Health Information Exchange and Care Integration

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Abstract

The Finnish health care system is a mixture of public and private services. Its governance and funding is highly decentralized. Contrary to governmental policies and expectations, autonomous decisions by local authorities and service providers associated with lack of information models and common technical standards have led to a broad spectrum of one-off ICT –systems with little technical and semantic interoperability.

National strategies to overcome these challenges have prompted initiatives to create sharable electronic health records (EHR) by supporting a collection of federated interoperable repositories with regional middleware services. In the Hospital District of Helsinki and Uusimaa an established regional *e*Health network (RHIN) connects 24 public hospitals, 29 municipal health centers (primary care) and two private health care clinics. There are 7.500 end-users, information from 1,4 million citizens and 40 million links to EPRs.

Migration to a national eHealth network (NHIN) providing a platform for delivery of a longitudinal view on patient's relevant health records (summary care record) will assist care integration between providers and improve the safety and quality of healthcare.

Keywords:
Electronic patient records, interoperability, health information exchange, shared EHR, regional and national information networks, core data set, summary care record

Introduction

Parts of this paper have been presented at the Second International Conference on the Digital Society and published in the proceedings of this conference [1]. In this paper policies and decisions aiming to improve coordination of care and healthcare information exchange (HIE) are first described, followed by evidence of benefits from two controlled studies.

Despite the adoption of appropriate and timely sharing of patient data within the same care settings across legally distinct organizations (RHIN) policies were newly revised upgrading regional HIE to a national infrastructure and this migration process and context are described.

Policies for coordinating care and improving health information exchange

Finland's progress in the realm of information society thus far and its opportunities for future success could be rated as mediocre or good. Finland has managed to remain in the running, but has not achieved a significant competitive advantage. The ingredients for success are there, and our capacity to exploit them will be determined over the course of the next ten to fifteen years.

A number of recommendations by the OECD for incremental changes to certain structural features of the Finnish health system underline the transition phase of the system and the continuing need for building on the strengths of the system in the future [2].

In the healthcare domain 96 % of primary care health centres, 95 % of hospital districts and 89 % of private service providers use an electronic patient record (EPR). So far, the uptake of ICT in the field of social welfare and health care has not yielded sufficient gains at the national level [3]. The level of investment in ICT has been relatively low in this sector – approximately two per cent of all annual health care expenditure.

The government led project to restructure municipalities and services aims to diminish the waste of decentralised governance and merge municipalities to form health care areas with populations 20.000 – 30.000. These mergers are supported by a national development plan, Kaste Programme, that defines the development objectives for social and healthcare services in the next few years and the main measures for achieving them. By the end of 2008, the number of municipalities has decreased by 16 % since the legislation was approved in 2007, but it is too early to distinguish effects on healthcare services or organizational developments.

Local experimentation and reform in the Finnish health system have so far involved one or more of three types of

organisational development: regional cooperation among municipalities; integration of primary and secondary care and outsourcing of services to alternative providers.

Regional cooperation has attracted most interest, because The Act on Experiments with Seamless Service Chains in 2000 has provided the legislative foundation for regional health information organizations. Initial investment funding for regional *e*Health networks was made available by The Ministry of Social Affairs and Health.

The previous National Coordinator for Health Information Technology in the USA, David Brailer argued that the acid test for regional health information organizations (RHIO) would be a governance model that brings in all stakeholders [4]. The Act on Experiments with Seamless Service Chains did not include directives, nor did the Ministry of Social Affairs and Health issue formal guidance for building the RHIO governing body responsible for its accountability, authority and oversight.

A formal application to the Ministry by joint authorities of hospital districts or municipalities was the prerequisite for acceptance of stakeholders to join. After preliminary consideration of applications three hospital districts (Hospital District of Helsinki and Uusimaa, Hospital District of Satakunta and Hospital District of Pirkanmaa) were approved in 2001 for the primary phase of the national experiment on regional cooperation through ICT.

No strategies existed previously for regional information management and from the year 2000 The Act on the Experiments on Seamless Service Chains opened a window of opportunity for improvement, a new paradigm for cooperation between organizations and transformation of healthcare. Similar solutions for cross-organizational healthcare information exchange (HIE) were pursued at the same time in other countries or regions [5-7].

A few small rural regions have advanced even further in cooperation since 2001 and integrated specialized and primary health care services into a regional service system, which applies one electronic patient record system. This integrated model removes administrative boundaries and incorporates seamless processes between the providers. These regional health service districts cover basic secondary care.

Clinically integrated systems have been indicated to be the next step in health reform [8]. The increasing prevalence of chronic disease, and the need to improve the quality of specialist services like diabetes care, will require not only closer collaboration between providers but also clinical integration between primary and secondary care and the development of clinical networks.

Hospital District of Helsinki and Uusimaa

The Hospital District of Helsinki and Uusimaa (HUS) comprises 24 hospitals in the province of Uusimaa, which includes the Finish capital of Helsinki, in Southern Finland. In order to organise the provision of specialised medical care, Finland is subdivided into 20 hospital districts. The HUS district is the largest of these. As a joint authority it was founded in 2000 to provide health services for the 1,434,513 residents in its 30 member municipalities.

Among the HUS hospitals Helsinki University Central Hospital is nationally responsible for treating special, severe and rare illnesses. In 2006, more than 430,000 different people were treated in the HUS, roughly 310,000 of them outpatients.

The record locator service is a central reference database (register) containing links to patient data stored in their legacy systems [9]. The upgrading of the legacy systems is made possible by application integration across the extended regional infrastructure. Provider access is possible by web browsers and patient information includes (primary care/hospital outpatient) visits, critical data, images and reports, laboratory results, referrals and discharge letters. All data is sorted according to social security coding, which is standard procedure in Finland.

Standard API connections between primary care information systems and the reference data have been installed. The documents are produced in CDA R1/R2 format and messages transferred in a standard pattern (HL 7/XML).

The service was launched in 2003 and presently most (29/30) municipalities, as well as all hospitals (24), are connected to the RHIN and apply the record locator service for regional exchange of information. Currently 7.500 professional end-users view over 200.000 documents (x-rays and documents) monthly.

The process of information sharing and archiving of EPR documents will be enabled in the future by the centralized *e*Archive instead of the RHIN. The RHIN locator service may be transformed to a centralized indexing service and a shift in the administration of patients' consents for sharing information within the *e*Health Network is to be expected. The role of the RHIN may be seen in the future as an enabler in healthcare delivery of services by orchestrating processes and work flow.

Established and Perceived Benefits of RHIN

In the past, patient information located in different organizations was inaccessible online for the professional. The only way to access information was to order the papers by mail. In addition to the costs and long delivery time, the difficulty was to know which systems contained relevant information. The regional RHIN Navitas service has been designed to overcome these barriers and to enable a seamless, cross-organizational access to patient records in the HUS region.

The interest in interoperability has increased with the growing number of EPR installations and HIE needs and as a result of reports on the role of information in relation to medical errors, patient safety and healthcare quality. Interoperability has been defined as the ability of two or more systems or components to exchange information and to use and understand the information that has been exchanged [10].

When different levels of interoperability for healthcare information system applications are considered, preserving the content (syntactic) and meaning (semantic) of the exchanged data must be eluded. The evolution of interoperability in the healthcare domain has mostly developed through information integration across the entire healthcare chain based on standards (e.g. CDA) and messaging (e.g. HL7) supported often by vendor specific solutions.

Navitas is a regional service designed to overcome the organizational and interoperability barriers restricting the use of clinical information between secondary and primary health care. Navitas is provided as a fully hosted ASP (application service provision) service to HUS and the municipalities in the joint authority of the Hospital District by a consortium of three vendors. The system was originally developed as part of an EU funded InterCare project together with HUS and the participating companies. It has been originally in use since 2001, but the present version was implemented in 2003.

The core of the federated model allowing participants to view and share patient information is the Navitas record locator service. It is a service which maintains a regional directory of links pointing to patient and treatment information located in any of the connected health care information repository systems in the region: each participating organization has its own patient information system in addition to the 11 presently stand-alone patient information systems in HUS. HUS has also many other clinical information systems e.g. the laboratory system and HUSpacs, which have all been integrated to the link directory. The regional health information network architecture for healthcare information exchange in HUS is described in figure 1.

At the moment there are 15 different patient information systems in some 55 organizations connected to the locator service. Specific adapter software has been installed locally into each of the systems through which links are fed into the locator service. Links are HL7 (Health level 7)/ CDA (clinical document architecture) compliant messages containing the identification of a patient and a short description of the contents of the particular patient record. No actual records or documents are stored into the locator service directory.

Navitas has a regional user database and centralized authentication and authorization services; this enables the participating organizations to have complete control over their own users. The health care professionals can access Navitas from their personal workstations using a web browser. The data transfer is encrypted and only private, dedicated networks (VPN) are used to transmit the data. Viewing of the patient data through the links requires the patient's informed consent. When clicking a link, a window will open up to display the actual clinical information. The information is queried by the Navitas locator service from the patient information system itself. The view provided by the locator service is a read-only view, structured in a user-friendly and visual way.

The Navitas locator service is available today for all health care professionals in the Hospital District. The directory contains information from 1.4 million citizens. Currently there are over 40 million links in the database. The number of links has been minimized in order to make it easier for the professional to get a holistic view on the patient's medical history. In HUS, for example, several visits are grouped into one care period.

The Regional *e*Health Network Navitas is actively used by 7.500 professionals in different organizations. The monthly access number to the directory exceeds 200.000 and over 2 million annually. More than half of the quaries that result in access, stem from the need to view images and the rest from document retrieval.

Two controlled studies are described in brief to demonstrate how shared healthcare information has revised the current practice between primary and secondary care. They not only facilitate the delivery of improved services, but create information system benefits by improving the performance of healthcare processes.

Case 1 Information exchange with *e*Referrals.
The first case represents healthcare information exchange with an *e*Referral system integrating primary and secondary care physicians by allowing interactive *e*Consultations between healthcare professionals. The focus is not only on the 5 - 10 % of patients, who are generally referred by GPs for specialized care, but also on some 30 % of primary care patients, who represent actual cases where *e*Consultation referrals to the hospital specialist were deemed necessary by GPs.

We have set up a wide-area referral network between primary care and three university hospitals [9,11]. This network was initially launched in 1990. In the university hospitals all specialties are involved. In 2002 there were 67,000 e-referrals transferred between the Helsinki University Hospitals and primary care. The solutions extend from the initial VPN use (Vantaa) to EDIFACT standard (Espoo) and HL-7 (Helsinki). A transition to standardized HL7 messages utilizing C-way message transfer systems (HUSway) through a single Network Access Point (HUSnap) has been implemented. Over 100 000 *e*referral messages (40 % of total) were transferred between health care providers in 2005 and by the end of 2007 the number of *e*Referrals has increased to 200.000 (70 % of total).

The *e*Referral between primary and secondary care not only speeds up the transfer of the referral, but also improves the access to service by offering an option for interaction in the form of *e*Consultation between general practitioners and hospital specialists. By sharing information and knowledge remote *e*Consultations create a new working environment for integrated delivery of *e*Services between the health care providers. Interactive eConsultations enable supervised care leading to the reduction of outpatient first visits (-36 % for clinical visit intended referrals and - 50 % for total referrals) in the outpatient departments for internal medicine, i.e. more timely appointments and cost containment.

The implementation of the referral system increased the number of referrals from primary care. The total number of referrals to the outpatient clinic was 7,5 vs 2,8 referrals per 1,000 inhabitants over the age of 15 for *e*referrals and paper referrals. Despite the increase in the number of

*e*Referrals, the running costs of the outpatient department were 20 % lower than with the traditional process. The direct costs for applying the *e*Referral were only one seventh of the costs for traditional outpatient visits (32 € vs 211 €). The patients needed fewer repeat visits to the outpatient clinic after being first consulted through the *e*Referral.

From the patient's viewpoint *e*Consultations provide just-in-time expert opinions from hospital outpatient department specialists, make the expertise accessible more quickly than the traditional process and reduce the need for low value or unnecessary visits to the hospital. Eight out of ten patients preferred to continue receiving medical care in this way.

*e*Referrals and *e*Consultations particularly had an effect on the care of less urgent patients in contrast to urgent *e*Referrals. Only one out of ten patients with urgent (visit within one week) *e*Referrals to the outpatient clinic received *e*Consultations whereas over 50 % of less urgent patients were managed with consultation alone. This allows the urgent patients to have access and be examined at the outpatient clinic within the set target time range.

Case 2 Image exchange with RHIN.
The second case describes HIE benefits from transferring and viewing digital images remotely with the regional *e*Health network by primary care physicians and orthopaedic surgeons. This seamless radiological chain, besides creating a tool for remote radiological *e*Consultations, also discloses some difficulties in compliance with care pathway performance and the need for better integration of processes between primary and secondary care.

The picture archiving and communication system (PACS) project (HUSpacs) was initiated in the Hospital District of Helsinki and Uusimaa in 1998 and the first two hospitals became filmless in 1999. All hospitals in the catchment area of HUS became filmless by 2004. Installing one of the largest regional PAC systems in the Hospital District of Helsinki and Uusimaa produces roughly 1 million imaging examinations with 20 terabytes of storage capacity.

HUSpacs infrastructure includes local short-term archives and a centralized long-term or back-up archive, which are connected with a wide-area network (ATM). Different modalities are integrated by applying standards (HL7, Dicom), which allow the radiological information system (RIS) and hospital information system (HIS) to share patient information.

These archives also serve the regional *e*Health network in distributing images and sharing radiological reports between hospitals and primary care, supporting HIE between healthcare professionals in the care process. The framework for the assessment of the regional HUSpacs after re-engineering of hospital and external processes has been previously described [12].

The assessment was performed in two health centers. The municipality of Vantaa contracts all its images from the HUS hospital in Vantaa (Peijas Hospital). Tikkurila, which is a suburb of Vantaa with 45.000 inhabitants, has a secure connection (VPN) to the record locator service and HUSpacs archive, i.e. in the health center GPs may view the clinical and radiological information documented in Peijas. The health center of Kerava, a municipality with 30.000 inhabitants and approximately at similar distance from Peijas Hospital, but without the availability of digital image transfer, served as control and received the images from Peijas by mail delivery.

In 2003, the radiological HUSpacs chain between Peijas Hospital and the health centers was evaluated. Based on request, previous images of the same anatomical region were pre-fetched for the reporting radiologist, films were digitized and stored in the HUSpacs database. These images are also routed to the web-server in Vantaa. The radiologist dictates the report to the RIS, which sends an HL7 message containing the report to Tikkurila.

The primary aim was to assess the effect of the regional HUSpacs process (production, archiving, viewing of images, as well as remote consultations) on improved access to or quality of care. We also inquired about the satisfaction of personnel in these institutions to the regional HUSpacs application.

The setting of the trial was comparative and included patients with conservatively treated fractures of the ankle or wrist. They had to be first diagnosed in Peijas Hospital and later controlled by their general practitioners in the Tikkurila or Kerava Health Center. The availability of images and imaging reports, as well as the impacts of these were compared in the digital health center (study center) in Tikkurila with a health center (control center) in Kerava, where GPs were lacking HIE services.

The study group consisted of 60 patients with conservatively treated ankle or wrist fractures – 41 participants in the digital and 19 in the traditional follow-up group. The clinical follow-up information on encounters in the health centers was collected from electronic patient records after the patients had given their consent to this. Activity based costing was applied for personnel cost evaluation and investments were available from the HUSpacs project.

The performance measures in the process were set to evaluate how often patients actually received the recommended therapy of care pathways designed by Peijas Hospital for the two conservatively treated fracture groups. We also examined the quality of the control visits in respect to the availability of image information and assessed the direct costs for processing images in both groups of fracture patients.

The quality of processes were superior in the digital group, since the GPs had available the primary incident images for all the 41 patients, whereas in the traditional process none of the GPs could track the primary images during the first control visit. The whole process included 122 programmed visits to Tikkurila health center and for only two visits (1,6 %) the GP was unable to apply the regional *e*Health network for sharing images or reports due to web service problems in their work stations. Instead, in these cases they acquired the image information from their health center radiological unit or booked a later control call for the patient.

Although the primary images were missing for the first visit, plain films in Kerava were later available for follow-up, because the control radiological examinations were performed in the health center. However, the time for preparing the digital process in Tikkurila by nursing and administrative staff was only 16 % of the staff time needed in the traditional work process in Kerava. After investments were included the costs for applying HUS-pacs for the regional image transfer, were nevertheless 50 % lower than in the traditional film process. However, no significant differences existed in activity based costing for clinical follow-up visits.

The orthopedic and the GP could view the same image in real-time (figure 2). These *e*Consultations were available once a week for GPs in the digital health center, but GPs from both municipalities also requested radiological consultations at a similar rate. These consultation reports were available in the digital process on the same or next day, whereas it took three days for the reports to reach Kerava by mail delivery.

Migration process to national health information network

The integration of healthcare services has been pursued in Finland by issuing a bill (The New Health Care Act) in 2007 to be considered as the basis for new healthcare legislation. There is good fit with the English integrated health service reform model to the previously described rural experiments of Finnish health care, to the proposed new health act and to application of the regional *e*Health network services. Still there would remain competition between public and private organizations, although outsourcing and private-public-partnerships have created collaboration alongside competition.

The Finnish Parliament passed in 2007 an umbrella legislation mandating the building of a centralized national eArchive and secure communication network connecting all health service providers. Another corollary act requires the creation of a National *e*Prescription service. The statutory contractor for the national eArchiving and ePrescription services is the Social Insurance Institute (SII) [13]. Public and private healthcare providers and pharmacies, responsible for documenting and managing health care information in their legacy systems, are required to use the national services for archiving of documents and prescriptions. They are also obliged to modify their ICT applications accordingly [14].

The national migration plan from regional or local EPR -systems to the NHIN and interoperable EHR have been a combination of following activities:

- the development of legal framework for shared EHRs and ePrescriptions,
- the defining of responsibilities between the national actors (e.g. the Ministry of Social Affairs and Health, SII, National Institute for Health and Welfare, National Supervisory Authority for Welfare and Health and the Association of Finnish Municipal Authorities),
- the development of a common structured core data set for EHRs (e.g. common headings, classifications and terms),
- selection of technical standards both for communication and long term archiving of EHRs,
- the definition of the technical architecture for NHIN,
- the development of use-cases both for the ePrescription and eArchiving services,
- selection of vendors for the development and implementation of national services, and
- the creation of certification requirements for the NHIN, regional and local EPR-systems and ePrescribing services.

The Ministry of Social Affairs and Health has the authority for coordinating the transition process, creation of decrees, development of use-cases and guidelines for system integration. SII is responsible for deploying and maintaining the eArchive, national ePresciption services and e-services for citizens.

The Institute for Health and Welfare (previously National R & D Centre for Welfare and Health) is liable for the content of terminological services, development and maintaining national codes and classifications. A code and terminology server for semantic interoperability has been in place for RHINs and will be scaled for national use by the National Institute for Health and Welfare.

The National Supervisory Authority for Welfare and Health (Valvira) is obliged to create national authorization and identification services for both healthcare professionals (e.g. doctors and nurses) and for service organizations. These services are based on PKI-system and the use of health professional cards (HPC). Valvira also offers on-line attribute services including information on the engagement roles of healthcare professionals and their subsequent justification to view patient information.

Health service provider organizations (e.g. hospital districts, community-wide enterprises, public and private health or medical centers and pharmacies) have a major role in this migration process. Because patient data is sent to the eArchive as documents including standardized metafile and body (HL7 CDA standard), present EPR-systems must incorporate many new features. The most demanding of them is the extraction of patient data items from present RDB-files. Extracted data must then be transformed into the harmonized document form using nationally defined terms and classifications. *e*Prescription applications need to be integrated both functionally and technically to present EPR software. Finally all service provider organizations should implement HPCs and PKI-services to enable trusted communication with ePrescribing and eArchiving services.

In spring 2007 the vendor (Fujitsu Services Ltd) for the national eServices was chosen and has initiated the operation of the project in September 2007. First pilots for ePrescriptions and eDocuments are planned in 2009.

The process to determine the migratory procedures from a regional to a national health information network application is currently being considered based on specifications

that were proposed before the summer 2008 by a cluster of hospital district and RHIN service providers [15].

Roadmap to NHIN

Although some hospital districts adopted a federated model for regional HIE, a central data repository based on a single vendor solution was chosen by several smaller hospital districts due to lack of coordinated efforts to strive for a common integration and architecture strategy. A national health information network would be achievable by allowing integration of federated or centralized regional *e*Health networks to share EPR information, but to circumvent the challenges of interoperability between hospital districts the Ministry of Social Affairs and Health had to revisit its information strategy and architecture.

The updated strategy and communication architecture for health care drawn by the Ministry of Social Affairs and Health has set the following targets:

- for semantic interoperability all EPR-systems should implement a common core data set for EHRs and use HL7 CDA.
- communication between EPR-systems and the *e*Archive shall be based on a standardized message system (e.g. HL7CDA-messages. XML-formats and SOAP envelopes)
- all patient records will be archived into a logically single national archive
- new national architecture, incl. legacy systems, RHINs and national services, must be trusted. Two new acts, EU directive 95 and Act on Patient's Rights form the basis for privacy protection and security

The core data set is a compilation of the key information relating to the health and medical care of the patient [16]. The uniform structured data in an EPR are created chronologically as a summary of the periods of medical care and/or consultations. The data are entered by either the healthcare professionals or persons carrying out the data inclusion. The purpose of the core data set is to provide a general picture of the patient's health and medical history and the related treatment and instruction.

The core data can be used as a link to the detailed medical and patient record data. On the other hand, core data can also be sunk straight into the text. Appropriate document modification may be applied to produce a view of the record which shows the core data or part of the core data. It is also possible to prepare from the structured core data summary care reports or a care plan. These can be utilized for continuum of care, quality control, decision support and research.

In the Finnish NHIN patient records are transferred to the eArchive in the form of documents. For secure long term archiving, the data structure must include a metafile with multi-faced security policy. This metafile should consist of the following information:

- used security policy
- unique identification of data producer, patient and organization
- context and purpose information of the data
- the nature of data
- information for purposes data can be disclosed
- information when patients consent is required for disclosure of data

This national EHR-archive will disclose records in the form of HL7CDA document if necessary legal and other conditions exist. The centralized eArchive forms the basis of the future collection for citizens' life-life long health history. In the future the eArchive will be the point of record sharing in Finland.

The federated data sharing in hospital districts faced decisions on how to migrate from a regional to a national HIE. Technically there were three different variations: (a) regional locator services remain separate from the national *e*Archive, (b) regional locator services and national *e*Archive functions are coordinated and they share work loads, and (c) regional locator services remain between legacy systems and national *e*Archive [11].

The two latter variations – integration and active participant – have remained theoretical, because they would not bring additional advantages, but only costs. They have therefore been discarded from further consideration and discussion.

The first option induces a set of regional operations and processes to be continued after the deployment of the national *e*Archive. In radiology this would mean that images would be stored in the national long term archive after six months, but other images could be readily applied regionally for viewing in secondary and primary care from a regional short-term PACS archive. This consideration stems from the need for availability of information intensive images (f.ex. dynamic magnetic resonance images) in clinical practice and requirements for network capacity to transfer these images across different settings. These demands may not be otherwise always met.

In case regional locator services would be more suitable than the national *e*Archive for information search, consideration for applying regional *e*Health networks in these circumstances might be substantiated. The data-sharing solution of regional *e*Health networks would also enable access to patient encounter data that is not yet stored in the national repository, but resides only in the local EPR. The data is transferred to the national *e*Archive only after the approval of the encounter.

Regional booking and *e*Referral systems which are incorporated into regional *e*Health networks would be applicable in this option. Both of these systems are presently under construction in the national architecture and need to be reconsidered later. Chronic disease and care coordination strategies are being planned and measuring performance indicators will call for data warehouse solutions in order for outcome evaluation and resource allocation to be applied regionally. These requirements have now been partly solved by applying improved mapping procedures to link effectively disparate patient information that is not in structured form (core data set).

Health information exchange in RHINs should therefore be established for those services that need to be preserved

or partly developed for regional care coordination. These services are suggested as:

- regional governance services (e.g. regional resource planning, booking and accounting, regional management)
- regional primary care accident and emergency services (f.ex. acute care portal supported by mapping of data from disparate EPRs)
- regional registries (f.ex. chronic care disease registries in diabetes)
- regional imaging (f.ex. short term archives in radiology, fundus and endoscopy image managing)
- regional consulting services (f.ex. consultation markets for public and private experts)
- regional user and use management

These regional services may be acquired and implemented with present regional *e*Health networks. The regional services may support in synergy the national infrastructure and distribute specific services that are not provided by NHIN. The road map needs to be discussed and developed in coordination with hospital districts operating federated models of HIE.

Certification is an integral part of the migration process to the NHIN. Its central role is to establish trust in all stakeholders. This means that the NHIN as a whole and all its parts fulfill regulatory and other mandatory requirements. Furthermore, the NHIN should meet functional and technical requirements. It is also mandatory for all RHIN and local EHR-systems connected to the national services to possess the same level of functionality, security and privacy protection.

In the context of this migration process certification has been defined as a process confirming that a system or component complies with its specified requirements and is acceptable for operational use [17]. Certification has been divided into two separate processes, the development of certification requirements and the practical certification by an authorized organization using previously developed certification requirements.

As a part of the migration process to the NHIN, the Ministry of Social Affairs and Health initiated a project (TJSERT-project) to develop basic certification criteria for ePrescribing and eArchiving processes. Requirements were developed during the years 2007-2008 by the National R&D Center for Welfare and Health and University of Kuopio. Certification requirements were developed for three basic areas: security and privacy protection, interoperability and functionality.

In the initial phase of the project it was necessary to develop a new method for creating certification criteria for large ICT-systems such as NHIN (LS-CeRM, Large-scale Systems Certification Requirements Methodology). This four-layer graphical method was then used to develop concrete and practical certification requirements. One integral part of the LS-CeRM method is that it allows to validate in practice that requirements are fulfilled [18].

For ePrescribing systems a total of 141 certification targets were recognized (53 for EPR-systems and 88 for pharmacies), and 457 separate criteria developed. In eArchiving 41 targets were established and 109 criteria prepared. From all targets 20 are compatible for both ePrescription and eArching systems. Because in ePrescribing many use-cases were available, it was possible to develop a detailed set of requirements. For eArching systems no use-cases were at our disposal.

Any provider aiming to use the national eArching or ePrescribing services need to comply and fulfill the certification criteria developed in the TJSERT-project. Considering the present state of art of RHIN and EPR systems this can not be achieved instantly. Therefore every requirement was classified for its urgency and three urgency classes (1, 2 and 3) are applied. Class one forms the mandatory basic level. The Ministry of Social Affairs and Health has in the end of 2008 selected class 1 requirements for ePrescribing, and first ePrescribing systems will be certified in the spring of 2009. Later this year level 1 requirements for EPRs to be connected to the eArchiving system will be selected.

The roadmap should implement a holistic view on health care information infrastructure in such a way that local, regional and national services form a comprehensive system that delivers services at all health system levels and improve the effectiveness of various subsystems. Key points in the national eHealth roadmap are application of harmonised architecture approaches and use of standards in all development efforts. The existing and working regional systems should form the basis for future national infrastructure and these current RHINs should be modified to serve also the national requirements for health data management.

Discussion

The social model in Finland resembles the Nordic type based on high taxation and public health care services provided by autonomic municipalities. This decentralization has resulted in investments on one-off electronic patient records needing networking and integration with different stakeholders. As a consequence, federated regional health IT models were developed supported by legislation and funding.

Transformation in healthcare has been slow, nevertheless. This may depend on the pace of information technology adoption, since 80 per cent of the technology in use over the period 1995-2005 is less than ten years old, but 80 percent of the workforce was trained more than ten years ago [19]. It was therefore somewhat unexpected that experienced Finnish physicians considered information technology in healthcare to have led to greater efficiency and facilitated information retrieval [20].

These results are part of an extensive physician survey in 2003 and represent comments from 480 physicians, whose age was between 40 and 55 years at the time of the survey. The physicians who expressed opinions about changes in their work represented only 18 % of the responders to the survey, which undermines the general applicability and reliability of the result.

Achieving reforms of the social model will not be easy and most of the innovations need to be introduced at the national level [21]. The role of the Ministry of Social Affairs and Health warranted the change in healthcare information technology (HIT) architecture from regional to a more centralized *e*Health network, although integrated care will remain for the most part at regional level. The information architecture model is not a pure centralized form, but rather a hybrid, that is dependent on legacy systems and deployed on a service oriented architecture (SOA).

The consequence of this regional cooperation may be envisioned applying theories and practice of the social life of information [21]. People with similar practices and similar resources develop similar identities. These common practices allow people to form social networks along which knowledge about that practice can travel rapidly and be assimilated readily.

Two types of networks may be created – networks of practice and communities of practice. In the first network, professionals may be more loosely connected than in the second network, where they are working together on the same or similar tasks. These new types of collaboration may be used to organize regional health districts into a cluster matrix organisation. Horizontal relationships make up communities of practice, whilst vertical relationships link shared practices as demonstrated by the *e*Referral and *e*Consultation applications.

These two types lend themselves to transformation of healthcare and coexist in the integration models for primary and secondary care [8]. Hospitals would be joined with medical groups or primary care in vertically integrated organizations, that remind the networks of practice and could be adopted in rural areas. An alternative would be for hospitals to remain organizationally distinct and to form long-term alliances with one or more multi-specialty primary care medical groups in a form of virtual integration suited for virtual integration in urban areas.

In healthcare interactive dialogue between management sciences and information systems science has not received much contemplation. The use of ICT systems in health care is not direct evidence of their capacity to generate actual value. ICT systems are enablers for benefits to be reaped if working methods are simultaneously revised. This was demonstrated in the *e*Referral use case.

However, benefits may accrue by just reengineering the care processes [22]. New surgery arrangements for artificial joint patients involved relocating the anaesthesia phase outside the operating theatre The reorganization of the patient care process for joint replacement surgery succeeded in achieving a 50 % increase in operations before the introduction of a new IT system planned as part of the project.

In Satakunta Hospital District a regional *e*Health network based on a federated model with record locator service use has been operating since 2004 [23]. Direct costs were calculated for the district and its four primary care units. The results showed that net savings were annually on average 6 % of the total health care costs. Savings were related to an estimated 20 % reduction in redundant examinations and repeat visits due to lack of diagnostic information. Indirect cost savings were achieved by the delivery of timely care and by avoiding prolongation of disease, absence from work and unnecessary travel costs.

Virtually all work processes are affected by imaging results and telemedicine applications in radiology have been proven to result in savings through avoidance of unnecessary patient transfer or patient travel [24]. HUS-pacs may therefore be seen not only as a technical imaging data transferring system, because it brings added value for regional services and has deep influences on the way of working as was demonstrated by the second use case.

The interrelationship between ICT systems and information and its significance for evaluation of achieved benefits of ICT system use has been stressed [25]. In the future noteworthy ICT system benefits in healthcare should be more the result of development work on the macro level. Therefore, the National Health Project has initiated attempts to improve the quality of patient record systems during 2007-2011 through the construction of a national health information network.

To promote better access to patient information in the legacy repositories of different health care providers, a national project has produced national specifications on the requirements for the content and structure of information systems concerning open interfaces, data protection, information security and construction of information system architecture. The project also concentrates on the distribution of classifications and codes necessary in ICT.

All large scale ICT-systems (the Finnish NHIN is a typical example) sharing personal health data require both careful security and privacy protection planning and implementation of practical security and privacy protection tools and services. From this perspective the Finnish NHIN with a centralized eArchive is exceptionally demanding because all EPRs are stored and disclosed by the same “governmental” organisation. Security features of the Finnish eArchive are based on a new ISO 21457 standard (Secure archiving of electronic health records) [26].

Remodelling of EPR data structure, present identification and authorization mechanisms, development of rule and role based access control services, creation of new audit records, consent management services and audit services for citizens are needed to create a trusted environment for the NHIN. In the long run we need to proceed to the policy based on data access and disclosure mechanism.

For identification of health professionals the national PKI infrastructure applying health professional cards is in the implementation phase. Later a role based access control service will be implemented. Identification of entities are based on the same technical infrastructure.

For trustfulness it is necessary to define the level of non-repudiation of events and which processes or events should be audited. The previously mentioned TJSERT-project already highlighted more than 20 processes or events that should be audited.

It is also necessary that citizens can check to whom, when and for what purpose the national eArchive has disclosed his health information. This is also one service of the Finnish eArchive. Patients and citizens can check data disclose audit-log via the Internet without restrictions.

The National Institute for Health and Welfare has started a project to build a health information portal for citizens. The objective is to make online health education and expert advice available to citizens. It has been also planned that patients will get access to view their own patient records stored in the centralized *e*Archive and unlimited right to check who, when and why, has accessed his or her data. This checking can be done also using the Internet.

Finally, this opens the option for a personalized health record (PHR) to be connected with the EHR. The citizens will be more informed and this may result in to an increasing demand for personalized health services.

Conclusions

Finnish experiments demonstrate the migration from regional to national *e*Health network to be a multidimensional and complicated process. It is not only a technological challenge, but also political, organizational, process related and human factors must be taken into account. Typically this kind of change is loaded (sometimes overloaded) with many expectations and benefits. The migration process should be carefully planned and each step forward should reap benefits to the users. The ICT technology is not the most demanding and most of the necessary solutions are already available on the market. From ICT point of view the most demanding tasks are the creation of common understanding of functionalities and processes of the NHIN, selection of harmonized standards, building better semantic interoperability between EPRs and creating trust in the NHIN.

National development work currently focuses on the specification of technological structures, the networking of actors and the construction of a legislative foundation. In addition to these an agreed and shared common information model (care ontology) would enable the semantic interoperability of information systems and their clinical integration. The governance model for data and information exchange is an essential component of a national IS infrastructure and the current RHINs have experience and implementations of these that need to be included as part of the future development. The common foundation supports the modernisation of operational processes, the broad application of operative innovations and the enforcement of the role of the citizen.

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Figure 1. The Regional *e*Health Network Architecture in the Hospital District of Helsinki and Uusimaa.

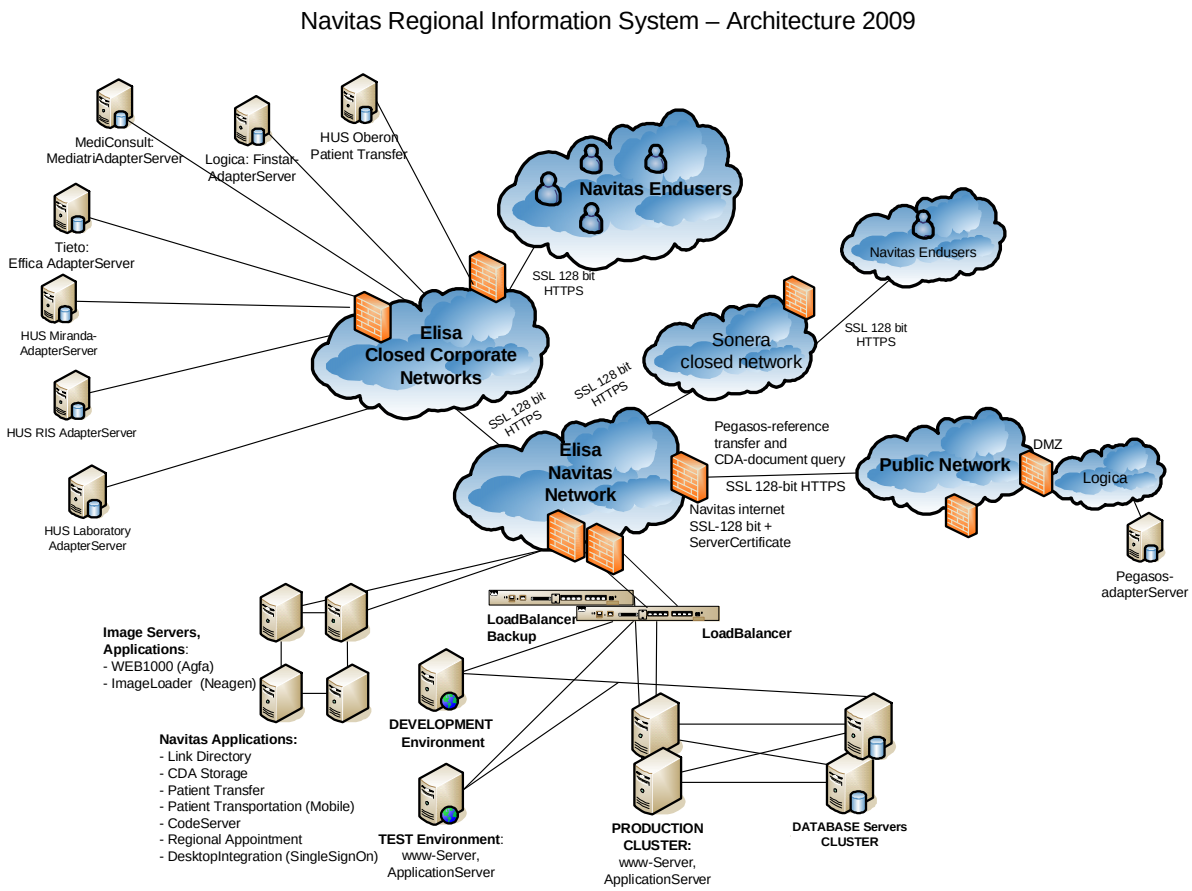

Figure 2. Regional *e*Health network provides an opportunity for GPs and orthopaedics to view the same image in real-time and exchange information as consultations.