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A Review of Telemedicine Services in Finland

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Abstract— **Telemedicine is gaining popularity due to the provision of ubiquitous health care services that is a fundamental need for every socialized society. In this paper, telemedicine services in Finland are discussed, as well as how they came into existence, how they are funded, evaluated, and what are their impacts on health care systems and society. Telemedicine services like teleradiology, telelaboratory, telepsychiatry and remote consultations, are being offered in all hospital districts. Primary health care centers in Finland are lacking telemedicine services, and are planning to have them. Electronic Patient Records (EPR), with e-referral and e-discharge letters, have prevented patients from unnecessary repeated laboratory examinations and treatments. The e-Archive (Finland's national EPR) is in the planning stage, making EPR on national level, to promote ease of access to patient records and ubiquitous care. The e-Prescription project is also in the planning stage, which aims to enhance drug safety, prevent forged prescription, and prevent threat to a patient's life.**

Keywords— **Telemedicine, Teleradiology, Finland, Ubiquitous Care.**

I. Introduction

Telemedicine results from the contribution of Information and Communication Technology (ICT) towards heath care, and the improving health and welfare of society. This is achieved by providing ubiquitous health care services to remote regions. Telemedicine has many advantages, such as serving people in remote areas due to unavailability or lack of health care professionals, and improving health care quality via consultations with specialists. The biggest considerable advantage of telemedicine is the savings of time (travel to appointments, requirements for both patient and professional to be available, administrative tasks, etc.), cost (organizational work load, administrative resources, reduced travel, utilization of consultation services at a distance, etc.), and effort for a patient.

Finland is a Nordic country in Northern Europe, with a population of 5.3 million people. Finland's northern areas cover about 30% of the total area, even more, these areas are sparsely populated. Even though citizens in these areas may have access to primary health care, they are consistently lacking specialized care. For patients in northern areas, it can be very difficult to visit Oulu district hospital for special care. Teleradiology was the first telemedicine application started in northern areas of Finland that improved the health care system and eventually benefited patients, heading towards Finland's goal for the completion of the ubiquitous health care dream.

Finland has good international relations and supports international research and development programs, particularly in the areas of ICT and health care services. Finland cooperates with its neighboring country Russia in many development programs and has bilateral agreements on education, health and economic co-operation. Finland is among the first three countries who established the first international teleradiology connection in the world, and it was established between university hospitals of Oulu (Finland), Reykjavik (Iceland), and Tromsoe (Norway) [1].

After an introduction to telemedicine highlights in Finland, the article is organized as follows: section 2 highlights the background of telemedicine in Finland; section 3 describes about the methodology involved in this paper, how the literature was collected and reviewed; section 4 discusses current applications of telemedicine in Finland, and factors associated with its implementation and evaluation; and section 5 summarizes the literature studied. The paper concludes with discussion and future implications for telemedicine systems in Finland.

II. Background and Status of Telemedicine Services

This section discusses about the Finnish Health Care system, the background of telemedicine services in Finland, how they were evolved, evaluated, implemented and adopted in the Finnish Health Care system. Furthermore, it describes the current telemedicine development, and the status of telemedicine services according to a survey made in 2005.

Teleradiology refers to electronic transfer of radiological images such as x-ray, computed topography (CT) images and magnetic resonance images (MRI) from one clinical setting to another for diagnostic purposes. The first experiments took place in 1969, but did not enter the practical world until the

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beginning of 1990's. Telemedicine services were a major interest in the sparsely populated northern areas, but services quickly spread around the country [2]. Finland has an extensive health care system, comprised of 21 hospital districts including five university hospital districts (Helsinki, Tampere, Kuopio, Oulu and Turku). One hospital district provides specialized health care to several primary health care centers in its area [3]. Private health care in Finland comprises of private clinics and private hospitals. The physicians working at private clinics are mostly specialists who work full time at a public hospital. By 1994, all five university hospital districts had teleradiology services implemented. Hospitals utilize teleradiology services to transmit radiological images to specialists such as neurosurgeons, and the neurosurgeons, after analyzing and studying the images used to report or consult, would contact the client's hospital via telephone earlier as all data networks were implemented simplex i.e. one-way, but later on they started reporting and consulting via videoconferencing.

Finland has implemented an electronic patient record (EPR) system as a primary patient database in its health care system; however, some records are kept and presented in traditional paper format. Oulu University Hospital has used multimedia medical records since 1995, and now they have merged e-referrals and e-discharge letter features to this. In 2005 [4], 16 out of 21 hospital district were providing e-referrals and e-discharge features to its subsidiary health care centers. These features allow health care professionals to view a patient's electronic record along with laboratory results and the imaging database, thus avoiding unnecessary examinations. Imaging databases include x-ray, and DICOM (the Digital Imaging and Communications in Medicine) format radiological images such as computed tomography (CT), ultrasound (US), and magnetic resonance imaging (MRI) images [1]. The EPR usage in Finnish health care system in 2005 [4] is shown in Table1.

Finland has also produced the first pocket-sized Nokia Communicator PDA (Personal Digital Assistant) device with integrated GSM phone, under the EU funded MEMODA project (Mobile Medical Data) during the years 1998-2000. These PDA terminals were utilizing GSM data pathways, helping physicians to view DICOM images on a secure connection and proved to be most effective for neurosurgery department. These PDA terminals were enhanced during the years 2002-2004 under the EU funded PROMODAS project (Professional Mobile Data Systems). The major enhancement was upgrading transport technology to GPRS (General Packet Radio Systems) that eventually reduced the system operating costs, and it is in clinical use these days [1].

The pharmacies in Finland are required to check every prescription by law. According to The Association of Finnish Pharmacies, pharmacies have to cope with over half a million unclear or inaccurate prescriptions for medicine every year, such as wrong dosage for a medicine or unavailability of drug in the market or prescribed medicine effects CNS (central nervous system). These checks have also revealed forged prescriptions and even fake physicians [5]. Therefore, Finland started a national e-Prescribing pilot-project in 2004-2006 [6], covering two hospital districts and a couple of primary health care centers involved with it. A doctor creates a prescription with a legacy system, signs it with electronic signature, and sends a SSL secure message to national prescription database referred to be as the Prescription Centre. When a patient goes to a pharmacy, pharmacist accesses the database, makes required changes, marks dispensing information on the electronic prescription, signs the markings with a personal smart card, and saves the markings to the prescription in the database. Then, the medicine is dispensed to the patient.

Table 1 EPR usage in Finnish health care system

Quantity	Hospital District	Primary Health Care	Private Health Care Providers	Status	Usage intensity
17	×			In use	> 90%
1	×			In use	50 – 60%
2	×			In use	25 – 49%
1	×			Planning	
229		×		In use	> 90%
3		×		Testing	
8		×		Planning	
11		×		Merging with neighbor	
25			×	In use	> 90%
3			×	---	

The Prescription Centre is accessible to health care professionals and pharmacists through a professional smart card, issued by Valvira (National Supervisory Authority for Welfare and Health). The Prescription Centre will contain other information along with medicine name such as pricing, interchangeable products, and clinical nutrients. The legislation for e-Prescription has been accepted in December 2006, and a national e-Prescription database has been

created by the Social Insurance Institution (KELA). After a successful implementation, the patients will still have a right to choose prescription on paper [6]. It is aimed to be fully integrated with different EPRs to cover all pharmacies, and to reside continuously updated knowledge about all prescribed drugs of the patients, which will offer a platform for drug safety decisions. The prescription information is stored in the Prescription Centre for 30 months only, and then is archived in the Prescription Archive for 10 years, and then destroyed. It will help health care professionals to view, subject to a patient's oral consent, a patient's previous treatments, medication, avoid adverse drug interactions, and overlaps. The stored data can be used for supervision, drug safety operations, the payments for drug reimbursements, and research.

The health care system uses different systems for information management, which makes the distribution of patient's records complex, limiting use of systems, increasing costs, and paper archive preferred. Therefore, the Government of Finland decided to implement EPR on a national level rather than on a regional level, and store the records in a uniform technical format so that it can be distributed and accessed evenly. The National EPR project is expected to be finished by the end of 2011, and is maintained and handled by the Social Insurance Institution (KELA). The legislation for the National EPR was laid out in December, 2006 [4], and it will reside on a national public key infrastructure (PKI) for health care professional. The patients can refuse publishing of their records in the directory database, and their records can only be seen with an oral consent. The National EPR will offer citizens to view health information, such as reference and discharge letters, certificates, statements, results of examinations, and log data about visits to the personal health records, eventually making the system more secure to view without oral consent of a patient.

Other telemedicine applications include: sending laboratory or pathology results to physicians or specialists; telepsychiatry, teleophthalmology, teledentistry, distance teaching for other health care institutes and personnel via videoconferencing; and forwarding digital real-time reading parameters (pulse rate, oxygen saturation, blood pressure, ECG, etc.) of a patient in an ambulance heading towards the hospital.

III. Methodology

This section reveals the method of the study; namely, how the literature was obtained, the challenges and problems in accessing data, efforts to access and gain information, literature contents, and what information was of interest are explained in this section.

Initially, a search was made for various scientific articles regarding telemedicine focusing on the impact, progression, projects, and applications. The author hoped to find sufficient information through searching e-journals, e-databases, universities' publication databases, and organizations' published information. However, this proved to be a much more difficult task than was expected. One of the main hindrances to finding accurate and current information was language barriers. The official languages of Finland are Finnish and Swedish; Swedish being spoken and written in the metropolitan areas only. Because of this, it was very difficult to obtain literature and other information in English. The literature search started from e-journals, e-databases, search engines, and moved ahead to contact organizations, universities, library services of Aalborg University, Tampere University of Technology, Aalto University, individual professors, in addition to Pirkanmaa Hospital, and authors of different publications which were accessible only through direct exchange. After contacting individual authors, it was soon apparent that most of the journals are in the Finnish language and only the abstract is available in English, even though the language of the article may be listed differently in literature publication databases. After contacting library services in Finland, they suggested to look into TelMed – the leading database for medical publications in Finland, which eventually helped to access 3 more publications. While searching for pertinent information, it became painfully clear to the authors, that there is a serious gap in information regarding telemedicine in Finland. Further, we can understand from a European Union point of view that much more information could be disseminated regarding past and present telemedicine initiatives, particularly if it were made available in a common language, i.e. English.

The search for literature resulted in 30 papers and 4 research and review reports. Most of the papers were review articles – telemedicine pros and cons, project implementation phases, uses, and future aspects, but none of the papers revealed the technical aspects of interest: topology, operation principles and management. Out of the 30 papers obtained, 20 of the papers were dated 1991 -1999, while the rest were published in the year 2000 or later, no information or articles were found for the year 2010. Papers were accessed through e-journals, e-databases and universities research centers (Telemedicine Laboratory, Tampere University of Technology, and Finn TeleMedicum – Center of Excellence for TeleHealth, University of Oulu) while the reports were accessed from National Institute of Health & Welfare (THL) and its underlying centers: the National Research and Development Centre for Welfare and Health (Stakes) and Finnish Office for Health Technology Assessment (Finohta).

IV. Telemedicine applications and factors affecting implementation and evaluation in Finland

In this section, qualities of telemedicine applications in Finland are described. There are many factors affecting the successful implementation and use of telemedicine systems, including funding and reimbursement, licensing and insurance barriers, and social acceptance. Some of these factors, funding, current applications and social acceptance are discussed here, to give an overview about the status and evaluation of telemedicine applications in Finland.

A. Funding

In this section, the various sources of funding for telemedicine projects in Finland are discussed, how the telemedicine projects are funded and run, which organizations are key players for it, and which specific area they are involved in. The organizational structure for funding is widely distributed, varying from public to private sector, all contributing towards the better health and welfare for the Finnish Society.

The Ministry of Social Affairs and Health in Finland [7] is the top level organization for administration, innovation, and management of health services in Finland. The National Institute for Health and Welfare (THL) [8] is expert in the research and development of health and welfare. THL runs many research centers under their umbrella, including the National Public Health Institute (KTL), the National Research and Development Centre for Welfare and Health (Stakes), and the Finnish Institute of Occupational Health (TTL). These research centers are involved in research and development for societal health and welfare, and funded by THL.

The Technical Research Centre of Finland (VTT) [9] is the biggest funding source for multi-technological applied research projects in Finland, and the biggest research organization in Northern Europe. VTT is an international scientific technology network that runs research projects and research programs associated with universities to develop, enhance, and innovate the technology to put the applied research to improve competencies into action. Along with other technologies, VTT provides high-end technology solutions and innovation services in Telemedicine as well.

The Academy of Finland [10] is the prime funding agency for basic research in Finland. The academy operates within the administrative sector of the Ministry of Education. It allocates funding of about 300 million Euros for the highest quality, and produces the most innovative, scientific research. Universities are the most important partner for the academy as research is involved, it supports and funds research projects, research programs, and Centers of Excellence. Centers of Excellence (CoE) offer excellent opportunities to carry out high quality research with six-year funding. The Academy of Finland also encourages the mobility of researchers (to and from Finland), such as FiDi-Pro (Finland Distinguished Professor), to extend and improve research collaboration, businesses, industry, and public administration internationally as well as nationally. Internationally, the academy cooperates with a number of other countries as well as with international funding organizations.

The Finnish Funding Agency for Technology and Innovation (Tekes) [11] is another main public funding organization for innovative research and development that works with the top innovative companies and research units in Finland. Tekes supports the projects that contribute towards the greatest benefits in the economical and social sectors in Finland. Along with other fields of innovative interest, Tekes funds many projects in Telemedicine as well.

Sitra, the Finnish Innovation Fund [12] is an independent public fund which promotes the welfare of Finnish society and has a mission to build a successful Finland for tomorrow under the supervision of the Finnish Parliament. Sitra co-operates closely with both the public and private sectors. Sitra chooses and changes programs themes aiming at the welfare of the society. Sitra enhances impact of its programs by various methods that include research, strategy process, innovative experiments, business development, and investment in internalization. Currently, Sitra does not focus actively on any health care program but, in the past, a health care program has been completed. This particular health care program was a research, training, and experimental program, having paper-free health care and seamless service as one of the key areas.

KanTa, the National Archive of Health Information, is a collective name for several national medical information systems, which are e-Prescription, e-Archive (national EPR), and online access by citizens to view their medical and prescription data. There lies a problem of funding in KanTa; the State will fund construction and operational costs to KanTa till 1st April 2011 only. Afterwards, the system will rely on funding obtained via user fees, which will be set at a level sufficient [6].

Finland also participates in a European Union (EU) Commission's Seventh Framework Programs (FP7) project, titled ISISEMD (Intelligent System for Independent living and SElfcare of seniors with cognitive problems or Mild Dementia). The ISISEMD project focuses on the elderly living people, having some problems or a mild loss of memory (dementia). In the past, the EU has funded three telemedicine projects under Fifth Framework Programs

(FP5) in Finland, titled RUBIS, PROMODAS (Professional Mobile Data Service) and MOMEDA (Mobile Medical Data) [1]. The remainder of funding comes from the private sector and giant companies of interest, such as Nokia and Remote Analysis, who want to innovate and develop their products for the welfare and health system in Finland. Most of the research projects in Finland today are funded by a co-operation of these funding agencies, e.g. a project funded by Nokia, Tekes, Intel, and Nvidia Graphics. These funding agencies start a research program or project and hire scientific staff or handover research to universities in order to evaluate the larger, "real" picture.

B. Current Applications

In this section, the current status of telemedicine applications and implementation are discussed. This section reveals more about the role that telemedicine applications have played in the Finnish health care system, how hospitals started utilizing telemedicine services and how it benefited both parties of the patients and the health care system.

Finland has many telemedicine applications currently in use: teleradiology, telelaboratory, telepsychiatry, teleopthalmology, teledermatology and teledentistry. Video conferencing is the key part of most used telemedicine service, where the physician is at one location while the patient (and the nurse) is at another location. It is used to consult a specialist of a hospital e.g. for patients with psychological or ophthalmological problems, and the services are known as telepsychiatry, teleopthalmology and teledentistry respectively [2]. In 2005 [4], 11 out of 21 were providing remote consultations and 21 out of 179 primary health care centers had purchased videoconferencing equipments, the growth is expected to develop as more health care centers are either planning or testing it. Video conferencing improves the quality of health care especially in case of telepsychiatry [13] – mental health care, expands the co-operations between primary and secondary health care units, it is currently used in all hospital districts, almost all primary and secondary care units, and is planned to expand further. The telemedicine applications mentioned above have been implemented in university hospital districts and other hospitals in Finland; meanwhile, the other applications are in the pipeline.

- Teleradiology

Finland has many telemedicine applications currently in use: Currently, 18 out of 21 (86%) hospital districts in Finland utilize this application [2]. In 1969, initial experiments took place when radiological images were transmitted between Helsinki hospital district and Oulu hospital district using the broadcasting network of Finnish national television (YLE). Some hospitals started teleradiology services utilizing existing copper telephone lines (POTS) to transmit X-ray images, but later upgraded to using Integrated Systems Digital Network (ISDN) lines as transport medium. The teleradiology and telemedicine applications network expanded widely along with the passage of time, Asynchronous Transfer Mode (ATM) dominated data transport technology, replacing ISDN lines and the YLE broadcast network there. While ATM was a dominant data transport technology, some hospitals also utilized Ethernet 10Mbps connections, because of compatibility issues - the equipment didn't support any ATM cards as an interface. The imaging database can be viewed in three ways: regional database, regional PACS (Picture Archiving and Communication System) or EPR having e-referral and e-discharge letters. In 2005, 52 out of 179 primary health care centers were utilizing some teleradiology services, where as it use in district hospitals is summarized in Table2 [4].

Table 2 Teleradiology services in Finnish health care system

Measure		No. of hospital districts
Teleradiology	Production Phase	16
	Pilot Phase	2
	Usage > 90%	5
Regional Archive	Production Phase	10
	Pilot Phase	3
	Usage > 90%	3
	Either teleradiology or regional archive	18

- Telelaboratory

Telelaboratory refers to electronic distribution of laboratory results from one location to another location and this application between hospitals is very common nowadays. According to a 2005 survey [1], 90% of the hospital districts were using electronic methods of distribution for laboratory results, where-as 27% of the primary care centres were receiving daily laboratory results electronically via a regional database and the rest were either at planning or testing stage. In earlier times, Integrated Services Digital Network (ISDN) lines were used for inter-laboratory communication, which was later on replaced by ATM connections along with data transport technology upgradation.

- Telepsychiatry

Telepsychiatry refers to interactive psychiatric consultations over distance that enables simultaneous sound and video connections between two or more interested parties (patient - psychiatrist or patient, nurse/physician - psychiatrist). The primary communication method used in telepsychiatric consultation is teleconferencing, because a psychiatrist tries to understand the problem through therapy and observing a patient, and these observations include physical movement, thoughts, reaction to certain actions, expressions and many other factors of a patient that are often difficult to quantify but are known indicators in Psychiatry. Initially, 3 pairs of ISDN lines (384 Kbps) were used for teleconferencing, as the technological revolution continued, Finland switched to using ATM connections.

- Teledentistry

Finland has a shortage of dental health care professionals, lacking odontology services in sparsely populated regions. Odontology is a branch of dentistry that deals with the teeth, their structure, development, and their diseases. Teledentistry refers to provision of dental services at remote end using videoconferencing, but it is mostly used for distance learning specialist education and clinical consultation purposes in dentistry. Turku university hospital odontological clinic hosts specialist training, which is distributed to various health care centers and hospitals in Western Finland. Videoconferencing was made possible through standard videoconference equipment and wireless intraoral camera technology, utilizing ISDN as well as TCP/IP network connections. Wireless intraoral camera is a tiny digital camera that fits comfortably in one's mouth and shows a clear real time view of one's smile and teeth to a dentist for analysis and diagnostic purposes [14]. In some health care centres, computer-aided consultation is also utilized for patient diagnosis and treatment planning. For a patient, some photographs using digital camera or digital images for x-ray films are obtained and sent via email for consultation, saving patient's time and effort [15]. Teledentistry is expected to develop further in near future.

The data transport technology used in telemedicine services is compared in Table 3.

Table 3 Data transport technology for telemedicine services

Application	Transport Technology
Teleradiology	YLE Network, POTS, ISDN, ATM
Telelaboratory	ISDN, ATM
Telepsychiatry	ISDN(3 pairs – 384 Kbps), ATM
Teledentistry	ISDN, TCP/IP

C. Social Acceptance

It seems as though the Finnish society has accepted telemedicine applications from a technical point of view, but there continue to be hindrances to social acceptance. The patients had to wait a long time for appointments, but recent system has improved, and resulted in less awaiting times for appointment. In near future, a hindrance will appear, when KELA will start charging fees about e-Prescription and e-Archive services from patients.

V. LITERATURE REVIEW

This section summarizes the papers studied and a review of literature as show in Table 4.

Table 4 Literature review

No.	Study	No. of participants	Methodology	Tool	Results
1.	Teledentistry (specialist education) [16]	26 specialists	Cost analysis	Videoconferencing	Costs saving per student €40,000. Attracted more students
2.	E-health development project 'ProViisikko' [17]	5 hospital districts	Process innovation	Analytical tool Interactive consulting centre	Enhance patient care, patients can book appointments, check laboratory test results online, and receive SMS acknowledgment.
3.	Child and adolescent psychiatry [18]	42 child and adolescent units in 21 hospital districts	Questionnaire (qualitative and quantitative analysis)	Videoconferencing	Savings of time & cost, availability of mental health services, can be improved by encouraging hospital staff to utilize videoconference on a proper schedule and improve technical support.

Table 4 *(continued)*

4.	EPR and general practitioner (GP) [19]	GPs in 8 health care centers	Use EPR system to look for specific data	3 types of EPR systems (2389 patient cases accessed)	Need to overcome shortage of qualified personnel to use and enter data correctly into EPRs.
5.	Extending EPR to e-referral and discharge letters [20]	12 university clinics and primary health care centers of 13 municipalities	Send XML message between EPR or on a secure server using VLAN or VPN.	EPR, imaging and laboratory database	Saves time in referral management, avoids unnecessary repeat imaging and laboratory examinations. Legalization for national electronic signatures and patient privacy are awaited.
6.	Development of working process [21]	--	Literature review Case study (interviewing and quantitative analysis of care process)	Technology (ICT)	A hypothesis – e-health services can be effective tool in improving and empowering patients in their own care, suggestion to start e-health pilot project for diabetes care.
7.	Fundus screening of type 2 diabetes patients [22]	Primary health care centers in South-Ostrobothnia, approx. 3000 patients screened each year	Take mobile unit to local centre, take fundus images and updates on central archive	Mobile digital fundus screening unit and central archive	Type 2 diabetes patients' fundus screening performed according to national health guidelines (one in 2.5 years) avoiding diabetic retinopathy and reducing university hospital workload.

VI. Conclusion

Finland is a pioneer in ICT services, and home to giant ICT company Nokia. Finland is sparsely populated, especially in northern areas, where telemedicine services can improve and provide specialized health care to the society. The Finnish Health Care system has been utilizing telemedicine services since 1994 to its community. The statistics presented in 2005 reveal that almost all of the district hospitals have teleradiology, telelaboratory, and remote consultations services to offer to primary health care centers. About 30% of primary health care centers have bought videoconferencing equipments to support remote consultations, and created links to district hospitals, the rest are planning to have them in near future. All hospitals utilize EPR, which is no longer a good measure for accounting telemedicine services. Therefore, the merging of e-referral and e-discharge letters with EPR have extended telemedicine services, and helped in avoiding repeated examinations and viewing patient history. In order to cope with incorrect prescription and drug safety, e-Prescription project is a good step forward, which will help in avoiding overlaps, incorrect dosages, and prevent threats to a patient's life. The e-Archive (national EPR) project will help to digitize all hospital records, creating a uniform technical format for documents, making ease of access of patient records. The national EPR will include e-discharge, e-referral letters as well; the patient can refuse publishing of his/her information, and can check through log files that who viewed his/her records. The other applications are the fundus screening of type 2 diabetes patients, which prevents diabetes retinopathy (sight blindness), and teledentistry that cops with shortage of dental care professionals in Finland.

Due to language barriers, it was difficult to find literature about telemedicine services in Finland in English. After searching through library databases, e-journals, e-databases, internet, and finally contacting some Finnish universities research centers and institutions, the information was gathered to study and review telemedicine services in Finland. Majority of the literature was dated 1991-1999, but no any recent information in the last two years about telemedicine services in Finland was found. The funding for the development, implementation and evaluation of telemedicine projects is supported by various funding bodies, but a barrier for e-Prescription project appears in April 2011. The Finnish society has an acceptance to telemedicine services, but hindrances are expected to be in near-future regarding charging fees for e-Archive and e-Prescription services. Telemedicine services have contributed towards the betterment and welfare of the Finnish society.

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