Response to the Call for Evidence on the impact of ICT on health and healthcare

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Response to Question 1 - What relevant technology trends are likely to impact on health and healthcare in the next ten to fifteen years?

Summary Response to Question 1

Our research on the uptake of information and communication technologies within the healthcare sector indicates that in the next ten to fifteen years – telemedicine is likely to emerge as an alternative medium for healthcare delivery.

The uptake of [1]telemedicine in conjunction with modern ICT applications such as Personal Digital Assistants (PDA) would bring about a significant change in healthcare delivery. Telemedicine will allow patients carry out routine medical tests, reducing the number of visits to the physician and thereby reducing costs for routine consultations. In particular, telemedicine is likely to have a significant impact in the following three healthcare domains:

1 Telemedicine will be used increasingly for the following purposes: consultations or second opinions, diagnostic test interpretation, post-hospitalization or post-operative follow-up, emergency room triage and televisits.

2 The use of telemedicine applications to monitor patients will see an increased use (eg. for asthma, congestive heart failure, diabetes).

3 Teleradiology will see an substantial increase.

Detailed Response to Question 1

1 Telemedicine: The technology for healthcare delivery in the future

Today, the explosive growth of the Internet has promoted the trend for investment in information and communication devices and the healthcare industry is an active participant in this trend (Kazman and Westerheim, 1999). It would be fair to state that advances in communications technology are dramatically changing the delivery of healthcare services (Schooley, 1998). The changes in information technology, particularly in the telecommunications technology have brought about fundamental changes throughout the healthcare process (Applebaum and Wohl, 2000). The change process undergone is confirmed by research which states that in the period 1997-2000, 85% of healthcare organizations have undergone some sort of transformation (Sherer, 1995).

One of the most important technological changes in electronics has been the ability to convert signals from an analogue to a digital medium (images or signals are converted into digital code by using an analogue-to-digital conversion device) – a process referred to as Digitization (Wallace, 1997). Digitization in healthcare has meant that it is now possible to take healthcare related information in different formats (audio, video, sound) and deliver the same at high speeds in the same basic format. Simultaneously there has been a change in technology (from simple copper wires to optical fibres) via which information is transmitted. This in turn has exponentially increased the bandwidth (Wallace, 1997). The phenomenon of Multimedia has made possible the exchange of information – that can be combined from different formats (sound, video, animation, text and graphics) and presented in an interactive manner. This is fast making multimedia technology the "technology of choice" for the delivery of information (Wallace, 1997). **The coming together of digitization and multimedia technology has led to the emergence of the [2]Telemedicine concept**.

[1] Please refer to point A1 on page 5 for more precise details on the origins and scope of telemedicine.
[2] Please refer to point A2 on page 5 for a detailed information on current telemedicine technologies

2 The Internet and telemedicine

An American Medical Association study in 1999 (Swartz, 2000) indicated that 37% of all physicians in the US were using the Web and by 2000 this figure had risen to about 50%. It has been pointed out that more caregivers have adopted modern ICT applications such as wireless phones and PDAs which allow them to be in contact with patients and, in certain circumstances, to save lives. A study on the use of e-mail by physicians noted that email as a method of keeping in touch with patients tripled in less than one year - 10% of all physicians now use e-mail on a daily or weekly basis to be in contact with their patients (Swartz, 2000).

Initial web-based multimedia patient record systems have been developed which give remote access to telecare providers (Nairn, 2001). We believe that, in the future, web-based multimedia patient administration systems will become the norm for telemedicine. [3]A similar concept has been put forward by the National Health Service (NHS) in the UK, where healthcare institutions are being asked to adopt an Electronic Patient Record (EPR) system at six varying levels of implementation (NHS, 1998).

One of the biggest indicators that portends the rise of telemedicine has been the ruling by the Federal Communications Commission (FCC) in the US who had recently cast "…an historic vote dedicating a portion of the radio spectrum for wireless medical telemetry devices such as heart, blood pressure and respiratory monitors" (Health Management Technology, 2000, p12).

1.1 Mobile Computing and Healthcare

In the near future, third generation technologies such as Code Division Multiple Access (CDMA) 2000 are expected to raise the transmission standard to about 2.0 Mbps (Cancela, 2001). When this happens, it is quite likely that the vision of an "integrated voice, data, video technology" (Cancela, 2001) will become a reality which is likely to have a significant impact on the use of telemedicine.

The success of second-generation wireless networks has led to an explosion in the use of wireless applications to transfer voice and data services. This has raised the possibility that future wireless networks might support cost-effective broadband multimedia services (Pinto and Rocha, 1999). Technologies such as Wireless Application Protocol (WAP) have enabled patients and doctors to remain in closer contact. There are successful WAP-based products (such as LifeChart.com) through which doctors can monitor online their patient's condition, and take care of their healthcare needs (Purton, 2000).

Another example of the use of WAP is WirelessMed, through which UK Doctors have wireless access to clinical data on Medline, the largest US government database comprising more than 12 million medical references (which supports download speeds of up to 400-words in a few seconds). Another example of WAP-enabled healthcare products is MedicinePlanet which aims to bring local health information (health news, current health alerts, details on prevailing healthcare systems) to travellers using mobile phones (Purton, 2000). WAP technology is facing strong competition from other medical wireless systems based around PDA platforms which support downloads of a standard patient image in 10-15 seconds (Parkes, 2001).

[3] Please refer to point A4 for detailed information Budgeted Expenditure on IT in Healthcare Institutions and IT Healthcare Trends

The main disadvantages of mobile computing (limited battery and processor power) should diminish as new technologies, allowing higher bandwidths, are introduced onto the market (Satyanarayanan, 1996). Workflow-based applications, in conjunction with mobile computing technologies such as WAP and PDA, have the potential to transform the delivery of healthcare information. The use of PDA by physicians has witnessed rapid acceptance in recent times. About 40% of all physicians currently use PDAs (Serb, 2002). However, the majority of physicians are using PDAs to perform static functions. Most of them use PDAs to collect reference material with ePocrates - a drug reference application that can assist physicians in looking up drugs by name or diagnoses, cross-reference analogous medications or generic alternatives and obtain alerts on interactions. This application has been categorised by the US based Journal of the American Medical Association to be indispensable (Serb, 2002).

A few pioneering physicians have started to use PDAs in an interactive way i.e. to write prescriptions, to keep a record of all daily clinical patient interactions and for bedside charting. The financial viability of PDAs have been demonstrated by a pilot study which has shown that for every US $1 that was invested in PDAs, the return in the form of lower administrative costs was over $4 (Serb, 2002).

3 Estimates for uptake of telemedicine

Estimates for worldwide telemedicine services suggests that the market is valued at $2.5 billion a year (Surry, 2001). Other estimates for 2002 project the US market alone to be around $3 billion – a big leap from $65 million in 1997 (Industrial Robot, 1998). A study by Waterford Telemedicine Partners Inc in Feburary 2000 has indicated that telemedicine is projected to have an annual growth rate around 40% in the first decade of the 21st century. The study predicts that, by the year 2010, telemedicine will account for at least 15% of healthcare expenditure (Health Care Strategic Management, 2000). Telemedicine technologies, in conjunction with state-of-the-art Electronic Health Record (EHR) systems, are changing the face of healthcare. Telemedicine technologies have the potential to replace 5% of hospital stays, 5% of nursing home care, and 20% of home health visits (Fishman, 1997), resulting in savings of time and money for both patients and doctors. Additionally, caregivers have more time to devote to clinical activities such as medical diagnosis and treatment. A study on the medical reimbursement of telemedicine applications indicates that “telemedicine for radiology, prisoner health care, psychiatry, and home health care are the most cost effective applications …that are paid for by insurers” (Charles, 2001, p66).

4 Worldwide applications of telemedicine

One of the most widely used applications of telemedicine is teleradiology (Rao, 2001). The use of telemedicine applications to monitor patients has been recommended in asthma, congestive heart failure and for diabetes (Friedewald Jr, 2001). A study carried out by the Agency for Healthcare Research and Quality in the US identified 455 telemedicine programs worldwide out of which 362 are being used in the US (Trembly, 2001). The study has indicates that telemedicine is most commonly used for: 1] Consultations or second opinions (performed in 290 programs), 2] Diagnostic test interpretation (169), 3] Chronic disease management (130), 4] Post-hospitalization or post-operative follow-up (102), 5] Emergency room triage (95), 6] Visits by a specialist (78) and that about 50 programs provide services in patients' homes.

Countries such as Malaysia have already integrated [4]telemedicine with the electronic health record concept and there is a national telemedicine strategy in place. Teleconsultations are being carried out on a regular basis in Malaysia. In Sweden, telemedicine is being used to reduce the stay of children in hospital. This is being achieved by using local telecommunications to connect to the health monitoring equipment (for heart rate, rhythm and blood pressure) and is installed at the residence of the patient (Collins, 2001). In the UK, at the West Surrey Health Authority, patients who are regarded as potential heart failures are monitored electronically for 24 hours a day at their residences (Crompton, 2001). A report by the US based Association of Telehealth Service Providers has indicated that in 1996 there were about 22,000 telemedicine consultations, which rose to 42,000 in 1997 and by 1998 to about 58,000 (Tieman, 2000).

5 Conclusion

Based upon our analysis, it is clear that telemedicine is likely to emerge as an alternative medium for healthcare delivery. However, we would like to add a word of caution. In the future, as a result of synergistic interaction, telehealth and telemedicine systems would have an increased interest in knowledge recycling of the collaborative learning process acquired from previous telehealth and telemedicine practices. Current trends indicate that there has been a significant emphasis on the development of codified knowledge repositories, i.e., designing information systems for representing healthcare-related information to assist in medical decision making.

It is imperative that the health-care sector learns from the problems faced by previous technologies (such as AI) that occupied the pride of place from funding sponsors 30 years ago. Twenty first century clinical practitioners using telemedicine would need to acquire proficiency in understanding and interpreting clinical information so as to attain knowledge and wisdom whilst dealing with large amounts of clinical data. This clinical data that will be dynamic in nature and would call for the ability to interpret context-based healthcare information. This challenge cannot be met by an IT led solution. The solution needs to come from a domain that supports all the three integral healthcare system components (ie. people, processes and technology) of the future.

Knowledge Management (KM) is one such domain. The key to success for use of telemedicine in the 21st century is to look at the KM domain (see figure 1), a multidisciplinary paradigm which uses ICT to support the acquisition, generation, codification, and transfer of knowledge in the context of specific organizational processes. KM can assist telehealth and telemedicine to become viable as it has the capability to transform large amounts of medical data into relevant clinical information by integrating information using workflow, context management and collaboration tools.

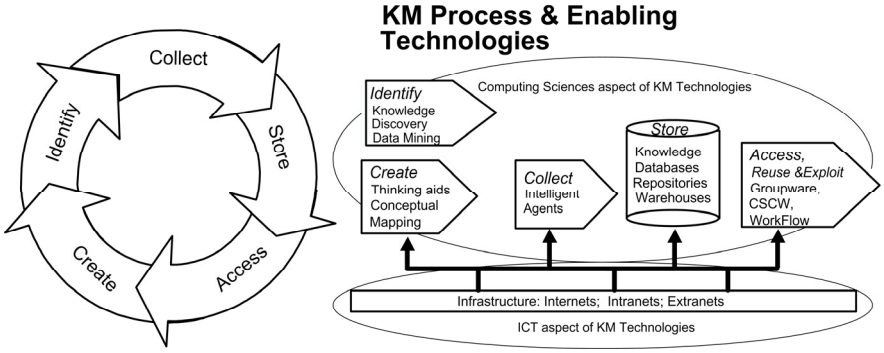

Figure 1 Overview of KM Technologies

[4] Please refer to point A3 on page 6 for a detailed information on true life examples of telemedicine applications

APPENDIX

A1 Telemedicine and telemedicine : Origins and Scope

Telemedicine has been derived from two Greek and Latin words. “Tele” in greek translates as distance while “Mederi” in latin means to heal (Rao, 2001). In a modern context, telemedicine can be stated to be a method of healthcare delivery where advanced video communications technologies are used to bridge the geographical gap that exists between the licensed caregivers and/or the care receiver, so as to provide medical diagnosis and treatment (European Health Telematics Observatory, 1999; Charles, 2000; Nairn, 2001; Garets and Hanna, 1998).

Telehealth has a much broader scope in comparison to telemedicine, as telehealth relates to the bigger issues in healthcare administration and regulation, whilst telemedicine is concerned with the clinical aspects of healthcare delivery (European Health Telematics Observatory, 1999 and Johnson, 2000). Some authors (Nairn, 2001; Noring, 2000) have further delineated between the two by positing that, in telemedicine, healthcare providers fall into the category of physicians whilst, in telehealth, the category of healthcare providers can be extended to include non-physicians, as telehealth encompasses health promotion and disease prevention.

The earliest documented use of telemedicine can be traced to the 1920s when radio was employed to link up physicians located on land with ships at sea who were facing medical emergencies. The next leap in telemedicine took place in the 1960s when the US-based National Aeronautics and Space Administration (NASA) pioneered the use telemedicine in space (astronauts had their pulse rates and blood pressure monitored remotely). By the 1970s, telemedicine additionally took advantage of new emerging satellite technologies (Rao, 2001).

UK, Canadian and Malaysian governments have seized the opportunity to make substantial efforts to link electronically different healthcare centres. In the UK, the Government has committed about USD $1.4 billion to bring about a transformation in all facets of healthcare. A significant component of this funding is being used in developing a nationwide electronic platform (Crompton, 2001). This high volume of investment worldwide in healthcare technologies has brought about the emergence of several telemedicine schemes all over the world (Crompton, 2001; Collins, 2001;The Economist, 1997).

Objective of Telemedicine Applications

The aim behind any telemedicine application is to transfer the expertise of the caregiver from one location to another (Johns, 1997). One of the most widely used applications of telemedicine is teleradiology (use of “image acquisition, storage, display, processing and transport”) from one geographical location to another location for diagnosis (Johns, 1997). With advances in technologies, such as telecommunications, multimedia and IT healthcare applications, telemedicine has the potential to transform the delivery of healthcare permanently.

A2 Current Telemedicine Technologies

The cost of setting up an average telemedicine station works about to $50,000 and incorporates “a computer workstation with 21-inch monitor, electronic stethoscope, ear, nose and throat scope, and an exam camera through which the patients and doctors can see each other”(Tieman, 2000).

There are two main models in telemedicine: (1) interactive video and (2) store-and-forward (Kazman and Westerheim, 1999; Nairn, 2001). The main difference between them is that interactive video allows real-time patient care, whilst the store-and-forward technology is asynchronous (there is a gap between transmission of data and patient care diagnosis). Today, store-and-forward technology applications in telemedicine include telepathology and teleradiology (Nairn, 2001). The use of email to transmit medical prescriptions by physicians to their patients is fast becoming another major application of store-and-forward technology in telemedicine (Convey, 2000).

Since store-and-forward technology is asynchronous (communication over telephone lines linking two computers or other peripheral devices using start and stop bits), applications based on this type of technology are being more widely used in comparison to interactive video applications, as they can easily be transmitted over a network. Modern store-and-forward technology applications, in conjunction with advances in telecommunications technologies (such as digital imaging, WAP and fibre optics) are resulting in the creation of a much larger telemedicine market (Johnson, 2000; Beavan and Frederick, 2000).

Technologies that offer healthcare videoconferencing as a substrate are still evolving. It is possible to send large amounts of clinical multimedia data (compressed audio and video images) on high speed lines such as broadband technologies over the internet (Nairn, 2001). Given the current pace of advances in internet and videoconferencing technologies, interactive telemedicine applications will feature heavily in futuristic healthcare systems.

The advantages of telemedicine include enabling direct links between the caregivers and/or care receivers thereby enabling effective medical care especially to rural populations, saving time and money for caregivers and faster diagnosis and treatment for care receivers (Kazman and Westerheim, 1999; Schooley, 1998; Charles, 2000; Huston and Huston, 2000; Fishman, 1997). Whilst it is clear that telemedicine is more viable compared to traditional telephonic consultations (Sandberg, 2001), in a normal patient care scenario it enables patients to have faster access to alternative specialists and, more importantly, to have access to information about their sickness (Blair, 2001).

One of the major bottlenecks affecting the uptake of telemedicine in the US is the fact that insurance coverage of telemedicine is generally limited to teleradiology and a few cardiac monitoring procedures (Health Care Strategic Management, 2000). Furthermore in the US, legislation affecting telemedicine is different in each state.

Another major limitation in telemedicine is that there is no adequate regulatory structure which addresses such issues as licensure, credentialing, intellectual property and MediCare payments (in the US) (Schooley, 1998; Edelstein, 1999). Governments have started to address these issues with the US Congress taking a pioneering stand in this regard. In 1999, it introduced 22 pieces of legislation relating to telemedicine (Edelstein, 1999).

A3 True Life Examples that Validate Telemedicine Applications

In the UK, the North Manchester primary care group has used telemedicine applications to reduce the “average waiting time for a dermatology appointment from 18 months to 17 days” (Cross, 2000). In the US, telemedicine is said to have had tremendous benefits in reducing hospital intensive care costs (ICU). Each day in ICU costs on average $2,500 to the insurance company, which can be reduced to $35 by a routine teleconsultation (Cross, 2000).

The use of telemedicine can significantly aid patients in the battle to combat diabetes whilst reducing the associated expenditure. It has been estimated that the use of telemedicine can save the US government, about "$247 million per year through early intervention and nearly double that if telemedicine can extend the reach of treatment" (Blair, 2001, p4).

In Cornwall (UK) a pilot telemedicine project for teledermatology was undertaken. General Practitioners (GPs) from three surgeries (medical centers) used to send pictures of skin conditions from Cornwall to the county's two consultant dermatologists. They would then make an assessment as to whether the patient was required to visit the dermatologists for treatment or whether the GP could treat them in Cornwall itself. This telemedicine application found that "one in four patients did not need to see a specialist and could be treated by their family doctor" and reduced the workload of the two overworked dermatologists (The Guardian, 2001).

In 2001, a telemedicine application was used for the first time to carry out telesurgery. Doctors via computer from New York operated on a 68-year-old woman in Strasbourg, France to remove her gall bladder (Alpert, 2001; Johnson, 2002). The patient was released from the hospital after 48 hours of surgery and recommenced regular activities the following week (Johnson, 2002).

Telemedicine has been used very successfully in the US state of Arizona. Due to the geographical nature of Arizona, it is not possible for its residents which number in thousands to have immediate access to leading edge healthcare, as closet centres are exist 150 miles away or more (Health Management Technology, 2001). The Arizona Telemedicine Program today has more then 96 telephysicians representing 60 medical sub-specialities such as teleradiology, teledermatology, telepsychiatry, telecardiology, teleorthopedics, teleneurology and telerheumatology. These telephysicians have seen more than 11,000 patient cases and have provided primary diagnoses, expert consultation and provision of second opinions. Another pioneering advantage of telemedicine in Arizona has been to decrease risky travel, especially for patients with unstable medical conditions (Health Management Technology, 2001).

The Arizona Telemedicine Program has resulted in significant cost saving for healthcare delivery as the average cost "for a rural patient's visit to an urban health center has dropped from $520 to $105" and there exists significant potential in lowering "the average cost for routine home health visits … from $140 to as low as $55 per visit". One of the more significant achievements of the Arizona Telemedicine Program was to reduce healthcare expenditures in prisons, with the average cost for a prison inmate's healthcare visit falling from $415 to $140 (Health Management Technology, 2001, p47).

One of the most important technological enablers that is likely to affect transmission of healthcare information and healthcare delivery is the connectivity via satellite technology. It was estimated that there were about 150 satellites in orbit in 2001 (Rao, 2001). More significant is the fact that about "1,700 commercial satellites are scheduled for launch in the next decade worldwide" (Rao, 2001, p227). This could be the technological catalyst that brings about a transformation in the manner how healthcare delivery takes place, particularly in those areas where there is a geographical gap between the caregivers and carereceivers or where there is a substantial time constraints on specialized caregivers. Tele-consultations between caregivers and carereceivers and between themselves could see a likely increase (Rao, 2001).

A4 Budgeted Expenditure on IT in Healthcare Institutions and IT Healthcare Trends

Modern healthcare is the largest sector of the US economy (Kazman and Westerheim, 1999). However, IT expenditure in healthcare organisations, as a portion of revenues, is in the region of 2%, far below the 7-10% mark in other information-intensive industries (Moran, 1998). HIs are demanding healthcare applications that offer a number of utilities whilst they themselves allocate only a very small component of the total funds at their disposal (see table 1). An analysis (see Table 1) of the Budgeted IT expenditure (as a ratio of the information systems budget to the total operating expenses) shows that some of the major technologies that have showed a lot of promise are Workflow Management Systems, Mobile Computing technologies such as Personal Digital Assistant (PDA), Wireless Local Area Network (WLAN) and Object Oriented Technology

Year	2000	2001	2002
No of healthcare organizations surveyed	224 healthcare organizations	212 healthcare organizations	255 healthcare organizations
Budgeted IT expenditure (Ratio of the information systems budget to the total operating expenses)	Average IT expenditure at 2.6% Over 50% put it between 2% and 4%	Average IT expenditure at 2.53% 25% spent about 1.5% on IT whilst 60% are spent around 2.5%	Average IT expenditure at 2.56% More than 50% spent between 2% and 3.5%
Information systems (IS) priorities	Internet and intranets - priority Clinical information systems (CIS) tops the IS priority General-accounting software was the predominant application that was being used on the Intranet	65% considered CIS as the most important IS priority 73% were not willing to outsourcing clinical information systems and services	71% considered CIS as the most important IS priority Need felt to improve IS for better clinical communication for physicians 80% - No interest in outsourcing clinical information systems and services
Clinical Use of Web technology (Intranets)	60% - felt that could IT could facilitate data exchange among caregivers i.e. physician ordering of tests and access to test results	Low interest in maintaining a patient's personal health record accessible via the WWW and matching patients with clinical research. However there is renewed importance of addressing changes in this area due to regulatory obligations	Despite acknowledging that medication interaction and dosing alerts are possible within most IS - implementation has not commenced The few organizations who had made big investments in different HIS (EPR and pharmacy) are reporting substantial returns
General Uses of Web and Intranet technology	Limited use as shown by the following 15% - to share clinical guidelines13% - to access multiple databases simultaneously 33% - as a bridge to other information systems 40% - for network wide communication of any kind	Some early success from linking "billing and insurance-query operations to payers via the Web" "Significant interest …in using the Web to improve data exchange with physicians and their office staff" About 50% indicated that they had no plans to try anything Web-related in the care-management area	33% - Using existing clinical and financial information sources to construct data repositories so as to that help spot trends and improve decision-making Further 22% are working to implement such practices whilst about 13% plan to start implementation of similar activities within a year

Table 1. Modern Healthcare's annual survey of information system trends in the healthcare industry Adapted from (Morrissey, 2000, 2001 and 2002)

REFERENCES

ALPERT, M. (2001), Surgeons without borders, *Scientific American*, **285** (5), p. 28.

APPLEBAUM, S. H. & WOHL, L. (2000), Transformation or change: some prescriptions for health care organizations, *Managing Service Quality*, **10** (5), pp. 279-298.

BEAVAN, B. & FREDERICK, J. (2000), Telemedicine raises some points to ponder, *Defense Counsel Journal*, **67** (3), pp. 400-403.

BLAIR, R. (2001), Slice of life, *Health Management Technology*, **22** (2), p. 4.

CANCELA, T. A. (2001), Promises to keep, *"Health Management Technology*, **22** (4), pp. 38-40.

CHARLES, B. L. (2000), Telemedicine can lower costs and improve access, *Journal of the Healthcare Financial Management Association*, **54** (4), pp. 66-69.

COLLINS, J. (2001), So far and yet so near with telemedicine *[1DD Edition], The Times*,p. 2 (London (UK)).

CONVEY, M. C. (2000), Telemedicine concerns healthcare risk mgrs, *National Underwriter*, **104** (46), p. 8.

CROMPTON, S. (2001), Virtual hospital speeds recovery *[Final 1 Edition]. The Times*,p. 2 (London, UK).

CROSS, M. (2000), Society: "Lives online: Tony Blair has committed the government to an electronic revolution of its care programme by 2005. Is this realistic? Can IT really change the way we deliver public services? *The Guardian*,p. 2 (Manchester, UK).

EDELSTEIN, S. A. (1999), Careful telemedicine planning limits costly liability exposure, *Journal of the Healthcare Financial Management Association*, **53** (12), pp. 63-69.

EUROPEAN HEALTH TELEMATICS OBSERVATORY, (1999), Draft International Convention on Telemedicine and Telehealth, [Internet], Available from: http://www.ehto.org/legal/draftconvention.doc Accessed March 15 2000.

FISHMAN, D. J. (1997), Telemedicine: bringing the specialist to the patient, *Nursing Management*, **28** (7), pp. 30-32.

FRIEDEWALD JR, V. E. (2001), Returning home, *Health Management Technology*, **22** (9), pp. 22-27.

GARETS, D. & HANNA, D. (1998), Emerging managed care technologies, *Health Management Technology*, **19** (11), pp. 28-32.

HEALTH CARE STRATEGIC MANAGEMENT. (2000), Telemedicine will grow 40% annually, help health systems create 'centers of excellence', *Health Care Strategic Management*, **18** (2), p. 5.

HEALTH MANAGEMENT TECHNOLOGY. (2000), Advice from the American Hospital Association, *"Health Management Technology*, **21** (10), p. 12.

HEALTH MANAGEMENT TECHNOLOGY. (2001), Powering the Arizona telemedicine program, **22** (6), pp. 46-47.

HUSTON, T. L. & HUSTON, J. L. (2000), Is telemedicine a practical reality?, *Communications of the ACM*, **43** (6), pp. 91-95.

INDUSTRIAL ROBOT. (1998), Clinical telemedicine to expand by 2002, *Industrial Robot*, **25** (3), p. 15.

JOHNS, P. M. (1997), Integrating information systems and health care, *Logistics Information Management*, **10** (4), pp. 140-145.

JOHNSON, D. E. L. (2000), Telehealth expands unrealized dream, *Health Care Strategic Management*, **18** (6), pp. 2-3.

KAZMAN, W. & WESTERHEIM, A. A. (1999), Telemedicine leverages power of clinical information, *Health Management Technology*, **20** (9), pp. 8-10.

MORRISSEY, J. (2000), Internet dominates providers' line of sight, *Modern Healthcare*, **30** (15), pp. 72-92.

MORRISSEY, J. (2001), Wanting more from information technology, *Modern Healthcare*, **31** (6), pp. 66-84.

MORRISSEY, J. (2002), High on tech, low on budget, *Modern Healthcare*, **32** (4), pp. 57-72.

NAIRN, G. (2001), Technology pulls together medicine's diagnostic tools: telemedicine *Financial Times*,p. 9 (London, UK).

NHS, (1998), Overview of benefits from electronic patient records, [Internet], Available from: http://www.nhsia.nhs.uk/strategy/full/2.htm Accessed March 15 2000.

NORING, S. (2000), Telemedicine and telehealth: principles, policies, performance, and pitfalls, *American Journal of Public Health*, **90** (8), p. 1322.

PARKES, S. (2001), Medicine may be one of Wap technology's 'killer' applications: mobile services for doctors *Financial Times*,p. 4 (London).

PINTO, P. & ROCHA, R., (1999), Trends on wireless systems radio and satellite, [Internet], Available from: http://www.ehto.org/projects/trends.html. Accessed March 10 2000.

PURTON, P. (2000), Good prognosis for mobile health services: medical applications *Financial Times*,p. 24 (London, UK).

RAO, S. S. (2001), Integrated health care and telemedicine, *Work Study*, **50** (6), pp. 222-228.

SANDBERG, L. A. (2001), The pediatric promise, *Health Management Technology*, **22** (2), pp. 46-47.

SATYANARAYANAN, M. (1996), Mobile information access, *IEEE Personal Communications*, **3** (1), pp. 26-33.

SCHOOLEY, A. K. (1998), Allowing FDA regulation of communications software used in telemedicine: a potentially fatal misdiagnosis, *Federal Communications Law Journal*, **50** (3), pp. 731-751.

SERB, C. (2002), Health care at your fingertips?, *Hospitals & Health Networks*, **76** (1), pp. 44-46.

SHERER, J. (1995), The human side of change, *Healthcare Executive*, **12** (4), pp. 8-14.

SURRY, M. (2001), The cyber medics, *Asian Business*, **37** (10), pp. 46-47.

SWARTZ, N. (2000), Wireless house calls, *Wireless Review*, **17** (24), pp. 48-53.

THE ECONOMIST. (1997), Big sister is watching you: telemedicine, *The Economist*, **342** (7999), p. 27.

THE GUARDIAN (2001), Society: frontline: “How skin specialists became west country pioneers *The Guardian*,p. 10 (Manchester, UK).

TIEMAN, J. (2000), Monitoring a good opportunity, *Modern Healthcare*, **30** (43), pp. 75-80.

TREMBLY, A. C. (2001), Federal study backs use of telemedicine, *National Underwriter*, **105** (19), p. 13.

WALLACE, S. (1997), Health information in the new millennium and beyond: the role of computers and the Internet, *Health Education*, **3**, pp. 88-95.

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RAOUF NAGUIB. Prof. Naguib is Professor of Biomedical Computing and Head of the Biomedical Computing Research Group (BIOCORE) at Coventry University. He has published over 200 journal and conference papers and reports in biomedical image processing and the applications of artificial intelligence and evolutionary computation in cancer research. He has also published a book on digital filtering, and co-edited a second book on the applications of artificial neural networks in cancer diagnosis, prognosis and patient management, which is his main area of research interest. He was awarded the Fulbright Cancer Fellowship in 1995-96 when he carried out research in the USA, at the University of Hawaii in Mãnoa, on the applications of artificial neural networks in breast cancer diagnosis and prognosis. Prof Naguib is a member of several national and international research committees and boards, and has recently served on the Administrative Committee of the IEEE Engineering in Medicine and Biology Society (EMBS). He has also recently been selected to join the UK EPSRC Peer Review College and is a reviewer for the EU Directorate-General Information Society, eHealth. Prof Naguib has recently been appointed as Adjunct Research Professor at the University of Carleton, Ottawa, Canada.