affect the organisation of clinical work, often in unpredicted ways (May et al. 2001). In this section we highlight factors that determine whether the implementation of ICTs is successful or not. Evaluation and feedback are also key parts of managing the introduction of ICTs, which are discussed in detail in chapter 6.

New ICTs can improve patient care or enhance professional roles by transforming clinical practice, mitigating the shortage of health professionals or enhancing job satisfaction. However, healthcare professionals are more likely to resist the introduction of ICTs if they believe that it inhibits their 'clinical judgement' and adversely affect the professional–patient relationship.

The NHS has been slow to exploit existing ICTs and there is a gap between what is available and what is widely used outside healthcare. For example, nurses' access to computers and the internet at work is still limited (Royal College of Nursing 2005).

### 4.3.1 Clear goals in introducing new ICTs in healthcare

ICTs are more likely to be embraced and successfully implemented if they are introduced because of clinical pull rather than technology push. It is also essential to have clear goals and purpose when introducing new ICTs to increase buy-in from potential users (health professionals, managers, patients and carers). These goals should encompass high-level organisational aspirations as well as local clinical needs or goals. They should also be transparent to both the wider organisation and the local users. Examples of these are given below.

*Exclusively high-level goals:*

- Provide seamless service.
    - Break down boundaries between institutions and providers (especially for chronic conditions).
    - Integrate NHS, private and foreign providers.
    - Give more autonomy to individual groups.
    - Link community care and hospital provision and local authorities and law enforcement (especially in mental health and child protection).
- Ensure interoperability of services, devices, data streams and external information sources.
- Provide better communication between healthcare professional and patient.

*High-level and local goals:*

- Help patients to manage their health and healthcare.
    - Provide better information services.
    - Support self-care, eg linked in with sensors at home.
    - Giving patients more options about how, when and where they receive treatment.
- Ensure patient data available to professionals is complete, consistent, relevant, up-to-date and accessible quickly in emergencies. This would also support consistent evidence-based medicine and permit tailored services.
- Provide a better evidence base for providers to make decisions.
    - Collect massive datasets on public health.
    - Provide relevant data to allow more informed budget decisions (outcome-based funding, more efficient planning).
    - Monitor status of NHS provision.

### 4.3.2 Learning, training and support needs

The introduction of new ICTs requires healthcare professionals to be equipped with the necessary understanding of the concepts behind the systems as well as the skills to use specific new technologies. In addition, new systems will require support once they are introduced. This education, training and support must be taken into account when determining the full costs of introducing new ICTs.

The basic training and continuing professional development for healthcare professionals needs to integrate the use of ICTs into everyday professional practice. This goes beyond basic IT skills such as being able to use word processor and spreadsheet software packages to include the ability to operate effectively in an information society, or what is sometimes called 'information literacy' (Bruce 1997). Training in ICTs needs to be practical and able to be incorporated into mainstream activities. Such training also needs to be flexible so that it can be tailored to the particular needs of different health professionals. This is an area where the health informatics community could assist in curricula development and competency frameworks.

There has been a considerable amount of work on identifying the required training competencies and methods to assess these competencies, such as the Government IT professionalism programme (www.cio.gov.uk/itprofession/about/themes.asp). 'Hands on' training programmes are required as well as allowing time for professionals to become competent at using any new systems. Opportunities for regular use of ICTs are needed to ensure user competence. Additional learning materials, from written materials to other forms of self-help guidance, should be made available (Brebner et al. 2003).

There are several initiatives that have addressed some aspects of this problem. For example, experience has been gained by the PRIMIS and PRIMIS+ projects run by the University of Nottingham and NHS Connecting for Health (www.primis.nhs.uk/pages/default.asp). These provide training and assistance to Primary Care Trust and local Health Informatics Services staff in making the best use of their clinical computer systems and improving data quality and information management.

Another example is the NHS Information Authority, which identified eight health informatics learning themes for clinical staff that were endorsed by regulatory and professional bodies (NHS Information Authority

1999). Some of the functions of the NHS Information Authority were taken on by the NHS Health & Social Care Information Centre in 2005. The eight themes identified were as follows:

- communication: authoring and reading health records; clinical language; team working;
- knowledge management;
- data quality and management;
- confidentiality and security;
- secondary uses of clinical data and information;
- clinical and service audit;
- working clinical systems;
- telemedicine and telecare.

Between 1999 and 2005 the NHS Information Authority and since 2005 NHS Health and Social Care Information Centre have worked with the clinical community to integrate these themes into the clinical pre-registration curriculum and post-registration continuing professional development. Reports have been produced about moving informatics into mainstream for clinical education (NHS Health & Social Care Information Centre 2006a) and examples of good practice where these standards have been embedded into curricula (NHS Health & Social Care Information Centre 2006b).

However, we believe that the training and development for healthcare professionals needs to be broader than the training initiatives discussed above and should as a minimum also include the following:

- understanding how to find the most reliable sources of information from the ever-growing number of publicly available sources;
- guiding patients through publicly available information sources;
- incorporating use of ICTs into patient consultations;
- quick and accurate data entry at the point of care;
- understanding decision support processes;
- extracting data to support decisions and monitor the outcomes of practice;
- understanding the role of technology in the delivery and organisation of care;
- training other users, such as patients and carers, how to use ICTs.

It is essential that healthcare professionals are given training and support on how to use new specific ICTs when they are introduced. Ongoing access to technical support is essential so that difficulties can be addressed quickly: this is discussed in section 5.4.3. With the expected increase in patient-led care, patients and their carers will also need to be trained and have access to technical support.

It is also important that experts in ICTs working in the healthcare arena have a good understanding of the challenges facing the healthcare service, healthcare professionals, patients and carers. The growing community of health informatics professionals are well-placed to provide training and support to experts in ICTs moving into the health and healthcare areas.

#### *4.3.3 Incentives for use of ICTs*

Healthcare professionals are likely to increase utilisation voluntarily of ICTs if there is evidence that ICTs are effective tools. For example, using telecare technologies might help with management of chronic conditions and thereby assist in reaching management targets.

Targets set by central government have driven much activity in the health service in recent years. The activities of independent contractors to the health service, such as GPs, are influenced by financial incentives. In February 2003, a new GP contract was agreed between the profession's leaders and the government, which was later accepted after a national ballot of GPs. Primary care practitioners have proved extremely successful at meeting targets set within this new General Medical Service (nGMS) contract. These same mechanisms have the potential to be used to influence uptake and utilisation of new ICTs. If use of defined ICTs became an incentivised activity within the nGMS contract or an accepted 'target' for NHS Trusts, this would be likely to increase utilisation of such ICTs. ICTs are more likely to be adopted that deliver the means to support success in attaining targets, for example those set within the quality and outcomes framework as part of the nGMS Contract.

However, there is a danger that such targets increase the emphasis on data collection rather than effective care. This has been a concern in general practice and hospitals, and could merit further consideration and evaluation.

### 4.4 Clinical governance, confidentiality and data protection

Clinical governance is the system through which healthcare organisations are accountable for continuously improving the quality of their services and safeguarding high standards of care, by creating an environment in which clinical excellence will flourish. It aims to minimise risk and improve clinical effectiveness. ICTs used in healthcare contexts are subject to clinical governance regulation. The ICTs and the way they are used by health professionals should be the subject of scrutiny. Therefore healthcare delivered using ICTs should be subject to audit so that variations in the process and in access to healthcare as a result of using ICTs are minimised. ICTs also have the potential to promote clinical governance by providing access to good information about the quality of services, thereby promoting continuous quality improvement. ICTs should increase opportunities for patients to participate in their care, but how such information is accessed and used and by whom are key governance issues. Confidentiality and data protection are major concerns in relation to the more widespread use of ICTs, as health data are particularly sensitive. It is also important to ensure that good practice relating to ICTs is adopted appropriately.

As stated above, health data are sensitive. Rigorous mechanisms are needed for access control, particularly in the NHS where so many staff could have access. The mechanisms should take into account the role, team and organisation of those involved and their relationship with the patient.

Electronic clinical protocols or guidelines have the potential to be a major step in raising the quality of care. Paper guidelines can be ignored during the haste of an encounter. Electronic ones can pop up on-screen at the appropriate time and encourage best practice. Such protocols are based on current best practice, which must keep changing as knowledge increases. There must therefore be mechanisms for modifying the guidelines as experience dictates, which might be easier to achieve electronically.

### *4.4.1 Privacy and confidentiality*

Flexibility and ease of use must also be weighed against privacy concerns. The delivery of healthcare is always performed under significant time constraints, so any confidentiality guidelines for healthcare professionals must ensure that dealing with confidentiality issues does not take up so much time that they detract from the delivery of care.

Trust between healthcare professional and patient is a complex issue, as highlighted in the Society's public workshops on personalised medicine (Royal Society 2005b). Part of that trust is due to healthcare professionals keeping patients' sensitive data confidential. However, concerns about privacy of personal data need to be weighed against personal and wider public health benefits of sharing data. The NHS Information Authority investigated peoples' views on consent and confidentiality of patient information (NHS Information Authority 2002). Further investigation is needed into the degree that patients would be willing for their personal data to be shared for wider, societal benefits. It is beneficial to the public and the health service to be able to use large datasets on public health; this is addressed in detail in the AMS report *Personal data for public good: using health information in medical research* (Academy of Medical Sciences 2006). The Society has highlighted the potential benefits of using patient's medical history in developing personalised medicines (Royal Society 2005a).

Questions about which parts of an EHR can be accessed by which professionals and when remain unresolved. Doctors and patients may each feel they own the data. For example, one might question whether data about the success rate of a surgeon is the property of the surgeon, or of the surgeon's patients.

The Society's public dialogue work on cybertrust and information security highlighted the importance of the specific context in which healthcare information is used (Royal Society 2004b). The use of ICTs to manage chronic conditions such as diabetes or asthma was generally supported. However, its application for general practice online diagnosis was criticised, with concern being expressed about a greater pressure being placed on patients to self-diagnose. There was also concern about the potential for disclosure of lifestyle information either through pressure from insurance companies or through criminal activity. On balance, people felt that the prospect of better healthcare outweighed potential problems of breaches in data collection and management.

The Royal Academy of Engineering is currently undertaking a study investigating the dilemmas of privacy and surveillance. This study is expected to make suggestions for changes to the regulatory environment and to suggest guidelines for operators, institutions, Government and individuals about how to deal with the future digital world.

### *4.4.2 Responsibilities, processes and liabilities for decision making*

The introduction of new technologies raises issues relating to responsibilities, processes and liabilities for decision making (Stanberry 2000). ICTs can lead to the distribution of responsibility for treatment across several healthcare professionals, creating uncertainties over proper clinical governance of the patient. The liability associated with treatment must make both clinical and legal sense. However, new computer-aided decision-support systems are often based on a single decision-maker because of the need to identify an individual who might be held responsible were treatment to go wrong. This assumption is not borne out by the realities of shared clinical oversight in wards or elsewhere. Both of these issues can work against uptake up of new technologies, as they may compromise trusting relationships among staff and between staff and patients. It is easy to put this down to professional resistance but these concerns are quite understandable. It should be noted that there is currently no case law on how ICTs in healthcare will change legal liabilities.

Some of the issues relating to responsibilities are highlighted below.

- 'Being with' the patient in a physical sense implies that the clinician is accepting of responsibility for the organisation and conduct of care. Distancing the clinician from the patient, for example in teleconsultations, will affect direct clinical care and may have associated risks. Issues associated with the physical co-location of patient and healthcare professional are discussed further in section 5.3.4.

- In the event of a patient being harmed, it may be difficult to establish whether this was due to a misdiagnosis by a healthcare professional or to a technical failing of the system. The issue of who is liable might be raised in such circumstances. This situation is not significantly different to the use of any other technology by a healthcare professional. However, the use of ICTs in healthcare does give rise to the possibility of 'cascade failure', where one component of a system built of interdependent elements causes the whole system to fail.

- Failure to adopt ICTs might be seen as negligent. Where the most effective and appropriate means of delivering a quality service to patients is the use of ICTs, for example where electronic medical records may decrease prescribing errors, then failure to adopt such measures may be held as negligent. Consequently, it may become harder to defend non-utilisation if ICTs become more ubiquitous in healthcare.

- ICTs should be able to provide an audit trail for the actions undertaken by healthcare professionals. It should be noted that any legal action would require very robust evidence that will stand up in court.

Healthcare is increasingly being delivered by multidisciplinary teams of professionals, so that it is not always clear whether a specific individual is responsible or liable. ICTs will facilitate multidisciplinary team working, which may accentuate this problem. For example the responsibilities in teleconsultations are not entirely clear. This is particularly important for consultations where a patient, healthcare professional and a remote specialist health provider interact. Who is responsible if something is missed? Is it the specialist or the healthcare provider co-located with the patient? There is also a danger of misinterpretation of data recorded by other professionals who may have a different understanding of their significance (Stanberry 2001).

Healthcare professionals must be aware of the limitations of ICTs and need to produce protocols to guide the safe and effective use of ICTs in collaboration with healthcare managers. For example, guidelines on the use of telecare for chronic disease management will need to be developed.

## 4.5 Reshaping health through data

### *4.5.1 Reshaping the provision of healthcare by sharing data*

ICTs and in particular the EHR can help the various healthcare professionals with whom a patient interacts to share better their expertise and conclusions. Such seamless care is especially important in the treatment of chronic conditions and in the care of the elderly. ICTs can also help with management structures such as billing and resource management.

Standards for recording health information that allow sufficient flexibility to take into account local variations and differences between medical areas and professions need to be established. The EHR will be the main vehicle for healthcare professionals to share healthcare-related information. However, the exchange of healthcare-related information will not be limited to the UK, so standards and common interfaces need to be developed internationally as well as nationally. It is also essential to ensure interoperability between different systems.

The technical mechanisms for sharing information are reasonably well understood. For example in 1990 the European Standardisation Committee (CEN) established a Technical Committee for medical informatics (TC251), known as CEN/TC 251. International standardisation work on healthcare data structure has also been undertaken by ISO and HL7. Work has also been undertaken by IHE (www.ihe.net) and DICOM (http://medical.nema.org). However, it should be noted that standards have not yet been agreed. The importance of standards in ensuring interoperability was discussed in section 3.5.1.

There is not yet broad consensus on the core data that the EHR must contain, and it is challenging to find the right structure for it (see section 4.5.3). Standards for these core data should be settled as soon as possible, to enable patient records to be shared between the different institutions and professionals involved in a patient's journey. These standards should, wherever possible, have international industry-wide support.

There are practical considerations about capturing the context of entries in the EHR, such as whether any data are from unreliable sources or those that have been translated from another language are appropriately marked. The further one is from the point of data collection, the easier it is to misunderstand its significance. If the EHR gives insufficient context, professionals may waste time re-acquiring and re-analysing data.

It is not yet clear where the EHR data will be stored. It is likely that the EHR will be a virtual record. However, data could be stored in some combination of the following places: where it is generated, kept by the patient, in a central store or by an outsourced service provider.

Essentially, the key need is to get the right information to the right people at the right time. This is an area where it would be beneficial to bring together informatics experts, healthcare professionals, software and hardware developers and patient groups to look at the problem. It is also an area where healthcare will be able to learn from other areas.

### *4.5.2 Using data to reshape health practice*

There are considerable public health benefits to sharing data contained in a nationwide EHR system, as discussed in section 4.4. A fundamental goal is to use these data to give a better evidence-base for making decisions on health practice. Data quality and privacy are the two main challenges in making effective use of personal health records. There are three audiences for these data: health researchers and health professionals, Government policy makers and managers of health-related institutions.

Health researchers can mine health records to learn about areas such as drug interactions, unexpected side-effects of treatment or to determine the efficacy of particular treatments and preventative measures. The results of this sort of analysis could allow more thorough evidence-based decision-making by healthcare professionals. It could also be a useful data source for planning clinical trials: population data cannot replace proper clinical trials, but they can be useful in detecting trends worthy of further study. Since medical understanding evolves continuously in the light of further data, this flow of information from EHRs to researchers to professionals must be an ongoing process.

Government policy makers could use data to understand trends in epidemiology, for example to track the threat of obesity or the requirements of an ageing population. Government agencies such as NICE could use the data to make informed decisions about which drugs to approve.

Managers of healthcare institutions could use the information to inform their priorities and to make better budgeting decisions. For example, the information could help identify and measure patient outcomes and also determine the most appropriate staffing levels and skills mix. Managers of insurance agencies could use the records to decide on premiums and coverage.

### *4.5.3 Capturing and recording useful data*

The EHR has to accommodate the complexities of health data and ensure that professionals from different disciplines can understand each other's input in the care of a single patient. It should also have enough structure to be useful for data mining. Above all, the users who will input the data need to be willing to do so. For example, the field of psychiatry is better suited to free text fields rather than tick boxes and 'Other' fields. In different clinical areas, professionals may find it burdensome to enter free text and would prefer more structured data entry. Experimentation is needed to develop systems that health professionals find comfortable and useful.

A particular challenge is capturing the context, provenance and authority of data. For example the data collected by a patient's own personal medical devices will be treated differently to data collected in an intensive care unit, and a patient's personal log will be treated differently to a consultant's diagnosis. A standardised terminology, such as SNOMED CT described in section 3.5.1, will help address this problem.

It is vital to design data-entry systems that users find meaningful and helpful. For example, a comparison of paper and electronic nursing records concluded that more research was needed to ensure that the computerised system delivered their expected benefits (Urquhart & Currell 2005). Users who enter data understand well their own systems and requirements but they need to keep data in a format that other users can use by keeping raw data separate from edited data and making backups. This is another area where there needs to be ongoing experimentation to evolve good solutions, both with ICTs and with the people that use them.

In response to the rapid changes the NHS has gone through in the past few years, the Department of Health produced good practice guidelines for general practice electronic health records in consultation with the British Medical Association and the Royal College of General Practitioners (Department of Health and Royal College of General Practitioners 2005). These guidelines addressed the areas of information governance, GP to GP electronic record transfer, electronic documents attached to the EHR, increasing inter-operability using electronic data exchange standards, and education and training. It is too early to say whether these guidelines have been sufficiently taken up and implemented.

# 5 Impact of ICTs on patients, carers and healthcare professionals


**Summary**

The exact nature of the impact of healthcare ICTs on patients, carers and healthcare professionals is hard to predict but may change existing trends as well as creating new ones. Patients, potential patients and carers are likely to be involved more directly in healthcare, which will have considerable impact on healthcare professionals. The benefits of remote care facilitated by healthcare ICTs need to be weighed against the advantages of physical co-location. Health-related information has been made more widely available than it was previously by ICTs and this has already led to professionals guiding patients to the most reliable sources of information: we expect this role will grow in the near future. Some people will not be able to (or want to) exploit available technologies to influence their own healthcare, so there needs to be sufficient flexibility in provision to allow alternatives for those who cannot (or do not wish to) engage.


## 5.1 Introduction

Previous chapters have discussed the specific technologies and most appropriate strategies for successful implementation. However, it is absolutely essential to consider the people who will be using the new technologies and how ICTs will affect them. This chapter looks at the potential impacts on health professionals, patients, carers and the patient–professional relationship. It concentrates on the likely effects on the roles and responsibilities of these individuals.

## 5.2 Impact on patients and service users

### *5.2.1 Patient expectations*

Anecdotal evidence (for example the views expressed in our evidence gathering workshop with representatives of patient groups) suggests that expectations for ICTs in healthcare range from unrealistic aspirations derived from futuristic TV fiction, to opposition to anything that deviates from traditional ways of healthcare delivery. Increased awareness, often derived from media presentations, of what is currently at an early stage of development may lead to inappropriate demand, or to the belief that any disease can be cured provided that the technology is made available. Patients' views on how NHS resources should be spent tend to prioritise direct patient care (more nurses, more doctors) or other forms of technology (eg a new scanner) above investment in infrastructure such as ICTs. Also, patients will compare their experiences as customers of commercial operations such as banks with their healthcare experiences.

### *5.2.2 Access to knowledge*

ICTs and in particular the development of the worldwide web makes available more widely information which was previously available only to the privileged few. There is a great deal of information, both about health and how to remain healthy, and about diseases, including detailed information about symptoms and possible treatments (Nettleton et al. 2004; Hardey 1999). The benefits of a population with increased knowledge about health and of increased understanding by patients of their disease are well recognised. For example the NHS 'expert patient' programme is already achieving benefits in enabling patients to manage their chronic illness. The challenge is to assure the quality of the information available and to ensure that the information that patients get is accurate and appropriate. Many websites are full of erroneous information or biased commercial information (Craigie et al. 2002). There will be an increased need for organisations such as the Swiss Health On the Net (www.hon.ch) which validate sources of web-based patient information and for the development of services such as the Electronic Library of Health (www.nelh.nhs.uk), NHS Direct On-Line (www.nhsdirect.nhs.uk) and the US National Institutes of Health cancer-related web pages (www.cancer.gov). Similarly, the *British Medical Journal* has a website (www.besttreatments.co.uk/btuk) that compiles clinical evidence from the latest research aimed at patients and doctors. Google have recently launched a health topic under Google Co-op (http://www.google.com/coop), which allows users to look at search results according to treatment, research papers, symptoms, news, or alternative medicine and sort them by medical establishment. The information is not validated: instead, it relies on a free-to-join community of users and professionals to categorise the results and organisations such as the Health on the Net Foundation and the National Library of Medicine. Users can also choose from whom they get their results.

The increasing amount of health-related information on the worldwide web has already led to a new role for the professional of guiding the patient to the most reliable sources of information: this new role is expected to grow in the near future. Part of this role will involve explaining or expanding on differences in terminology between countries, given the international nature of the available information. There is a vast amount of publicly available information, which makes it impossible to ensure the quality of it all. We welcome efforts, such as those mentioned above, to help patients and healthcare professionals by providing high-quality information, although we acknowledge that it would not be feasible to do the same for all web-based information sources on every health and healthcare-related topic.

## 5.3 Impact on professional–patient relationship

### *5.3.1 ICTs in the professional-patient consultation*

Some practitioners fear that ICTs will interfere with the professional–patient relationship and are already using this argument to resist the introduction of ICTs, especially in respect of documentation during the consultation. Professionals are reluctant to do anything that could damage the delicate balance of a consultation. A good bedside manner is often seen as the mark of a 'good' doctor or nurse. It is also known that the skill with which such encounters are handled can have a significant impact on the outcome of the care being given.

The insertion of a computer terminal into the clinician–patient encounter can be damaging. There is evidence that, in the early days of general practice computing, patients felt that the doctor was more interested in the computer than in them. The limited research of using computers during the consultation shows this need not be the case (Sullivan & Wyatt 2005a, b, c; Ridsdale & Hudd 1994). However, new skills have to be learnt to cope with this 'third party' in the consultation (Wyatt 2002). For example, the EHR has been described as a third party in examination room encounters between patients and physicians, which requires thoughtful consideration to forestall problems and maximise effectiveness (Ventres et al. 2006).

Experience shows that the successful use of ICTs in a healthcare consultation depends on the professional's communication skills. For example, the professional with good communication skills who routinely uses a lot of eye contact will find handling ICTs is no different from handling paper. However, this requires that the device is appropriate for the particular environment and that the professional is confident with its use, which requires training and experience. The device must be as familiar and easy to use as a mobile 'phone has become to most people. However, if the professional has poor communication skills (eg if when using paper he or she looks more at the paper than at the patient), ICTs may actively (albeit unconsciously) be used as a 'protective' barrier.

Communication may be altered by use of ICTs, with both sides perceiving barriers to communication that were not previously present. Clinicians may find that use of ICTs shapes their encounters with patients in different ways from usual. In particular, use of ICTs may demand reciprocal adjustments by both healthcare professional and patient about their expectations of the consultation and their behaviours within it. These adjustments may take several forms: for example the use of videoconferencing technologies may require more interaction by participants than in a face-to-face consultation (Mair et al. 1997).

There is a danger of deskilling professionals if all they have to do is to follow instructions on screen. This is also compounded by the tendency of everyone to believe what they see on a computer screen. Training is needed to ensure that skills are maintained.

Clinicians have to examine which current practices can continue to be used with new ICTs and where new practices will need to be developed.

### *5.3.2 The balance of power*

The most important way in which ICTs will change professional–patient relationships, however, is in the changed balance of power which the increase in the patient's information will bring. Greater access to information is already bringing a fundamental change in healthcare delivery, from a system driven by the provider to one driven by the consumer. With greater information available to the patient, much of the mystique of professional practice will disappear. Some professionals may see this as a threat. Others will use it as an opportunity. Some patients will welcome it, but, for others, the increased awareness of uncertainty may create greater vulnerability. Both patients and clinicians will need to develop new skills in managing patient–professional relationships.

To become useful, information requires interpretation. This creates the potential for a 'new' role for the nurse as a 'knowledge broker', helping patients access the information they need and to decide how to use it. Nursing and allied healthcare professionals aim to teach patients about their disease and to help them understand information about specialists, resources and alternative treatments (Royal College of Nursing 2003). To achieve this, nurses will continue to need highly developed listening, communication and teaching skills and a clear understanding of the values and ethical principles on which such choices will be based.

Research in the USA has shown that patients, although keen on gaining information from the worldwide web, prefer sources that have the endorsement of their clinicians. The electronic generation of patient advice leaflets can be used to tailor advice to the individual patient's unique circumstances, which research has shown to be more effective than generic pre-printed material (Tang & Newcomb 1998).

### *5.3.3 Improved confidence in decisions*

Healthcare decisions should be supported by evidence. This applies at a high level (such as NICE deciding which drugs to approve in England and Wales) and at a low level (such as a professional making decisions at each point in the course of a treatment). The availability of ICTs at the point of care also facilitates explanations to the patient. Seeing the professional draw upon relevant evidence during the course of a consultation may enhance the patient's confidence in the decisions being made.

ICTs have the potential to foster patient choice. This issue raises several questions such as what if a patient chooses a course that goes against the evidence, should the treatment still be provided without cost by the NHS and if further expensive (remedial) treatment is necessary as a consequence, should that be free. For example, in the public workshops held by the Society on personalised medicines, views were split over the extent to which financial support should be given to provide research into groups with relatively rare, unresponsive genetic types (Royal Society 2005b).

#### *5.3.4 Physical co-location*

Patients greatly value the physical presence of healthcare professionals, both for consultation and, even more importantly, when they need direct care. Patients describe 'being there' as an important therapy and their view is well supported by research. Participants in the evidence-gathering workshop with representatives of patients' groups made the point very strongly that personal contact with healthcare professionals is very important to them. They feared ICTs might diminish opportunities for such contact to occur.

There are many potential benefits to patients of using technologies like videoconferencing and telecare, for remote consultations and monitoring, such as giving access to a wider range of expertise and reducing travelling or waiting times. As mentioned in section 3.3.2, technological developments will make videoconferencing vastly superior compared with what it is today. Research has shown the benefits of telephone consultations in a variety of situations, such as with patients requesting same-day appointments (Wallace 2002; Wallace et al. 2002a, b, 2004). The implications of telemedicine on the professional-patient relationship have also been studied (Wyatt 2002).

However, there will understandably be resistance to breaking this tradition of physical co-location from both professional and patient, with concern over impersonality or lack of spontaneity. For new ICTs the benefits of remote care need to be weighed against the advantages of physical co-location.

This means that the complete substitution of 'virtual' or 'remote' healthcare services for the physical and social interaction with a human healthcare provider is not suitable for all situations. However, telemedicine can be used as one component in long-term care or chronic disease management because of its ability to increase greatly the quantity and quality of data gathered on changes to an individual's health status. These data can be used to improve the targeting of therapies and provide more timely intervention.

### 5.4 Impact on professional roles and responsibilities

#### *5.4.1 Communication overload*

The volume of health information is increasing dramatically. No healthcare professional can be expected to know all the relevant information. ICTs may help healthcare professionals to receive the appropriate information in a digestible manner at the appropriate time.

It is possible that the huge number of protocols, guidelines, research findings and knowledge sources, which are often duplicative and sometimes conflicting, and which are already developed and being strongly promoted in the name of 'evidence-based practice', will simply 'turn off' the professionals who should be using them. This could be avoided by ensuring that health information is 'quality assured' to present it in a form that health professionals (and other people) will experience as easy to use. For example, the Nursing Knowledge Toolbox that is currently being developed by NHS Connecting for Health and the Royal College of Nursing hopes to include guidelines, digests and assessment tools.

#### *5.4.2 Changing professional boundaries*

The greater availability of medical information and best practice could allow fewer skilled staff to handle more patients. The development of practice nurses, nurse practitioners and ancillary staff has already shown that such a shift can be achieved, as mentioned in section 2.3. For example, ICTs could allow the physiological measurements to be acquired easily, as described in section 3.3.2. However, it is important to note that only a suitably trained healthcare professional will be able to make the judgement required to interpret and make decisions based on the findings, although ICTs can certainly assist in this as well.

Standardised algorithms and protocols might enable less skilled professionals (and the patients themselves) safely and effectively to diagnose, treat and monitor many clinical conditions, including some which are less common. Healthcare professionals could be increasingly trained to select and apply standardised algorithms and protocols, rather than relying on 'clinical judgement' (Hunt et al. 1998). However, it should be noted that the introduction of standardised algorithms and protocols will not always have this effect. For example, staff involved with NHS Direct and NHS24 in Scotland, which are both algorithm-based telephone systems, have reported the need for high levels of clinical judgement.

### *5.4.3 Scientific and technical support needs*

Health professionals (especially in hospital environments) need and demand that systems work reliably all the time. Therefore technical support must be immediately available, otherwise frustration will lead to rejection. The importance of technical support was highlighted in section 4.3.2.

Devices must be available at the point of care, both in time and place. A desktop PC in an office is no use to a district nurse working in a rural area. There is huge scope for the better use of mobile 'phones. This is a good illustration of where considerable benefits could be gained from better utilisation of existing technology.

More development is needed (and will certainly come) in hardware for mobile communications. The NHS is already suffering from problems resulting from inadequate bandwidth and is far behind in the availability of wireless technology. However, as noted above, there are considerable short-term gains to be had by better use of the existing technologies, even before starting to look to new and future developments. One example is the wireless local area network-based 'hands-free' voice-activated call system mentioned in section 3.3.4 (BT 2006).

## 5.5 Impact on carers

As part of the changes in healthcare described in chapter 2, informal carers (such as family members) are taking on increasing responsibility for the delivery of care of all kinds. Devices that help with the care of frail elderly people in their own homes, such as those described in sections 3.3.2 and 3.6, can relieve anxiety and lessen the burden of care (Magnusson et al. 2004). However, it would be wrong to assume that this will be universally welcomed. Carers at our evidence-gathering workshop expressed concerns about the practicalities and the aesthetics of technology in the home, such as security, maintenance, cleaning, insurance and appearance.

Some of the issues facing health professionals will also face carers. For example, carers might need training to use equipment in their homes. In such cases, carers will need appropriate training and support to operate monitoring and assistive technologies and administer treatment at home. For example, ICTs that raise an alarm will need to have clearly assigned responsibilities among patients, carers and healthcare professionals for taking action.

ICTs have the potential to help carers with several of the challenges that they face. ICTs that are capable of providing respite for carers would be extremely welcome. ICTs could help carers when they are acting as patients' advocates, such as dealing with social services, which would also be welcomed. For example, the universities of Sheffield and Ulster ran a project to assist carers looking after older people using ICTs in their homes, which used multimedia caring programmes, videophone, internet services and call centres. Another example is the role that telecare can play in helping to manage the risks of caring for people outside the controlled environment of the hospital or other care institutions (Barlow et al 2003). However, it is noted that the benefits of telecare have not yet been fully realised for vulnerable people and for the wider care system.

## 5.6 Ensuring equity of access

There will remain a substantial proportion of the population who either have no desire and/or no ability to empower themselves, through the support of ICTs, to control or even to influence their own healthcare circumstances. Some groups of people will be less able than others to access or to exploit available information technologies: elderly people; poor and socially deprived people; people who cannot read; non-English speakers; the 'IT illiterate' (ie those without basic IT skills); and people with sensory deficits.

There have been several studies looking at access to ICTs and the internet. EverybodyOnline is a project designed to help communities and individuals in disadvantaged areas across the UK engage with digital technology, which is run by the national charity Citizens Online and is supported by British Telecom (BT). It aims to help communities overcome any barriers they may have to technology so residents can take advantage of the opportunities digital technology and the Internet has to offer (EverybodyOnline 2005). BT conducted an independent study aiming to forecast the digital divide in 2025 (BT 2004). This study defined 'digital exclusion' as not having access to the internet at home. Based on this definition, it estimated that 51% of the adult UK population is currently digitally disengaged. By 2025 it is predicted that 40% of 30- to 59-year-olds will be digitally excluded and that 65% of the population over 60 years will be at risk of exclusion. Healthcare ICTs will need sufficient flexibility to allow for the provision of alternatives for those who cannot (or do not wish to) engage.

### *5.6.1 Elderly people*

Research has shown that many elderly people 'take to' IT as readily as younger age groups. The EverybodyOnline study concluded that poverty and perceiving a need to use ICTs were considerably greater factors than age in determining usage of ICTs. However, many elderly people do not use IT, as shown by a survey undertaken for the Welsh Consumer Council, which showed that only 14%

of over 65-year-olds in Wales use the internet (Welsh Consumer Council 2006). Access is likely to improve as technological development shifts usage from personal computers to mobile 'phones, but barriers associated with learning the skills (eg short-term memory loss associated with dementia) and with manipulating 'buttons' (eg for those with hand tremor) will remain for some time.

Work has also been undertaken looking at developments in telecare for the elderly (Chumbler et al. 2004; Doughty et al. 1996). Existing systems enable patients to summon help in the event of illness. However, in the future, services are more likely to make use of evolving technologies to provide automatic sensing of emergencies and to predict long-term deterioration in health using activity profiles.

### *5.6.2 Poor and socially deprived people*

Some of the technologies described in chapter 3 are based on individuals owning or being able to access specific ICTs, such as the mobile 'phone blood-sugar monitoring system about which we received evidence from Professor Lionel Tarassenko from the University of Oxford. This written evidence strongly argued it was better to develop a mobile 'phone rather than a web-based system, as mobile 'phone ownership was much more widespread across all social groups than internet access.

### *5.6.3 People who cannot read and non-English speakers*

People who cannot read will be similarly excluded. Organisations such as the National Literacy Trust (www.literacytrust.org.uk) and the Skills for Life Unit within the Department for Education and Skills have done considerable work in this area and should be involved to minimise inequity of access for those with reading difficulties.

Most health and healthcare information is currently provided only in English. NHS Direct (www.nhsdirect.nhs.uk) has only its most popular topics available in 12 other languages. Some ethnic minority groups are providing information in their native languages. For example in a recent report on health literacy the National Consumer Council recommended that the electronic medical record should have the facility to be translated into different languages (National Consumer Council 2004a). In Wales, the Welsh Assembly Government and many Welsh organisations have made efforts to provide Welsh translation.

### *5.6.4 The 'IT illiterate' (ie those without basic IT skills)*

This group will decline as children acquire basic IT skills as part of their general education, but this will take time and a core of people is always likely to remain. Organisations (such as Digital Unite, formerly know as Hairnet UK:, www.hairnet.org) work with people who have not previously had the opportunity to learn about computers and the internet.

### *5.6.5 People with sensory deficits*

Special provision will be required for those with visual and hearing impairments. Organisations such as RNIB stress the importance of good design in making websites, information, products, services and buildings accessible to the two million people in the UK with sight problems (RNIB 2006). Accessibility does not only affect people with disabilities, so an inclusive approach has benefits and rewards for everyone.

# 6 Evaluation of ICTs in health and healthcare

**Summary**

Evaluation must be built into the development process of ICTs from the very earliest stages. Evaluations must include the opportunity costs of introducing any new system as well as the associated training, maintenance, support, refinement and likely effects on working practices. However, current methodologies are not able effectively to evaluate the social and economic costs of introducing new healthcare ICTs. New ways of assessing barriers to implementation and methods to promote use of new ICTs are also needed. Developments in methods to assess the costs of not introducing ICTs are also required.

## 6.1 Introduction

In publicly provided healthcare systems, when limited resources are coupled with unlimited demand, decisions have to be made about the efficient allocation of scarce resources. This raises questions concerning the costs and benefits – both social and economic – of competing healthcare interventions. If extra resources are being devoted to processes and systems using ICTs, how do they compare with the costs and benefits of alternatives and what methodologies best capture the intended and unintended effects of using ICTs? Put succinctly, is spending on ICTs a good use of limited healthcare resources?

## 6.2 The need for evaluation

Although the possible benefits that ICTs present to healthcare systems, professionals, carers and patients are considerable, the evidence base to support the use of many ICTs is rather scant (Garg et al. 2005; Murray et al. 2005; Delpierre et al. 2004; Currell et al. 2003; Whitten et al. 2002; Mitchell et al. 2001; Mair et al. 2000). It is therefore essential that both qualitative and quantitative evaluation is a key post-implementation feature. This evaluation must look at the processes and systems that the new technology is supporting. As discussed in previous chapters, the users are central in any new system so healthcare ICTs must not be considered as 'black boxes' that 'do' things to people. Interdisciplinary research will also be necessary to increase our understanding of the range of benefits or disadvantages likely to result from the use of different systems in different contexts. Only through rigorous and thorough investigation will we learn how to enhance healthcare ICTs and to determine which specific systems actually help to improve healthcare processes and outcomes. It is necessary to plan for long-term evaluations to ensure a full understanding of the costs (anticipated and unintended) and benefits of different healthcare ICTs. It is possible that costs may dominate in the short term whereas benefits may be more likely to become visible in the medium- to longer term.

When evaluating the benefits of ICTs in health and healthcare, it is important to evaluate the positive and negative effects that can arise for patients, professionals and carers. These will include changes in health outcomes, non-health outcomes (eg provision of information and reassurance) and process-type factors (eg reduction in waiting time, reduced travel time and location of treatment).

When estimating costs, consideration must be given to the costs falling on both patients and the NHS, the spread of capital costs over time and the potential cost savings. For example, home-based monitoring of patients may generate higher demand for clinical intervention (rather than the opposite, desired effect) because some patients who are unfamiliar with or less trusting of new technologies may seek medical attention for reassurance. So although ICTs may seem to cuts costs, they may generate unanticipated costs and create new demand. Further work is required to look at the cost implications of ICTs.

Evaluation also needs to explore the sociological aspects of deploying ICTs in healthcare systems as well as the economic analysis discussed below. Previous work (eg Berg and Goorman 1999) has demonstrated that deployment is often confounded because information is typically 'entangled' with its context of production (how, where, why and for what purpose it was produced). There is pressure to standardise information for multiple users and so reduce contextuality, but it is important to know what sort of information can be standardised and what information needs to carry more 'context', such as telemedicine. Consequently, interdisciplinary research involving both social scientists and health economists is needed to address this problem.

The use of ICTs by healthcare professionals raises social, cultural, organisational and contextual concerns (Kaplan 2001; May et al. 2001; Berg 2001). The introduction of new healthcare ICTs often requires an unacknowledged investment in 'workability' by health professionals that has received minimal attention. In particular, there is evidence that the use of telecommunication technologies can threaten deeply the embedded professional beliefs around the nature and practice of their relationships with patients (see section 5.3) and other healthcare professionals (see section 5.4) (May et al. 2001).

More information is required about the efficacy of different ICTs. There has been little research that gives evidence of improved outcomes as a result of using healthcare ICTs. Several systems have been evaluated, including telemedicine (Hibbert et al. 2004; Whitten et al. 2002; Wallace et al. 2002a; Mair et al. 2000; May et al. 1999), e-health systems (Gustafson & Wyatt 2004), health informatics services (Rigby et al. 2001) and clinical information standards (Gardener 2003). Given the growing importance placed on evidence-based medicine, it is crucial to have evidence to demonstrate the efficacy (or not) of different ICTs in different contexts.

### 6.3 Identifying, measuring and valuing benefits of ICTs

As discussed in chapter 2, one of the guiding principles of the Government's 10-year plan for the NHS is that '*The NHS will shape its services around the needs and preferences of individual patients, their families and their carers*' (Department of Health 2002). This raises the question of what patients want from their health service and whether ICTs can help in the delivery of such a service.

ICTs have the potential to improve health outcomes. For example, quicker data-handling and more accessible healthcare data may result in faster health decisions and action, potentially saving lives and improving quality of life. Non-health outcomes are also likely to be influenced. For example, the amount of information that will be available to patients and healthcare professionals may have positive and negative effects, as discussed in sections 5.2.2 and 5.3.2. Process factors merit monitoring as these also have the potential to be improved. Telemedicine is likely to reduce waiting times and travelling times as mentioned in 5.3.4. As discussed in chapters 2 and 4, ICTs could help to facilitate the move towards treating patients in the community rather than in hospital. It is therefore essential that funders invest in evaluations that take account of standard outcome measures ranging from re-admission rates to quality of life.

Bend (2004) reports a review of 43 evaluations of new products or services developed to meet the information needs of citizens and the NHS. Consideration was given to value for money, satisfaction with NHS services, improvements in health outcomes and increased levels of trust. There was evidence that EPRs and interactive television improved 'satisfaction' outcomes. However, improvements in health outcomes were limited and concerns were expressed about trust. Bend (2004) notes the limitations of many of these evaluations and highlights the need for improved evaluations.

Patients' perspectives may also prove more complex than indicated by patient satisfaction surveys (Mair et al. 2006; Mair & Whitten 2000), which have been widely criticised in the economics literature (Huntley & Ryan 2003). Current evaluations are clearly limited and more research exploring public perspectives of the limitations of ICTs in healthcare is therefore merited.

In terms of economic evaluations, three health economic techniques can be used: quality adjusted life years (QALYs), contingent valuation and discrete choice experiments (DCEs). These are described further in appendix two. However, it should be noted that their application in the area of ICTs is limited and further research is required in this area.

Technology appraisals undertaken by the National Institute for Health and Clinical Excellence (NICE) make recommendations on the use of new and existing medicines and treatments within the NHS in England and Wales. NICE commissions Health Technology Assessments (HTAs), which evaluate a technology through the systematic review of scientific evidence. HTAs have focused on the clinical benefits of technologies, using clinical measures of outcome and QALYs as markers of benefit. Although ICTs may lead to improvements in health outcomes, as seen above, many of the benefits derived from ICTs may not improve health outcomes, but improve non-health outcomes and process factors. The QALY approach is likely to be inappropriate for valuing such benefits from ICTs (Ryan 2004) and more appropriate techniques are contingent valuation and DCEs. Over the past 15 years, these techniques have been developed in health economics to value all aspects of healthcare (Ryan et al. 2003).

Contingent valuation and discrete choice experiments have had very limited applications when evaluating ICTs to date. Ryan et al. (1998) used DCE to evaluate the introduction of a patient health card (PHC) in general practice. The DCE looked at the importance of the PHC compared with three other aspects of general practice: (i) number of days between making a non-urgent appointment and seeing a doctor; (ii) waiting time in reception area; and (iii) seeing a doctor of your choice. Although the patient health card was of value, it was the least important. This study highlighted the need to evaluate any new healthcare technology against existing systems including an assessment of whether it meets users' needs and perceptions. Practical problems with implementation of healthcare ICTs can then be more effectively identified and solved in the specific operational context in which they will be used. In addition, studies are needed to confirm (or not) initial cost/benefit assessments after the introduction of new healthcare ICTs.

## 6.4 Identifying, measuring and valuing costs of ICTs

Wanless (2002) suggested that the Government's aim to reduce costs in the NHS by 1% per year might be partly achieved through increasing the use of ICTs. This section considers the economic concept of cost, likely cost implications resulting from ICTs and current evidence.

The economic concept of 'opportunity cost' assumes that resources are scarce and that every time resources are used in one way, the 'opportunity' of using them in other beneficial activities is given up. The opportunity cost of any technology is therefore defined as the benefit forgone from *not* using that resource in its best alternative use. Only if a resource has a next best use does it have an opportunity cost.

### *6.4.1 Staffing costs*

Staffing costs often comprise the largest component of healthcare resources. Time invested by managers, administrators, medical professionals, health workers and clerical staff in the planning, implementation and use of the ICTs must be accounted for. In addition there will be staff costs associated with running and maintaining the healthcare ICTs. Training costs are also likely to be incurred.

However, once up and running, staff cost may be reduced by ICTs. For example, computerised systems could help staff dealing with patient registration and medical records to cope with increases in patient numbers without employing extra staff. Similarly, monitoring of chronic conditions using mobile 'phones and home monitoring systems could reduce the number of visits patients make to their GPs or specialists, and assistive robots could perform routine tasks so enabling qualified staff to spend their time more effectively.

### *6.4.2 Capital items*

Capital items are clearly important in the area of ICTs. Costs will include the hardware, system and applications software and network/telecommunications infrastructure, as well as any capital or equipment costs of maintenance.

Despite an initial outlay, the opportunity costs of capital should be spread over time. This is accounted for by spreading the opportunity cost of capital assets over the number of years of life judged to be relevant. Depending on the perspective of the study, costs to patients, their families and their friends may also be included in an evaluation. These costs may be both in terms of time and money. For example, time and money costs may be saved in using telemedicine rather than travelling to a central location.

In his review, Bend (2004) addressed the issue of costs savings. Of the projects examined, cost-savings were suggested for both the EHR pilots and the National electronic Library for Health. Cost savings for the EHRs were argued to include avoiding replication of tests, examinations and appointments. However, it is worth noting that these cost savings were based on the opinion of those involved in the projects and not on an evaluation. It was argued that savings would be made through national licenses for resources such as the Cochrane database (www.cochrane.org) for the National electronic Library for Health. Further annual cost savings were estimated to be between £3.2 million and £12.2 million based on a survey of time saved using the Library, depending on assumptions made about take-up.

### *6.4.3 Social costs*

It is sometimes assumed that healthcare ICTs will enable a more preventative approach to healthcare, but this begs the question as to whether the healthcare system will be able to respond to the likely huge and time-sensitive growth in demand for monitoring. Patients may well expect higher and more frequent IT-based exchange (for example via web-based services) than the economic threshold for these predicts or allows. This could result in either increasing costs to healthcare suppliers or creating new forms of resentment among frustrated patients, or both.

## 6.5 Long-term issues

When policy-makers choose to support and deploy certain healthcare ICTs rather than others, these choices will have a major impact over the longer term in creating a technological 'path dependency' that closes off other options over time. This means that once Connecting for Health is stabilised as a working system and standards are in place, it will not be easy to switch from one configuration to another. This is why it is important to explore the policy options early on through comparative analysis of other models being developed elsewhere.

The current use and implementation of healthcare ICTs should be monitored to inform the future use and choice of ICTs. This will require evaluation to be an integral part of the implementation of all systems. For example, there may be lessons to be learnt from both the successful and unsuccessful elements of the different approaches adopted in England, Northern Ireland, Scotland and Wales. There might also be lessons to be learnt from overseas developments, such as the introduction of electronic health records by Kaiser Permanente in Hawaii (Scott et al. 2005; Teasdale 2005).

It is likely that evaluations involving interdisciplinary teams will be particularly useful and should therefore be encouraged. Such teams should include researchers from diverse backgrounds, including healthcare professionals, computer scientists, engineers, health informatics specialists, sociologists, anthropologists, economists, psychologists and those from business and management backgrounds.

# 7 Conclusions and recommendations

## 7.1 Realising the potential of healthcare ICTs

Healthcare ICTs are an important tool to deliver better healthcare by either enhancing existing processes or generating new capabilities. The technologies described in this report have the potential to transform healthcare delivery in many ways and address future health challenges, such as allowing individuals with chronic conditions to monitor and in some cases manage them more effectively. It is essential that these technologies are integrated into the healthcare delivery systems and are part of the delivery of better patient care. Consequently funding of properly designed and implemented healthcare ICTs will be directly helping to improve patient care. Realising these benefits requires a culture where everyone involved in healthcare recognises the potential value of healthcare ICTs in delivering better healthcare. Raising awareness of the potential benefits of healthcare ICTs is one element of the required training and continual professional development; recommendations relating to these are made in recommendation R8.

**R1: We recommend that all stakeholders consider how ICTs might be able to assist in delivering better healthcare. For example, the potential contribution of healthcare ICTs should be considered by Government health Departments while formulating policy and by healthcare professionals and managers in determining how best to meet performance targets.**

## 7.2 New and existing technologies

Advances in science and engineering have resulted in, and will continue to result in, many ICTs being used beneficially by patients, carers and healthcare professionals. New and existing technologies will be utilised at individual, local and national levels to address predicted challenges, such as the ageing population, the emergence of new diseases and the increase in people suffering from chronic diseases.

The NHS has been slow to exploit existing ICTs and there is a gap between what is available and what is widely used in healthcare. Using existing technologies more widely as part of regular health and healthcare practices has the potential to bring considerable benefits to health. Healthcare professionals are well placed to identify potential healthcare ICTs because of their understanding of healthcare delivery systems.

**R2: We recommend that both existing technologies and developments in new technologies are continuously monitored so that those with net benefits to health and healthcare can be assessed and then effectively deployed.**

**a At a local level we recommend that this is undertaken by the Chief Executives of local healthcare trusts as well as by healthcare professionals.**

**b At a national level we recommend that the Government health Departments undertake this, assisted and advised by the newly established NHS National Innovation Centre as well as the Purchasing and Supply Agency (PASA), Medicines and Healthcare products Regulatory Agency (MHRA) and National Institute for Health and Clinical Excellence (NICE).**

**c We recommend that Government health Departments recognise the value of independent contributions from learned and professional societies (such as British Computer Society and Institution of Engineering and Technology) and the medical Royal Colleges in identifying new and existing technologies that might benefit healthcare.**

## 7.3 Design, implementation and evaluation

There are many factors that make healthcare a very challenging environment for any new technology, such as the urgency of many healthcare needs, the intolerance to system failure, needing to interface with vulnerable people when most at risk, unrealistic expectations, serious cost constraints, the enormous scale and complexity of the NHS organisation and the poor record to date in large-scale public sector IT projects. Consequently we advocate an incremental and iterative approach to the design, implementation and evaluation of new ICTs where healthcare professionals and all other users are involved at all stages.

Clearly identified objectives of what is required by the user must be determined at the start of the design process to prevent the initial scope being added to or being expanded. Existing technologies designed for non-healthcare solutions will not necessarily meet the healthcare-related objectives. ICTs should be able to cope with structural and social change and be usable by people of varying needs and abilities as well as different backgrounds.

Experimentation is essential to the development of new ICTs: successful and unsuccessful parts of systems need to be identified, adapted (or dropped) if necessary and then refined in an iterative process. Small trials will help define user specifications for larger systems and allow the development of prototypes and new methodologies. For example, experimental software can be tested on a small scale to see whether it is capable of overcoming current barriers, such as security concerns. Local experimentation needs to be undertaken within centrally set standards to ensure interoperability. We make recommendations about the development of standards in R5.

Evaluation needs to be built into the development process from the very earliest stages. However, current methods do not exist for effective evaluation of the social and economic costs of introducing new healthcare ICTs. These evaluations need to take into account health outcomes, non-health outcomes (eg provision of information, reassurance) and process factors (eg reduction in waiting time, reduced travel times, location of treatment). User perspectives (healthcare professionals, patients, carers and the public) need to be assessed and the workability of new ICTs in practice needs to be examined. Tools to assess barriers to implementation and methods to promote utilisation of new ICTs will also need to be developed. Evaluations also must include the opportunity costs of introducing any new system. They need to account for associated training, maintenance, support, refinement and likely effects on working practices. Methods of assessing the costs of not introducing ICTs also need to be developed. An examination is needed of whether the introduction of ICTs has any negative effects such as widening of inequalities and, if so, how such effects can be overcome.

Funding will be required at the different stages of development. The initial stages of development will involve developing prototypes, new methodologies and experimental systems. Funding will also be needed for the commercialisation of these systems. It is also essential that all stages of the development are undertaken within standards to ensure interoperability.

**R3: We recommend that the Government health Departments and their associated national IT programmes adopt an iterative and incremental approach in the design, implementation and evaluation when introducing new healthcare ICTs. We make several additional recommendations to support such an incremental approach:**

**a We recommend that healthcare professionals and their professional bodies seek to be involved in the design, implementation and evaluation of healthcare ICTs.**

**b We recommend that healthcare managers ensure that sufficient time is made available for healthcare professionals to contribute effectively at all stages of design, implementation and evaluation of healthcare ICTs.**

**c We recommend that the Research Councils fund underpinning work on new assessment and evaluation methods whereas Government health Departments, medical charities and the private health sector should fund applied research such as the assessment of efficacy.**

**d We recommend that the Research Councils fund work to develop prototypes, new methodologies and experimental systems for new healthcare ICTs.**

**e We recommend that industry and the Department of Trade and Industry fund the commercialisation of new healthcare ICTs.**

**f We recommend that the national IT programmes ensure that all stages of the development are undertaken within standards to ensure interoperability and that evaluation is built into development.**

There are currently considerable differences in the deployment of healthcare ICTs in the four UK countries. There will be lessons to be learnt from both the successful and unsuccessful elements of the different approaches adopted in England, Northern Ireland, Scotland and Wales. For example, the English NPfIT, being delivered by Connecting for Health, is introducing large and complex systems at a much faster pace and on a greater scale than anything being attempted in the other countries. The levels of user-engagement at differing stages of the national programmes should also be evaluated.

There will also be lessons to be learnt from overseas developments in the use of ICTs in health and healthcare, although the different healthcare structures will need to be taken into account.

**R4: We recommend that future policy developed by the UK health ministers is informed by an evaluation of the effectiveness of the different approaches to deployment of ICTs in the four UK countries. We recommend particular attention is paid to evaluations of the effects of the different speeds and scales and the levels of user-engagement of the national programmes. We also recommend that the Government health Departments and their national IT programmes monitor overseas developments to learn lessons from different approaches taking into account the different healthcare system structures.**

### 7.4 Ensuring interoperability

It is essential that any healthcare ICTs have adequate flexibility to work with a diverse range of healthcare providers, healthcare professionals, patients and carers. Standards need to be set to cope with this diversity, as there will need to be common interfaces between the many different organisations, agencies, bodies and individuals involved. Standards will also allow for the incremental design approach advocated in recommendation R3. It is vital for the UK to be at the heart of work towards convergence between the different international standards being developed as the exchange of healthcare related information will not be limited to the UK.

Fully interoperable systems cannot be deployed until national and international standards are agreed. We acknowledge that the Government health Departments have been working towards achieving convergence between the standards being developed. However, we encourage these efforts to be increased to reach convergence as soon as possible so that the potential benefits of healthcare ICTs can be realised sooner rather than later.

**R5: We recommend that the Government health Departments build on their ongoing work to achieve convergence as quickly as possible between the different national and international standards being developed through further collaboration with industry and standards bodies such as the BSI (on a national level) and SNOMED-CT, CEN, ISO, DICOM, HL7 and the EU (internationally).**

### 7.5 Access and ownership of data

There is a tension between individual privacy and public benefit of sharing health data. Although these issues have been studied by several organisations, further investigation is needed into the degree to which patients would be willing for their personal data to be shared for wider, societal benefits. The Council for Science and Technology highlighted the need to engage in dialogue with the public and stakeholders on the benefits and risks associated with better linkages and wider access to personal datasets (Council for Science and Technology 2005). Similarly, the AMS recommended that the Government health Departments should develop public engagement programmes around the purpose and value of using personal data in medical research (Academy of Medical Sciences 2006). We endorse these recommendations.

Even though ICTs have already spread very rapidly through the population, additional efforts will be necessary to ensure that groups who are less able to access or exploit available information technologies are not excluded by such systems. Such groups include some of the elderly, the disabled, the poor and socially deprived, non-English speakers, people who cannot read and the IT illiterate. Healthcare ICTs will need sufficient flexibility to allow for the provision of alternatives for those who cannot (or do not wish to) engage. Several organisations are undertaking initiatives to gain or ensure access for these groups.

The issue of access to the different parts of an individual health record is also important, such as who can view the data and also who has the power to make changes to it. The mechanics for being able to control access to data are reasonably well understood now. However, it is not possible to formulate sensible access policies until further engagement work is undertaken with patients, carers and the wider public on privacy and benefits of allowing access to data for research. These issues will need to be resolved before the benefits of sharing data can be realised, such as the potential benefits of using a patient's medical history in developing personalised medicines (Royal Society 2005a).

**R6: We recommend that Government health policy is informed by evidence derived from engagement with patients, carers and the wider public on confidentiality and sharing of personal data.**

### 7.6 Impact on roles and responsibilities

The increased use of healthcare ICTs will have a profound impact on the roles and responsibilities of patients, carers and healthcare professionals. The exact nature of these changes is hard to predict but may have the potential to counteract existing trends as well as creating new ones. For example, patients, potential patients and carers are likely to have a greater involvement in healthcare, which will considerably affect healthcare professionals. For example, the healthcare professional being in the same place as the patient has traditionally been the basis of most healthcare activity. ICTs expand the opportunities for the healthcare professional and patient to interact despite not being together. The benefits of remote care need to be weighed against the advantages of physical co-location for new ICTs.

ICTs make information more widely available than it was previously. This has already led to a new role for the professional of guiding the patient to the most reliable sources of information: we expect this new role will grow in the near future. Part of this role will involve explaining or expanding on differences in terminology between countries, given the international nature of the available information.

The ESRC and the Government health Departments have funded some investigations into the socio-cultural implications of ICTs in healthcare.

**R7: We recommend ESRC and Department of Health continue to fund investigations into the socio-cultural impact of ICTs in healthcare, looking at the changing roles and responsibilities for healthcare professionals (including the effects on work processes and the organisation of care) and the impact on patients. We also recommend that Government policy is informed by the evidence derived from these investigations.**

### 7.7 Learning, training and support

The basic training and continuing professional development of healthcare professionals should equip them with the ability to operate effectively in the information-rich healthcare environment rather than just providing basic IT skills, such as being able to use word processor and spreadsheet software packages. This is an area where the health informatics community could assist in the development of curricula and competency frameworks.

**R8: We recommend that the higher education institutions and professional bodies (such as the medical Royal Colleges) responsible for the different disciplines adapt their curricula to integrate the use and understanding of healthcare ICTs into the basic training and continuing professional development of healthcare professionals.**

In addition to the basic training and continuing professional development, it is essential that healthcare professionals are given training and support on how to use new ICTs when they are introduced. Ongoing access to technical support is essential so that difficulties can be addressed quickly. With the expected increase in patient-led care, patients and their carers should also be trained and have access to technical support where appropriate.

**R9: We recommend that local and national health authorities ensure that sufficient funding and time are allocated to provide initial training and ongoing support for healthcare professionals.**

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# 9 Working group

The members of the working group involved in producing this report were as follows. The members of the working group were invited in their personal capacity rather than as a representative of their organisation.

| | |
|---|---|
| Professor Peter Wells FMedSci FREng FRS (Chair) | Institute of Medical Engineering & Medical Physics, School of Engineering, Cardiff University |
| Sir Mike Brady FREng FRS | Department of Engineering Science, University of Oxford |
| Dame June Clark | Professor Emeritus, University of Wales, Swansea |
| Professor Brian Collins | Department of Information Systems, Cranfield University<br>Vice President, British Computer Society |
| Mr Paul Garner | Head of Pervasive ICT Research Centre, BT |
| Dr Glyn Hayes | Chairman, Health Informatics Forum Strategic Panel, British Computer Society |
| Professor Richard Kitney OBE FREng | Department of Bioengineering, Imperial College London |
| Professor Frances Mair | Department of General Practice & Primary Care, University of Glasgow |
| Professor David May FRS | Department of Computer Science, University of Bristol |
| Professor Mandy Ryan | Health Economics Research Unit, University of Aberdeen |
| Professor William Stewart FREng | Visiting Professor, University College London and University of Southampton |
| Professor Andrew Webster | Department of Sociology, University of York |
| Dr Damon Wischik | Department of Computer Science, University College London |

Secretariat: Dr Nick Green, Kate O'Shea, Dr Rachel Quinn

This report was reviewed on behalf of the Royal Society Council by a review panel comprising the following people. The reviewers were not asked to endorse the findings or recommendations of the report.

| | |
|---|---|
| Professor Martin Taylor FRS (Review Panel Chair) | Physical Secretary and Vice President of the Royal Society |
| Professor Martin Bobrow CBE FRS | Cambridge Institute for Medical Research, Addenbrooke's Hospital |
| Professor Peter Lipton | Department of History and Philosophy of Science, University of Cambridge |
| Professor Peter Ratcliffe FMedSci FRS | John Radcliff Hospital, Oxford |
| Sir John Taylor OBE FREng FRS | Roke Manor Research |

# 10 Details of evidence and workshops

We are very grateful to everyone who submitted evidence and participated in the evidence-gathering workshops. Individuals and organisations who submitted evidence and attended the science and technology evidence gathering workshop are listed in sections 10.1 and 10.2 below.

The responses to the call for evidence, additional evidence and evidence-gathering workshop reports are available on the Royal Society's website.

(CfE): submitted written evidence in response to the call for evidence

(Add): submitted additional evidence to the working group

(SW): attended science and technology workshop, 24 October 2005

(HCPW): attended healthcare professionals workshop,1 November 2005

(PGRW): attended patient groups representative workshop, 4 November 2005

### 10.1 Organisations

Association of British Healthcare Industries (CfE)

BIOCORE, Biomedical Computing Research Group, Coventry University & Centre for Systems Studies, Hull University Business School (CfE)

Branham Group, Canada (CfE)

British Medical Association (CfE)

BUPA (Add)

Cambridge-MIT Institute's Future of Healthcare Knowledge Integration Community (CfE)

CODEWORKS Assistive Technology Lab (CfE)

Digital Unite, formerly Hairnet UK Ltd (CfE)

Engineering and Physical Sciences Research Council (CfE)

Institute of Physics and Engineering in Medicine (CfE)

Institution of Engineering and Technology, formerly known as Institution of Electrical Engineers (CfE)

NCRI Cancer Informatics Initiative (CfE)

NHS Confederation (CfE)

NHS Connecting for Health (CfE, Add 1, 2 & 3)

Nuffield Hospitals (Add)

Particle Physics and Astronomy Research Council (CfE)

Precarn and University of Calgary, Canada (Add)

Royal College of Nursing (CfE, Add 1 and 2)

Royal College of Radiologists (CfE)

Royal Society of Edinburgh (CfE)

UK Computing Research Committee (CfE)

University of Edinburgh Interdisciplinary eHealth Research Network (CfE)

University of Surrey (CfE)

Vodafone Mobile Health Team (CfE)

Worshipful Company of Information Technologists (CfE)

### 10.2 Individuals

Professor Ross Anderson, Foundation for Information Policy Research (CfE)

Professor James Barlow, Deputy Director, Innovation Studies Centre, Tanaka Business School, Imperial College London (CfE, SW)

Dr Maulik Baxi, TaxilaCentre for Medical Reforms & Research (CfE)

Janette Bennett, BT Global Health Practice (CfE)

Mr Bahadar Bhatia, Healthcare Informatics & Computing Special Interest Group, Institute of Physics & Engineering in Medicine (SW)

Dr Ewan Birney, European Bioinformatics Institute (CfE)

Professor Donald Bligh, School of Engineering, Computer Science and Mathematics, University of Exeter (CfE)

Ms Sally Ann Boyd, Patient Advisory Group, British Heart Foundation (PGRW)

Professor Norma Brook, President, Health Professions Council (HCPW)

Professor Peter Buckle, Robens Centre for Health Ergonomics, University of Surrey (HCPW)

Professor Budgen and Professor Pearl Brereton, School of Computing and Maths, Keele University (CfE)

Sir Cyril Chantler, Chairman, Great Ormond Street Hospital (HCPW)

Ms Andrea Cooper, Head of Design Knowledge, Design Council (PGRW)

Mr Joe Corner, Director of Communications, Stroke Association (PGRW)

Ms Bose Damia, Independent Newham Users Forum (PGRW)

Dr Jerome Declerck, Chief Scientist, Siemens Medical Imaging (SW)

Mr Gilbert Devey, US National Science Foundation (SW)

Dr Stephen Elsby, EPSRC (SW)

Prof David Fitzmaurice, Department of Primary Care and General Practice, University of Birmingham (Add)

Dr Jonathan Flint, CEO, Oxford Instruments (SW)

Professor John Fox, Cancer Research UK (SW)

Mr Tim Gilling, Health Scrutiny Programme Manager, Centre for Public Scrutiny (HCPW)

Mr Stephen Harbon, Programme Manager, NHS PASA Centre for Evidence-based Purchasing (SW)

Dr Peter Harrop, Chairman, IDTechEx (SW)

Lynne Hayward, RGN Practice Nurse (CfE)

Professor Derek Hill, CEO, Ixico (SW)

Dr Alasdair Honeyman, Health Informatics Steering Group, Royal College of General Practitioners (HCPW)

Ms Julie Howell, Digital Policy Development Manager, RNIB Peterborough (PGRW)

Mr Matt Hunt, Chief Executive, Diabetes UK (PGRW)

Professor David Ingram, Director, Centre for Health informatics and Multiprofessional Education, UCL (SW & Add)

Dr Ashok Jain, EMPI Business School, Delhi University, India (CfE)

Dr Dipak Kalra, senior clinical lecturer at CHIME (Add)

Dr Jonathan Kay, Consultant Chemical Pathologist, Oxford Radcliffe Hospitals NHS Trust (HCPW)

Dr David Kelly, West Lothian Community Health & Care Partnership (Add)

Dr Rob Lang, Corporate Resources Director, MRC Technology (SW)

Professor Richard Lilford, Director of Research and Evaluation, Department of Public Health and Epidemiology, University of Birmingham – Connecting for Health (CfE)

Mr Colum Lowe, Design Manager, National Patient Safety Agency (PGRW)

Professor Paul Matthews, Professor of Clinical Neurology Director, Centre for Functional Magnetic Resonance Imaging, University of Oxford (SW)

Professor Carl May, Health Technologies and Human Relations Research Group, University of Newcastle upon Tyne (CfE)

Sue Middleton, Ipswich Hospital Cancer Services User Group (Add)

Dr Jo Milan, former director of ICT, Royal Marsden Hospital (Add)

Dr Gail Mountain, Director, Centre for Health & Social Care Research, Sheffield Hallam University (HCPW)

Sir J A Muir Gray, University of Oxford (Add)

Ms Cathie O'Driscoll, Consultant Child Psychiatrist, East London & the City Mental Health Trust (HCPW)

Ms Georgia Orunmuyi, Camden PCT (HCPW)

Mr Mark Outhwaite, Independent healthcare policy consultant (SW)

Dr Ferdinand Peer, Senior Manager Application Field Mobile Health, Vodafone Group Research & Development (SW)

Mr Jim Pollard, The Men's Health Forum (PGRW)

Professor Paula Procter, School of Nursing and Midwifery, University of Sheffield (CfE, SW)

Dr Jem Rashbass, Cambridge MIT Institute (SW)

Melvin Reynolds, AMS Consulting (CfE)

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Dr Kenneth Robertson, Clinical Lead for Information Management and Technology, Scottish Executive Health Department (Add)

Professor David De Roure, Head of Grid and Pervasive Computing, University of Southampton (SW)

Mr Martin Sadler, Director, Hewlett Packard (SW)

Mr Paul Sherman, Independent Newham Users Forum (PGRW)

Mr Bill Sharpe, CEO, The Appliance Studio Ltd (SW)

Jenny Shaw, Ipswich Hospital Carers User Group (Add, PGRW)

Professor Lionel Tarassenko, University of Oxford (CfE, SW)

Dr Gwyn Thomas, Director, Informing Healthcare – Wales (Add)

Professor Paul Wallace, Professor of Primary Health Care, UCL (SW)

Mr Conor Ward, Partner, Lovells (HCPW)

Ms Alex Westbrook, Nursing Development Adviser, Chelsea and Westminster Hospital (HCPW)

Professor Terry Young, Brunel University / MATCH (Add)

## 10.3 Science and technology evidence gathering workshop

Twenty-two individuals from academia, industry and funding bodies attended the workshop along with eight members of the Society's ICT and healthcare working group. The workshop was held at the Society on 24 October 2005. A list of the workshop attendees is included in section 10.2. The aims of workshop were:

- to inform the RS study through the working group members present and the meeting report;
- to identify potential new information and communication technologies with applications to health and healthcare that are likely to be used in 10–15 years;
- to identify the drivers and barriers for the development of relevant new ICTs, along with the strengths and weaknesses of specific ICTs.

The workshop consisted of plenary sessions and three breakout groups, each one looking at different sectors of health and healthcare: home care; primary care; and secondary/tertiary care. As there are overlaps between the different health and healthcare sectors, there was a discussion of cross-cutting issues during the closing plenary session.

A report of the workshop can be found on the Society's website along with the evidence.

## 10.4 Healthcare professionals and patient groups representatives evidence gathering workshops

OPM (Office for Public Management Ltd, an independent, not-for-profit public interest company) was commissioned by the Society to run two workshops and conduct several telephone interviews to provide evidence from patients and their representatives and clinicians on:

- Future issues in healthcare from clinician and patient groups' perspectives;
- How scenarios concerning the development of ICT in the next 1015 years will impact on such healthcare.

Two stakeholders groups were involved in the project:

- Healthcare professionals
  - 12 attended the healthcare professional workshop, which was held on 1 November 2005
  - 17 telephone interviews were carried out with healthcare professionals.
- Patient support groups
  - 9 attended the patient group workshop, which was held on 4 November 2005
  - 16 telephone interviews were carried out with patient support professionals.

A full report of the workshops and telephone interviews produced by OPM can be found on the Royal Society's website. The individuals participated in the telephone interviews anonymously, so they are not included in the list of individuals in section 10.2.

# Appendix one: predicted future availability of ICTs in healthcare

It is unrealistic to predict which technologies will have the greatest impact on health and healthcare in the future. The availability and the speed of adoption of new technologies will depend on the factors described in chapters 4 and 5, such as being available at a reasonable cost. The table below provides examples of ICTs that are likely to become widely used in the next 15 years. Some of the technologies listed in the medium- and long-term categories are currently available, but they are unlikely to be widely used in the UK for several years. Many of the developments in ICTs will be incremental improvements of existing technologies. The numbers in brackets refer to the sections of the report that discuss the specific technologies.

| **Area** | **Widespread use** | | |
|---|---|---|---|
| | **Short-term (0–5 years)** | **Medium-term (5–15 years)** | **Long term (15+ years)** |
| **Global communications and information infrastructure (3.2)** | • Electronic Patient Record and Electronic Health Records (EHR), PACS, RICS & HIS (3.2.2): short term but ongoing<br>• Hand-held devices for aspects of summary records and low resolution images. (3.2.2)<br>• Simple timings and alerts in EHRs (3.2.2)<br>• Improved human-machine interfaces, including voice recognition, enabling more people to use ICTs (3.2.2) | • Broadband networks up to 100 Mb/s, allowing complex patient monitoring in the home (3.2.1)<br>• Hand-held devices delivering higher resolution diagnostic images (3.2.2)<br>• Full motion video via cellular phones used in diagnosis (3.2.1)<br>• Wireless Local Area Networking (eg allowing staff to contact each other through voice activated hands-free devices) (3.2.1) | • Hand-held devices involving full EHR (3.2.2)<br>• Mobile scanner technology in NHS primary care practice (3.2.2)<br>• Data from EHRs to measure health outcomes and epidemiological studies. (3.2.2) |
| **Personal and ubiquitous technologies (3.3)** | • Radio Frequency Identification Devices (RFIDs) to track pharmaceuticals (3.3.1)<br>• Over-the-counter personal healthcare devices (3.3.2)<br>• Use of mobile phones to improve self-management of chronic conditions (3.3.2) | • RFID technology used in conjunction with home based monitoring equipment to assist with taking of medication (3.3.1)<br>• RFID used to track hospital equipment (3.3.1)<br>• High-definition TV becomes standard, improving videoconferencing and allowing high quality images to be sent to patients home (3.3.2)<br>• Introduction of new testing kits for a wider range of infectious agents and illness such as appendicitis and for genetic testing (3.3.3)<br>• Networking of body sensors to monitor physiological state (3.3.2)<br>• Smart homes enabling more people to live independently (3.3.2)<br>• Printing of electronics, ie smart pill packets (3.3.1)<br>• Smart toilet (3.3.2) | • Cheap, disposable sensors distributed throughout the environment, with applications such as early detection of infections in hospitals (3.3.1)<br>• Using RFIDs for dietary monitoring of individuals/families (3.3.1)<br>• Remote monitoring of a wide range of patient conditions, anticipation of illness (extension of use of mobile phones for self-management of chronic conditions) |

| | | | |
|---|---|---|---|
| **Data capturing and imaging (3.4)** | • First-generation molecular imaging techniques based on nuclear medicine<br>• Fast protein sequencing commercially available<br>• Continuing developments in imaging, eg 3D mammography<br>• Medical image analysis and computer-aided detection of disease | • Imaging of cellular and molecular processes leading to new therapies<br>• Combination of molecular imaging with DNA microarray technologies<br>• Image-based clinical trials | • Virtual reality in 3D and 4D body imaging<br>• Virtual reality to train doctors<br>• Molecular imaging begins to integrate with bionanotechnology for novel therapy delivery methods |
| **High-performance computing (3.5)** | • Grid technology used in healthcare enabling better use and management of large data sets, eg CancerGrid project, eDiamond project (3.5.4)<br>• Super computer models relating to spread of avian influenza and HIV treatments (3.5.5)<br>• Latest EHR & PACS access automatically logged, enabling audits trails to be produced, enhancing security (3.5.5) | • Middleware and WebServices incorporated into every PC, laptop and hand-held device. Wide range of healthcare applications (3.5.4)<br>• More advanced models elating to heart and lung disease | • Semantic web enabling richer use of large datasets (3.5.1)<br>• Real-time computation of complex wide spatiotemporal scale models of disease<br>• Intelligent data mining from a mixture of text, images, signals |
| **Autonomous and robotic systems (3.6)** | • Pharmacy robots<br>• Robots in image-guided surgery | • Low-cost mobile and wearable devices for drug administration/anaesthesia<br>• Carebots and robotic teddy bears<br>• Robots in homes for chronically ill/elderly | • Patients at home interacting with humanoid and mechanical pets<br>• Development of fully robotic systems<br>• Permanent artificial prostheses |

# Appendix two: health economic techniques

**Quality Adjusted Life Years (QALYs)** can be used to value changes in health outcomes. QALYs were developed to take account of the fact that an individual may be concerned with the quality of their life as well as the length of their life. To estimate QALYs, expected life years gained from given healthcare interventions are estimated (usually by healthcare professionals) and combined with information on the quality of these life years. QALYs gained from one healthcare intervention may be compared with QALYs obtained from alternative healthcare interventions, as well as from doing nothing (Dolan 1997).

**Contingent valuation** can be used to value health outcomes, non-health outcomes and process attributes. It is based on the premise that the maximum amount of money that an individual is willing to pay for a good or service is an indication of the value to them of that service. The technique is a choice-based approach where individuals are presented with a choice between not having the commodity and having the commodity but forgoing a certain amount of money. The money that they are willing to forgo to have the commodity is their willingness to pay for that commodity (Ryan et al. 2003).

**Discrete choice experiments (DCEs)** can also be used to value health outcomes, non-health outcomes and process attributes (as well as trade-offs between these various dimensions). DCEs are an attribute-based measure of benefit. The technique is based on the premises that, first, any good or service can be described by its characteristics (or attributes) and, second, the extent to which an individual values a good or service depends upon the levels of these characteristics. The technique involves presenting choices to individuals that vary with respect to the levels of attributes. From responses, it is possible to estimate the relative importance of attributes, how individuals trade between the attributes and, if a price proxy is included as an attribute, willingness to pay for defined services (Ryan et al. 2003).

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