The long road from potential to realized gains of information technology in healthcare – experiences from Norway

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Abstract

This paper deals with the contribution of information and communication technologies (herafter IT) in health to improve quality and efficiency in health care delivery. It also explores the technologies' potential contribution to innovation and economic development in Norway. The aim of this paper is to provide an overview of telemedicine and health IT in Norway. Using evidence from published studies this paper explores if the technologies have met the expectations and fulfilled the potential for improvement in health with focus on quality, efficiency and productivity improvement, highlighted with examples from Norway. In addition, this paper examines health IT's role in rural development, innovation and economic activity in general. This paper argues that telemedicine and IT in health has been slow to diffuse and that documented gains from IT investments are still hard to find. This paper also shows that even if IT in health has been slow to diffuse, the existing IT-use has spurred some economic activity in both private and not-for-profit companies in addition to public service provision. A full-scale implementation of health IT and telemedicine may have a significant potential for innovation and economic development in Norway.

Introduction

In the 1980s and early 1990s the rapid diffusion of information technologies in different sectors of society seemed to have little impact on actual productivity growth. This is best described by Robert Solow's famous paradox "*you see computers everywhere except in the productivity statistics*" [1]. This changed in the beginning of the 21st century. Positive impact of IT-capital on labour productivity became evident. An OECD report [2] showed that IT was having substantial impact on economic performance and the success of individual firms. It also became evident that the impact of IT on growth depended on several complementary assets such as skills, innovations, organisational factors and competition [3].

It is a strong political confidence in Norway that information and communication technologies[i] in health have the potential to revolutionize healthcare delivery. Policy documents reveal high expectations; "*healthcare is a sector where the savings of IT-use may be in the range of several billion Norwegian Kroner*" (1 billion NOK is 150 million US Dollars) [5]. This positive view seems to be shared with the rest of Europe. The following statement from the European Commission's first high-level conference on eHealth[ii] in May 2003 illustrates the political

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[i] Hamelink (1997) provides the following definition for the range of technologies that fall under the rubric of information and communication technologies; ITs encompasses all technologies that enables the handling of information and facilitate different forms of communications among human beings, between humans and electronic systems and among electronic systems. These technologies can be sub-divided into capturing, storage, processing, communications and display technologies [4].

[ii] EHealth in this context is defined as; "*the application of information and communication technologies (ICT) across the whole range of functions that affect healthcare, from diagnosis to follow-up*" [6].

importance of e-Health; "*eHealth is the single-most important revolution in healthcare since the advent of modern medicines, vaccines, or even public health measures like sanitation and clean water*" [6]. This optimism is not confined to the health sector only. The latest eEurope action plan aims to provide a favourable environment for private investment and for creation of new jobs, to boost productivity, to modernize public services and to give everybody the opportunity to participate in the global information society. This through secure services (eGovernment, eLearning, eHealth and eBusiness) and a widely available broadband infrastructure [7].

The term "information technologies in health" usually refers to the use of modern information and communication technologies to meet the whole range of healthcare needs of citizens, patients, healthcare professionals, healthcare providers as well as policy makers. Telemedicine is a component of the broader term IT in health and can be understood as health related activities and services carried out over a distance by means of IT. In this paper we will mostly give examples from telemedicine services and systems, but IT-use in health in general will also be discussed.

IT in health has potential for both cost reduction and increased productivity especially in areas like administration, purchasing and supply chain, but also in care coordination.[iii] The latter can be improved trough electronic patient records, appropriate access systems and electronic information exchange between different actors and levels in the healthcare system. Moreover, modern communication facilities may also improve access and reduce the cost of proving healthcare to remote areas and

[iii] This paper deals with clinical health IT and not management IT.

local communities through real-time consultations and store-and-forward telemedicine using for instance digital images and sound files.

These are direct and potentially measurable savings of IT as a capital input in healthcare. Productivity and efficiency improvement can also generate indirect benefits to the rest of the economy. A healthier workforce, less time off work due to illness and lower public health expenditures can improve productivity and growth economy-wide. It has been argued that providing high standard healthcare via IT and telemedicine can sustain and strengthen rural communities and may counter rural-urban migration [8]. It has also been argued that the use of IT in health may have potential to make rural communities more appealing for health personnel to work and live in and spur economic development trough local IT business initiatives [9].

The aim of this paper is to provide an overview of IT-use and telemedicine services in Norway. Using evidence from published studies this paper explore to what extent the technologies have met expectations and fulfilled the potential for improvement in healthcare delivery performance. This paper focuses on the potential impact of health IT on quality, efficiency and productivity, highlighted with examples from Norway. In addition, health IT's role in innovations and economic development is explored.

Norway - an Overview

Norway is one of the world's northernmost countries, making up the western and northern part of Scandinavia. The country has a population of approximately 4.5 million [10] with the majority living in the southern on-third of the country and in communities scattered along the coast. The northern region is sparsely populated with long distances between the communities. Norway is endowed with natural resources - petroleum, hydropower, fish, forests, and minerals. In 2004 GDP was 250 Billion USD. In 2005 the overall GDP grew at 2.4% and the unemployment rate was 4.6% [11]. It is a strong political commitment to maintain viable local communities and facilitate a sustainable demographic pattern in all parts of the country with special emphasis on fishing and farming communities. This is reflected in all parts of politics from education and health to industry. One of the political strategies to secure sustainable economic prosperity for rural and remote areas is to promote high-speed Internet access throughout the country with the government funding rural broadband development in areas where it is not commercially feasible [12].

The government is funding and administering most public services including transport infrastructure, education and healthcare. The public sector accounts for almost one fourth of mainland investment and a third of the total labour force [13]. The costs of providing public services have increased considerably over the last decade [14], and one of the main challenges for the public sector is to increase efficiency to be able to meet future demand from an increasing elderly population with a decreasing workforce.

The Norwegian Health Care System

Norway has developed a national health system funded by general taxation to cover the health care needs of the population. The Norwegian healthcare system is based on the principles of universal access to healthcare and decentralization of production and delivery of services to local governments. The system operates at three levels. At a national level the Ministry of Health and Care Services is responsible for legislation, policy development, budgeting and planning and information management. Five regional health authorities are responsible for planning and provision of secondary care services like in-patient care and specialist services. The municipalities are responsible for the provision of primary care including disease prevention, health promotion and social care. The health care expenditure as a percentage of the GDP was 9.6 in 2002 [15].

All residents of Norway are insured under a compulsory national insurance scheme. All insured persons are granted free hospital in-patient treatment including all medicines. Most travel cost associated with acquiring health services are also covered by the government. The patients themselves only pay a small user-fee for out-patient consultation at the hospital in addition to co-payments for laboratory tests, X-rays, some pharmaceuticals and travels. The patients also pay a limited share of the costs of treatment at primary physicians, psychologists, physiotherapist, chiropractors and some prescriptions. The patients' first contact with the health care system is usually with a primary care physician. If the primary physician needs assistance he/she sends a referral to a specialist at a secondary care hospital. The patients are free to choose both primary and secondary care providers.

IT- Strategies and Status

There is a strong political commitment in Norway to support activities to develop and implement IT in all sectors of society [16]. Like most of the European countries Norway consider information technologies so central to national economic growth that the Government has initiated national "e-strategies" within almost all major areas in public management [17]. In the most recent strategy "eNorway 2009", the authorities still emphasize the need for an active political involvement in development of a modern information society [14].

Several reports and action plans for IT in healthcare have also been initiated during the last two decades. The first national action plan for health IT and telemedicine was published in 1996 ("More health for every bIT") [5]. This plan focused on IT and telemedicine as a tool to modernize healthcare and to use the technology to enable development of more locally-based services. In 1998, the Ministry of Health and Social Affairs formed a committee with a mandate to further assess and implement IT and telemedicine services in healthcare. This committee had members from both the Ministry of Trade and Industry and the Ministry of Municipal and Regional Affairs. In addition to focusing on IT's impact on quality and efficiency this report highlighted the importance of supporting the technologies' potential to strengthen rural communities and spur economic development trough local IT business initiatives [9].

The current national action plan for IT in healthcare "Te@mwork 2007" [18] is the third action plan in line. This plan repeats much of the content from earlier plans with the main focus on the need for increased electronic information exchange between all parties in the health and social sector.

Norway is considered an advanced country with regards to general use of IT. 35% of the households have broadband access. 74% of the citizens have a personal computer (PC) at home and 63 % have Internet access at home. 58% use PC on a daily basis while 50% of the citizens are daily Internet users [19]. There exists few statistics about the supply side for the use of IT in the public sector. Moreover statistics on the demand side shows that 69% of all Norwegian enterprises and 52% of the citizens interact with public agencies using the Internet [20].

Health IT and Telemedicine in Norway

Brief History and Status

In 1988 the Norwegian Telecom Company launched a large project with the purpose of testing if videoconferencing was a practical and safe method of providing healthcare services to the people living in remote areas. Telemedicine case studies were initiated in pathology, dermatology, ear, nose and throat (ENT), microbiology, psychiatry, gastroenterology, and cardiology. Most of these projects continued as small-scale routine services [21].

To be able to transmit patient sensitive data between institutions a secure health net was established. This network became in 2004 a nation-wide secure computer network (the Norwegian Healthnet) owned by the five regional health authorities. The health net is built on open-source Internet technology with focus on information security, capacity and availability [22]. All public hospitals in Norway and about half of the primary physicians and some private specialists are connected to the health network.

In addition to a secure network, electronic patient records (EPR) are a necessary condition for IT and telemedicine services to be optimally utilized. More than 90% of hospitals and primary physicians in Norway use

EPR. Several different EPR-systems are installed at different institutions. These different EPR do not share data between them. More work is needed to establish a common framework for the content of the EPR, national procedures and databases. A strategy to improve these aspects is now being work out [24].

Telemedicine System and Services

Telemedicine can be divided into synchronous and asynchronous services. Synchronous telemedicine services is sessions where the patient and the healthcare personnel meet in a real-time consultation using videoconferencing providing two-way live audio and video interaction. Videoconferencing is used for meetings, distance education and direct patient examination and treatment. One of the first telemedicine applications to become a routine service in Norway was teledermatology, which linked the specialist at the largest secondary care centre in northern Norway to a studio at a local hospital in Kirkenes, 800 km away. The primary physician and the patient were consulting the specialist via a video-link, supported by close up-images captured by a video-camera. This service has been provided to the patients in the Kirkenes area since 1989 and to the Hammerfest area since 1996 [25]. In 1993 the local hospital in Kirkenes purchased a phototherapy machine together with other special equipment enabling treatment of the patients locally as well [26]. In 2002 the number of teleconsultation in dermatology at the specialist centre was 615 per year (3.4% of the total consultations at the specialist centre). This number has however dropt to 168 per year in 2005 (1.1% of the total consultations at the centre). Other medical specialities that use real-time videoconferencing are ear-nose-throat, psychiatry, emergency medicine, dialysis and adjustments of hearing aids.

Asynchronous telemedicine services are services transmitting still-images or audio-files from primary physicians to specialists. These are either sent in a secure e-mail system or are included in an electronic referral and sent to a specialist. This type of referral provides information and patient data that enables the specialist to make diagnosis and recommend treatment without seeing the patient face-to-face for a physical examination. If the information in the referral, the quality of the still-images or audio file is not adequate for a decision about treatment, the information may be used for triaging at the out-patient clinic. In teleradiology, digital x-rays together with case histories are transmitted electronically from one location to another. By the end of 2005 nearly 100% of the hospitals in Norway had installed digital radiology equipment including radiology information system (RIS) and picture archiving systems (PACS) [27]. Teleradiology is used for instance in neurosurgery to decide on patient transfers and treatments [28]. Other examples of store-and-forward services are consultations in dermatology/ulcers, ENT, heart murmurs in children, pathology and ophthalmology.

The electronic messaging service is aimed at improving the coordination of care through making treatment and administration of the patients more efficient. Today it replaces traditional letters sent by postal mail. A wide range of messages are being sent. Among the most frequently electronically sent messages are laboratory reports, electronic discharge letters and radiology and pathology reports. 28% of all discharge letters from hospitals to primary physicians are sent electronically and the number have been stable over the last couple of years [29].

Healthcare institutions in the northernmost health region "Helse Nord" have established routine messaging services. Table 1 shows the type and number of electronic messages sent from the hospitals to the primary physicians in this region[iv]. The total number of messages was almost one million in 2005, an increase of 32% from 2004 and 113% from 2003. The total number of electronic messages sent from the primary physicians to the hospitals and between hospitals was 93 700 in 2005, where 62% of these messages were electronic referrals. The overall aim is to replace all traditional information exchange with electronic messaging services within all five health regions [18]. This requires that patient information is easily transferred from the EPR to the electronic messaging system and vice versa.

Table 1. Number of messages sent electronically from the hospitals to the primary physicians in the northernmost health region* in 2005

Type of electronic messages	Number	%
Discharge letter	370 597	38.1
Laboratory result	465 428	47.8
Radiology report	75 632	7.8
Pathology report	33 568	3.4
Receipt	23 045	2.3
Other	4 704	0.5
Sum	972 974	100.0

*There are 11 hospitals in the northernmost health region; Helse Nord. Nine of them are small local hospitals and two are central hospitals.

While electronic messaging has become relative high-volume services, much of the remaining telemedicine activities are sporadic and often driven by enthusiasts.

[iv] Data from the other four health regions were not available at the time of writing.

Telemedicine services are mostly provided by secondary care centres to local hospitals and primary physicians in the northernmost region of Norway. This region is sparsely populated with long distances between the communities.

Other parts of the country have few telemedicine services with highest activity in radiology. Most of the telemedicine projects however have not reached beyond the project phase. Regional health authorities are now making an effort to integrate telemedicine services in community hospitals or intermediate care centres instead of primary physician offices.

Reimbursement

As of 1996, telemedicine defined as a consultation where the patient together with a physician consulting the specialist from a distance, became officially reimbursable. The specialist hospital is reimbursed trough a fee-for-service system for all telemedicine activity at the out-patient clinic. As of 2003, still-image telemedicine in dermatology and ear, nose and throat (ENT) became reimbursable at the out-patient clinics as well. The primary care physician however is not reimbursed for their time in a telemedicine consultation, but they can bill the health authorities if a telemedicine consultation last longer than standard consultations.

IT as Capital Input in Healthcare

The healthcare sector is different from most other service sectors. Healthcare production is technology-intensive and knowledge-driven. Advances in medical technologies and knowledge have improved treatment possibilities and health outcomes and has been one of the main contributors to the increase in health spending. The sector is fragmented with the supply side including many different professionals and institutions at different levels (primary, secondary and tertiary health care) in addition to providers of pharmaceutical, medical devices, supplies and equipments. On the demand side patients have little or no information about potential diagnosis, appropriate providers and treatments and hence rely on health professionals to advice them on appropriate and effective treatment as well as to implement care. The complexity of the health sector however may make the adoption of health IT investment a bigger challenge than for the rest of the society.

Improvement in Quality and Access to Care

The safety or efficacy of the telemedicine services must be established before implementation. A review of efficacy studies of telemedicine carried out by Hersh et al. found that only a few of them revealed evidence that the diagnostic and management decisions provided by telemedicine was comparable to face-to-face care [30]. Efficacy studies carried out in Norway have analysed dermatology [31], pre-recorded heart sounds [32], ENT [33] and they all showed that using store-and-forward technology was a safe mode of consultation. But relatively few attempts and even fewer successful attempts, have been made to demonstrate that telemedicine actually improve patients' health [34]. Currell et al. [35] conducted a review of seven trials of telemedicine services, but could not find evidence of clinical benefits. Hersh et al. [36] found some evidence that telemedicine in home care for specific diseases could produce favourable clinical outcomes.

Telemedicine however offers an opportunity to improve access and quality of healthcare in rural areas. Healthcare researchers often define rurality as distance from healthcare facilities. Characteristics of rural areas are: ageing population because of migration, loss of services resulting in more and longer travels, inaccessibility, sparser infrastructure and pockets of deprivation [37]. In Norway especially in the northern region many people live in remote areas with long distances to medical specialists and hospitals. Telemedicine may be a useful tool to bring the services closer to where people live.

Several local hospitals in Norway have a shortage or even lack of radiologists. A distributed radiology service have made it possible to send radiology images between domestic hospitals as well as to hospitals abroad to utilize excess capacity. One other example where telemedicine is used to improve access for the patients is the real-time dermatology service mentioned earlier. The patients suffering from psoriasis receive phototherapy at the local hospital supervised by a specialist via videoconferencing and hence avoid a two-week stay at the specialist centre with the following production loss. The patients are staying at home for the whole treatment phase avoiding both travels, in-hospital stays and they can work as normal [38]. Other examples of services that are bridging distances are; radiotherapy, where remote supervision has been tested and found feasible for small or local radiotherapy centres [39], remote examination of dialysis patients via videoconferencing and monitoring of the haemodialysis machine where hospitalizations and planned ambulatory visits were avoided [40] and still image referrals in ophthalmology as a part of routine check-ups for retinopathy for diabetes patients, avoiding travels [41].

Telemedicine may also be a tool to recruit and keep qualified healthcare personnel in rural areas. Experiences have shown that if the students are recruited and trained locally it is more likely they to choose to work in their local community as well. 75% of the medical students recruited from and educated in the northern part of Norway worked in the region upon graduation [42]. IT may be used to partly train students locally and for in-service training of other healthcare personnel. The potential for basic and further education may also be substantial.

Efficiency and Productivity Improvement in Healthcare Production

Health IT and telemedicine offers potential improvements in healthcare operational efficiency and productivity and an overall reduction in healthcare costs. Productivity measurement in health care however is a complex endeavour. The main output of the healthcare sector is health improvement. Health care production is a multiple output activity where the quality of the output is essential for efficiency. In addition, this is further complicated by lack of information on prices and quality measures.

A typical economic analysis of telemedicine services and systems is assessing whether telemedicine is performing in a clinical acceptable way in addition to comparing the costs with the costs of conventional service delivery. At present, the primary savings of telemedicine services are avoided costs of patient travels to secondary care hospitals. These travel costs are covered by the public health budget. In the northernmost health region the travel expenses amounts to 15% of the total budget for secondary healthcare services. Since telemedicine has the potential to reduce travel costs, these savings can be used for other healthcare purposes. This may increase efficiency in health care delivery by allowing more patients into the system at equal or less costs. This however will require that telemedicine services cost less than the total aggregated savings.

Several studies have documented that IT and telemedicine services are less costly than traditional methods (see for example Harno et al. [43], Ohinmaa et al. [44]). Other studies found telemedicine services and systems to be more costly (se for example Jacklin et al. [45], Rumpsfeld et al. [46] and Kopach et al. [47]). Some studies also found telemedicine to be more costly and more effective. For example Kopach et al. found that an electronic medical documentation system both increased costs and effectiveness. The latter by reducing the average time of note completion per discharged patient [47]. In such trade-off situations decision-makers must decide if the extra benefit of telemedicine is sufficient to justify the extra cost.

Even if there has been an increase in published literature on telemedicine in the last decade reliable evidence that telemedicine is a practical and effective alternative is still hard to find [34]. Review studies have found few good-quality studies of telemedicine interventions and the generalisability of most assessments were limited [48-50]. In a recent study Hailey (2005) calls for more information on costs and effectiveness to help decision makers define the appropriate scope and application of services in different settings. He further argues that the most immediate needs seem to be improvements in conduct and reporting of results and additional information on the performance on telemedicine services and systems under routine conditions [51].

Integration of telemedicine services and systems into day-to-day care activities in an organisation is a major task that needs to be addressed in order to develop successful services. The technical and organisational support required for telemedicine to operate between geographically spread institutions at different levels is substantial. Real-time telemedicine is especially resource demanding. The patient first consults the primary physician and if a specialist consultation is needed a referral is sent. When the specialist has decided that the patient can be seen over the video-link, the consultation is scheduled. Then the patient and the primary physician are consulting the specialist in a videoconferencing session. All real-time video-consultations in Norway have two medical doctors present where one of them is the specialist and the other is the referring physician. This is not a legal requirement only a strong recommendation from the medical community itself. This is time-consuming especially for the primary physicians seeing the patients for a second consultation, which would have been avoided if he/she used traditional referrals to a specialist centre. In addition to expensive equipment, bandwidth and support, the practice with two medical doctors present simultaneously during a patient consultation adds to the expenses of the service and does not contribute to increased labour productivity. As medical doctors are scarce resources, allocating these resources more effectively may produce more health outcome and increase efficiency.

Store-and-forward applications on the other hand have a greater potential to increase productivity and efficiency in health. Still-images of skin problems for instance can be sent electronically from a primary physician or a community nurse to a specialist. The time it takes for the specialist to review and recommend treatment is less than the time it takes to see the patient in person at the centre. Loan et al. (2000) estimated that a store-and-forward consultation took an average of 2 minutes [52]. Another telemedicine store-and-forward service that is less time consuming than traditional care is the use of digital imaging when screening for retinopathy. It takes less time for the specialist to grade images than to conduct the examination at the out-patient clinic. The retina images can be taken by a nurse or a technician and stored at the hospital or transmitted from rural health clinics. Luzio et al. (2000) reported that the average time it took for the specialist to grade each patient was approximately 5 minutes [53]. A third store-and-forward telemedicine with a potential to save specialist time is the use of electronic sound-files for examination of children with heart murmurs [32]. All these services have potential to improve productivity by saving specialist time.

Information systems and electronic information exchange may have a potential for both quality and efficiency improvements. A rapid and safe sharing of information may improve the coordination of care through modern and streamlined procedures for all staff. IT may also provide rapid access to the latest knowledge, evidence-base and clinical guidelines for improved decision making and professional development. Information systems may better monitor performance and plan future services. IT also has the potential to provide faster communication between professionals and between professionals and patients. Future research should establish both the potential and actual benefits of such clinical IT and information exchange systems.

IT alone is not sufficient for efficiency and productivity improvement. The impact of IT on productivity is contingent on other complementary factors such as, training, innovations, organizational and cultural adjustments. Kuhn and Giuse (2001) found that today's core problems with IT-investments are integration, human-computer interaction, socio-technical issues, and support of processes. They also point out that further investment in IT may not necessarily bring on higher organizational productivity [54]. The hardware and software proportion of

IT investment programs is modest (20%) compared to the associated intangibles and organisational components [55]. Effective use of IT requires a holistic solution that recognises that success needs a series of interrelated forces to interact, which is a difficult task for all organizations.

Skilled personnel are an important component for health IT to maximize its potential. Implementing management IT system in health care is quite different from implementing clinical IT systems or telemedicine. Silverstein [56] highlights the importance of medical knowledge and hands-on care experience to avoid IT failure in healthcare. Many potential users lack the time or resources to learn how to use these technologies effectively.

Some health IT systems are insufficiently tailored to requirements of their users [57]. Tailored and user-friendly technologies that are used on a regularly basis are more likely to be integrated into daily working routines. To include a sound-file with heart murmurs for instance into an electronic referral will require some experience in using the electronic stethoscope and in transmitting the sound to the computer. Experience from the northern part of Norway shows that the incidence of heart murmurs in children are too low to give the primary physicians the hands-on experience they need to actually use the technology in a patient consultation.

IT in Health and Network Externalities

National gains from IT investment in healthcare can be realized partly from aggregation of productivity and efficiency improvements in healthcare institutions, aggregated productivity gains in firms and industries due to more healthy workers, but also from IT based networking between actors and institutions. Network externalities result from positive feedback. As the base of users increase more and more users find adoption worthwhile. Every new clinic or institution that connects to the health network is advantageous not only to the new connector, but to all other in the network as well. It has been argued that the networking must reach a critical mass of users before such externalities are realized and for this to improve overall efficiency [58].

Until recently the healthcare institutions did not have a common communication infrastructure. As of 2004 the national health net has been operational connecting all hospitals to the network. But since only half of the primary physicians and only a few nursing homes and home health care personnel are connected, the potential positive network effects may still be limited. A common infrastructure is not enough for a smooth communication. Interoperability has become a major issue in the healthcare. Interoperability is the ability of software and hardware on different machines from different vendors to share data. There is a lack of standards, common concepts and coding, which is crucial for information exchange between the actors in healthcare. Two main suppliers dominate the market for electronic patient records and patient administrative systems for hospitals and primary physicians. Three different systems are implemented at hospitals while the primary physicians have six different systems. This cause problem when patient relevant information is exchanged between the systems. Staff at the primary clinics has for instance been rewriting the patient information from an electronic discharge letter into their specific EPR-system. To overcome this problem software suppliers are now designing new communication modules that can operate alongside the old systems, avoiding large switching costs for health institutions. Switching costs arises if a firm or organisation needs to re-invest because their existing technology is incompatible with other tools. Once a technology or a format for storing and exchanging information has been chosen switching can be very expensive [58].

IT as a Product: Innovation, Research and Service Production

The evolution of telemedicine services and systems consist of several stages from development of technical prototypes to large-scale implementation. Some services require development of completely new technological solutions while others rely on well known technologies adjusted for use in healthcare. Alongside this technological evolution different forms of evaluations and research are conducted; evaluation of technical and medical efficacy in the prototype phase, user assessments and outcome evaluations. The pure IT and telemedicine technologies are always parts of a larger system consisting of networks, security solutions, general computer equipment etc. Suppliers of IT products, IT consultants and IT-service providers are essential both during and after the implementation phase of IT in health.

A significant contribution to the development of health IT and telemedicine are given by national competence centres. These are contributing with research, development and consulting activities aimed at decision makers in health, health care personnel and others. These are publicly financed and most of them owned by national health authorities. A brief description of four such centres is given below:

The Norwegian Centre for Telemedicine (NST) [59] is a part of the University Hospital of North Norway and is a research and development centre that aims to gather, produce and provide knowledge about telemedicine both nationally and internationally. The NST works actively to ensure that telemedicine services are integrated into health service provision. As of 2002, WHO designated NST as a Collaborating Centre for Telemedicine.

The Norwegian Centre for Health Informatics (KITH) [60] is a company owned by the Ministry of Health and Social Care, the Ministry of Labour and Inclusion and the Association for the Municipalities. KITH focuses on standardisation and coordination activities related to codes and terminology, electronic information exchange, information security, EPR and digital imaging systems in radiology.

The Norwegian Centre of Electronic Health Record (NSEP) [61] was recently established at the Norwegian University of Science and Technology (NTNU), with funding from the Research Council of Norway and the University itself. The objective of the centre is to perform multidisciplinary research and university-level education related to EPR-systems.

The National Centre on Emergency Health-Care Communication (KoKom)[62] is a public centre working with emergency medicine and owned by the Ministry of Health and Social Care. The objective of the centre is to act as advisor to both national and local governments on the use of dispatch centres in healthcare. The centre is also a member in a national committee assessing if Norway should accept TETRA as a national standard for radio communication in emergency health services.

Research and development (R&D) activities within IT and telemedicine are also carried out in traditional research institutions, hospitals and universities. The Research Council of Norway initiated a large research programme (ICT in healthcare and medicine), designated to cover research and development within IT in health. 42 health IT-projects (most of them PhD-projects) have been funded through this particular programme since 1998 [63]. Other national R&D-programmes have also funded health IT research and development. Private consultancy firms have been involved in health IT and telemedicine projects in Norway. They have assessed potential benefits, analysed actual benefits of IT in health and they have been involved in improving the cooperation between research institutions and providers of IT systems to create a more flexible market for new health IT-applications.

In addition to a supply of products from existing IT firms, new innovative private companies have been established as a result of spin-offs from research and development activities related to IT in health. These companies are mostly providers of customized software for IT-systems within hospitals and communication solutions between institutions. One such spin-off company is Well Diagnostics [64]. They develop and provide applications within areas like medical multimedia handling, system integrations and secure communication between health institutions.

Other private companies providing solutions that maximize gains from existing IT investments by building seamless integration are also providing software for healthcare institutions. Communicate [65] is one such firm. They have delivered solutions for electronic processing to almost 40 hospitals in four out of five health regions in Norway since 1997. Their solutions are used to integrate different applications within and between health centres, between regional health authorities and for integration with the primary healthcare providers and other external partners.

Close links between research institutions and the IT-industry is important to ensure an efficient transfer of new technology and knowledge. Public funding has been made available to ensure joint R&D-ventures with leading IT providers. Such joint ventures' main objective is to develop systems that ensure convergence of different application interfaces. Providers of EPR- systems are for instance participating in R&D-projects to ensure information exchange between the different EPR-systems.

Public and private providers of IT service such as management of hardware and software, operations, and software maintenance are growing. IT workers in healthcare are increasing in numbers especially in connection to hospitals. A 480-bed hospital for instance employed approximately 47 IT-workers in 2005, an increase of 132% in 10 years (see Table 2).

Table 2 Number of employees at University Hospital of North Norway

	1996	**2006**	**Change**	**Change in %**
IT-personnel	20	46,45	26,45	132 %
Total employees	2800	4200	1400	50 %

IT-use in healthcare has created new jobs both in research, development and service production, and these will most likely continue to expand in the years ahead. There will probably be a substantial market for IT management both for support and software development like new inventions, new versions and up-grades.

Discussion and Conclusion

Healthcare in particular suffers from a shortage of research on quality, productivity and efficiency of IT investments. Possible explanations for this is that healthcare institutions have been relatively slow to adopt IT, health IT usually result in quality rather than quantity or cost improvements, and the industry is capital-intensive which can make it difficult to separate out the effects of IT [66].

New technologies are often slow to diffuse. It takes time to make organisational adjustments, to train the workforce, to implement effective work processes and to adopt new technologies into the organization culture. The latter may be a particular challenge for the healthcare system due to a high degree of tacit knowledge (the clinical eye and mind) and hands-on experiences which may be difficult to transform into textual information fit for IT-systems.

Modern information technologies are in essence about storing a huge amount of information, spread it widely, and making it as accessible as possible. Healthcare on the other hand has core principles like thrust, privacy and security and patient confidentiality is protected by law. This makes healthcare IT to be especially concerned with security and responsibility issues. IT applications in health need to build on systems that meet confidentiality requirements and uphold the right to privacy of those whose information is stored or processed. This requires that all IT-systems and services and communication infrastructure in health is built on technologies that enhance security, privacy and confidentiality. These requirements may further slow the process of healthcare adopting IT-systems and telemedicine services.

The actual realization of the potential gains of health IT and telemedicine has been difficult to achieve. The real impact of IT in health is still largely unknown. Most services and systems have not made it pass the pilot or project phase and decisions are still based on intuition and limited evidence from a narrow range of pilot projects and small-scale impact assessments. Without better understanding of the real impacts of the technologies both in terms of costs-benefit and organisational implications the pursuit of over-ambitious, unrealistic goals may mean that scarce healthcare resources are misapplied and worthwhile services are under-provided.

It may even be that IT and telemedicine for diagnostic and treatment purposes has reached its potential or that the actual potential is less than anticipated. Medical specialities that traditionally use images for diagnostic purposes like for instance radiology may be one of the few fields were the technology is successfully implemented and adopted into the organisational culture. The technology may also have a potential in highly visualised fields like dermatology for both treatment and triaging. But other specialities where hands-on care is an important part of the examination, telemedicine may neither be appropriate nor beneficial. In the future real-time telemedicine may only be a useful tool in situation where the benefits are large and evident. Videoconferencing may for instance be a useful option in life-threatening emergency situations where the medical specialist is at a different location from the patient and the weather condition makes emergency transfer impossible. To establish telemedicine's actual potential should be a priority in future research.

Future health IT and telemedicine research should also focus on the underlying issues of how the patients, physicians and specialist can communicate more effectively using a wide range of technologies. Ensuring that the most appropriate technologies are used in the most cost-effective way should be the primary aim of developers and researchers within the telemedicine field [34].

Even if IT in health has been slow to diffuse and there is a shortage of research on the impact of the technology, the existing telemedicine and IT-use has spurred some economic activity in private, not-for profit companies and in public service provision. A full-scale implementation of IT in health may therefore have a significant potential for innovation and economic development in Norway.

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