Ten Years of the e-Health System in Estonia

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Abstract. The e-health system in Estonia, called the Estonian nationwide Health Information System (EHIS) has been operational since the end of 2008. The main success factors for the e-health system in Estonia are clear governance, legal clarity, a mature ecosystem, agreement about access rights, and standardization of medical data and data exchange rules. We present a short history, outline the general business and technical architecture and discuss the lessons learned.

Keywords: e-Health system, e-state system, Estonian nationwide Health Information System (EHIS).

1 Introduction

There are 1.3 million citizens in Estonia and every citizen and every resident has a unique ID-number. In Estonia, 88% of households have a broadband connection (2015), 82% of households use a mobile Internet connection (2016), 96% of income tax declarations are made via the e-tax board (2016), 32% of votes were cast over the Internet (2017), and 99% of bank transfers are carried out electronically. The NATO Cooperative Cyber Defense Centre is in Estonia and Skype, Transferwise and Taxify have been developed there.

The healthcare system in Estonia is based on health insurance, paid by employers. Healthcare providers in Estonia can be private, municipal or governmental. Most hospitals are publicly owned, and most general practitioners are private entrepreneurs. Healthcare costs make up to 6% of the GDP (9.5% in the OECD area). The e-health system in Estonia, called Estonian nationwide Health Information System (EHIS), has been operational since the end of 2008. EHIS, by containing the health data of every Estonian resident virtually from birth to death, integrates different healthcare databases and services and makes it possible to access medical data, prescriptions and medical images online in a secure and trusted way. The goal of the Estonian e-health system is to develop patient-friendly, efficient and high-quality healthcare services. In addition,

it aims to make time-critical medical information accessible for physicians and to decrease the level of bureaucracy in the daily routine of physicians.

The three main layers of the EHIS are the data layer, the data transfer layer and the application layer. The data layer consists of the data repositories for storing the medical documents and images. The data transfer layer provides a secure Internet-based infrastructure for data exchange both for citizens and healthcare providers. The developing and open-ended application layer is to provide services for different parties (citizens, healthcare providers, government authorities, policy makers, etc.) according to their demands now and in the future. Ten years of experience has shown that both the citizens and healthcare professionals, as well as politicians and government authorities, have accepted the e-health system.

In Sect. 2, we present a short history of the e-health system in Estonia. Next, in Sect. 3, we describe the services and the architecture of the Estonian e-health system. In Sect. 4 we present the e-state infrastructure, including the security and legal infrastructure, that is used in the e-health system. Finally, in Sect. 5 we conclude by discussing some lessons learned from the Estonian e-health system operation.

2   Historical Overview

The story of the Estonian e-health system states back to the first years of independence of Estonia and is closely related to the activities and influence of the first Prime Minister, Mr. Mart Laar, and his team. Mr. Laar served as Prime Minister of Estonia from 1992-1994 and 1999-2002. In those years, information technology was seen as an opportunity to develop the economy and politics in Estonia – a small and developing country. Firm foundations were built for many of the initiatives that today form the e-state of Estonia[3], including e-banking, e-health, e-documents [1–4], e-school, e-taxation, e-voting, etc.

As Estonia lacked legacy software at that time, and information technology was underdeveloped in the Soviet period, the utilization and deployment of information technology began to evolve rapidly during the first years of independence. Society believed in information technology and started using information technology in all domains, including healthcare. Fig. 1 illustrates the history of the e-health system in Estonia. Between 1990 and 2000, hospitals, general practitioners and other health providers started developing their own information systems and introducing the use of electronic health records. Several small and medium sized software companies, focusing on the development of healthcare systems, were founded at that time. In the same decade, the informal planning and the first ideas of the development of a nationwide e-health system were initiated.

The active preparation of the Estonian e-health project by the government authorities and proponents of e-health system took place between 2003 and 2005, however some important events took place earlier. In 2001, the digital invoicing

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[3] https://e-estonia.com/
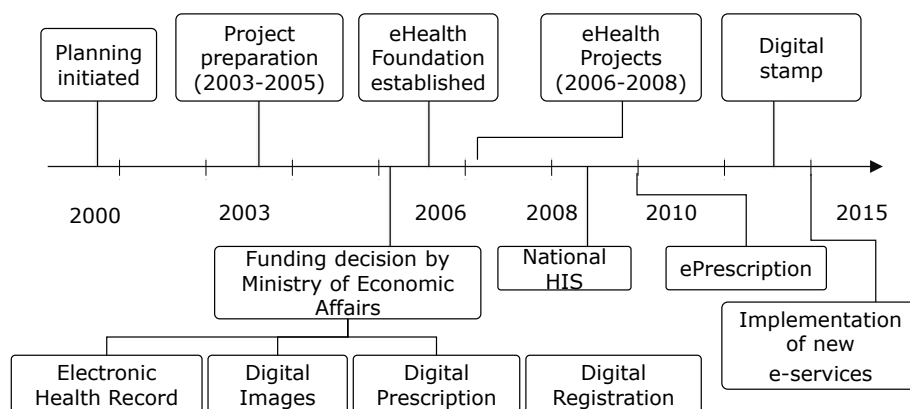
Fig. 1. The history of the EHIS platform.

system for electronic transfer of reimbursement claims, called Estonian Health Insurance Fund (EHIF), was launched. In 2002, all pharmacies were obliged by law to transmit the prescription information for reimbursement to the EHIF electronically. Over 75% of healthcare providers and 45% of all pharmacies had signed data transmission contracts. In 2005 all the reimbursement claims and prescription data in Estonia were submitted electronically.

The foundation for EHIS was established in 2005, when the Ministry of Social Affairs launched a concept for the e-health system. This concept postulated four main projects, i.e., electronic health records, digital images, digital registration and digital prescription. Soon after that, the official body for the development of EHIS, called the e-Health Foundation, was established. The e-Health Foundation was responsible for the development, financing and management of the the system. EHIS was funded by the EU ($€$ 1,196,206) and Estonia ($€$ 398,735) and was launched at the end of 2008.

EHIS continues to develop and add new functionalities and services. E-prescription, digital stamps, a driver's license health certificate application, drug-drug interaction services and e-registration are examples of such e-services. Today, EHIS is operated and developed by TEHIK[4], a government-owned private company. The system contains the health records of all the residents in Estonia and more than 10,000 healthcare professionals use the system on a daily basis[5]. In September 2017, the actual number of medical documents in the system was more than 30 million.

Although Estonia has about 1.32 million citizens, EHIS contains health information for 1.54 million people. Overall, 14 different medical document types are in use, covering more than 17 million out-patient case summaries, around 2 million stationary case summaries, and more than 8 million different medical

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[4] https://www.tehik.ee/
[5] https://e-estonia.com/e-health-estonian-digital-solutions-for-europe/
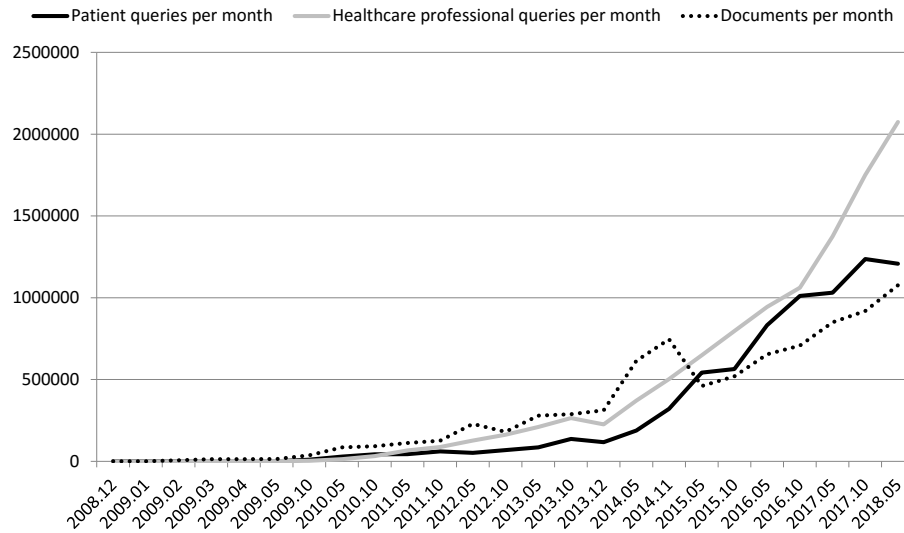
Fig. 2. The use of digital health data in EHIS platform.

diagnostic examination reports, including radiology reports and laboratory results [5]. Fig. 2 illustrates the growth in the number of the queries in EHIS per month. It was close to zero when the system started in 2008 and now more than 1.2 million queries per month are made by patients (black line) and more than 1.6 million by the healthcare professionals (gray line). In these queries, about 800,000 different healthcare documents per month (dotted line), are utilized.

3   Services and Architecture

EHIS is not a big centralized database but a federated system of mutually independent yet integrated healthcare-related software services [6]. Fig. 3 illustrates the main elements of the system.

The most widely implemented e-health project in Estonia is a nationwide health information exchange platform, which is called the nationwide Electronic Health Record (EHR) system. The EHR platform, which is based on widely accepted international standards such HL7 CDA (HL7 Clinical Document Architecture)[6], DICOM (Digital Imaging and Communications in Medicine)[7], LOINC (Logical Observation Identifiers Names and Codes)[8], etc., enables exchange of digital health documents in a standardized way. The EHR project began the ongoing standardization of digital health data artifacts in Estonia. By the beginning of 2017, a number of 1,163 healthcare institutions were sending and

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[6] http://www.hl7.org/

[7] https://www.dicomstandard.org/

[8] https://loinc.org/

retrieving medical data using the EHR platform. The average number of queries was close to 50,000 queries per day. It is important to note that all medical data entered is digitally signed either by the physicians or healthcare institutions. Digital signing is also discussed in Sect. 4.

The other widely used healthcare service provided by EHIS is e-prescription. Physicians upload prescriptions, in electronic form, to the prescription center database, from where any pharmacist can request currently valid or previously dispensed prescriptions. The e-prescription system, that has been launched at the beginning of 2010, was very quickly accepted by all parties and today approximately 99% of medical prescriptions in Estonia are issued electronically. For more information about the e-prescription experience in Estonia, see [7].

The Picture Archiving and Communication System (PACS) is for sharing medical images between health institutions. Today all radiology facilities in Estonia have the duty to send, achieve and retrieve radiology images using the central PACS. Radiologists and all referring physicians have web-based access to PACS once they have signed the necessary contract with the Estonian Health Image Archive Foundation, the responsible authority of PACS.
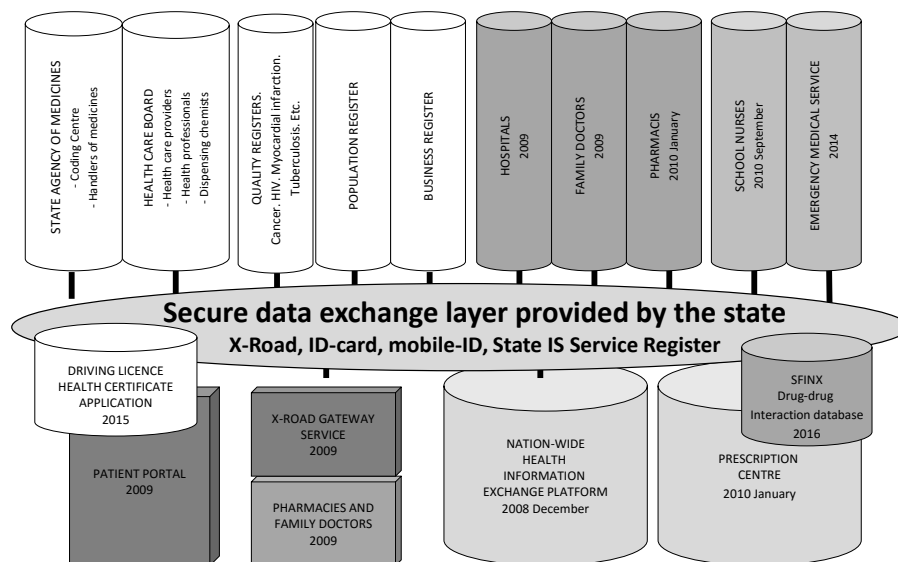

Fig. 3. Main elements of the Estonian nationwide Health Information System (EHIS).

EHIS also hosts many central registers and databases such as of hospitals, family doctors (general practitioners), pharmacies, school nurses, medicine interactions, and different quality registers (cancer, HIV, tuberculosis, etc.). Furthermore, it utilizes several nationwide registers such as the population and the business register.

One of the crucial parts of EHIS is the patient portal [8–11]. Using the patient portal, the user can:

- log in with ID card or mobile ID;
- view and update personal data and add contact data of close relatives;
- view his/her medical data from healthcare providers;
- view electronic referral letters and electronic prescriptions;
- add representatives for him/herself for actions such as collecting e-prescriptions;
- make declarations of intent (e.g. donation of organs);
- access health insurance data;
- hide sensitive health data from doctors and representatives;
- complete a health declaration form before an appointment;
- view the log of who has accessed his/her data.

Feedback from the healthcare providers' and the Estonian e-Health Foundation's helpdesks shows that, when patients do not have access to their health data (for example during system upgrade), they immediately contact the helpdesk. They are periodically interested in their data and want to view their test results before appointments. This information supports the idea that making health data easily accessible to patients will encourage them to take a more active role in monitoring their health.

4 The Infrastructure

EHIS is not a separate system but an integrated part of the Estonian e-state system used by the public and the private sector. The e-state system, by secure data exchange and authentication methods, provides a mature ecosystem for the e-services in Estonia. E-banking, e-school, e-taxation, e-voting and other e-services are all using this ecosystem. The most important parts of this ecosystem are the X-Road [12–14] (governmental service bus) and the e-identity [15] PKI (Public Key Infrastructure). X-Road (or X-Tee in Estonian) [9] is a data exchange layer for enabling a secure Internet-based data exchange between information systems. To ensure secure transfers, all outgoing data from X-Road is digitally signed and encrypted, and all incoming data is authenticated and logged. X-Road is based on the protocols and patterns of the standard SOA (Service-Oriented Architecture) stack [16, 17], i.e., SOAP (Simple Object Access Protocol) messages and WSDL (Web-Service Description Language) and utilizes the following principles:

- it enables the information systems of X-Road members to communicate with the information systems of data service providers across any software platforms;
- X-Road members are able to request access to any data services provided through X-Road;

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[9] Both X-Road and X-Tee are registered trademarks.

- in X-Road, international standards and protocols are used wherever possible;
- exchanging data through X-Road does not affect the integrity, availability or confidentiality of the data.

Since 2002, in Estonia, every resident has had a digital identity. This identity is based on the unique identifier (personal ID number), digital certification organizations (police, certification center), and physical security devices like smart card (ID card), mobile SIM card (mobile ID) and smart ID. The digital identity has two functions: authentication and digital signature. The digital signature is available also for companies in the form of digital stamping.

Besides X-Road and e-identity, the important infrastructure for e-health is a legal environment initiated by the Estonian government and implemented by the Parliament. The first idea was to create separate legislation for the e-health system. However, due to the natural relationship between the e-health system and the healthcare system, and also due to the desire to direct healthcare professionals to accept and to use the e-health system, the relevant legislation was made part of the healthcare legislation.

The Health Services Organization Act, which regulates the healthcare service provision, was extended by a new chapter for EHIS. This chapter lays down the responsibilities of patients, health service providers, and provides requirements for document standards, etc. For example, all healthcare providers must send certain health data to EHIS. The set of documents is defined by the law. The Act also states that access to patient data is available only to licensed medical professionals, legal representatives or patients trustees. In the Estonian e-health system, the concept of the attending doctor has been introduced. This means that the physician or a nurse must prove the treatment relation to the patient, when accessing the patient's data in EHIS. The Act also states (and this is realized in the patient portal), that the patient has the right to hide their data so that healthcare professionals are no longer able to view them. This could be done either by hiding a single document or by hiding all their personal data in EHIS. All attempts to view healthcare data in EHIS are monitored by the government authorities and reported to the patients in the patient portal. In case of suspicions of unlawful access to the data, necessary actions are taken immediately. According to the Act, the ethical committee was created to lead the discussions on patients rights and to select the proper system for the EHIS. Citizens can access their own data, declare intentions and preferences, and monitor logs.

5   Discussion and Conclusion

The Estonian e-health system is unique as it is nationwide, integrates defined healthcare data of all healthcare providers and provides an overview of the health condition of every resident from birth to death. Such a comprehensive data system requires a robust security system. The security of the Estonian e-health system is ensured by the following six techniques:

- A secure authentication and authorization of all users with ID card, mobile ID or smart ID;

- Digital signing (by individuals) or digital stamping (by institutions) of all medical documents;
- Accountability and transparency provided by an untamperable and unremovable secure log (audit trail) containing all actions;
- Coding of personal data ensures separation of personal data from medical data;
- Encrypted database records allow a minimal confidentiality risk from the technical administrators of the system;
- Monitoring of all actions together with the corresponding countermeasures (both organizational and technical) allows identification of fraud and misuse quickly and definitely.

Huge change management issues that digitalization brings to healthcare is always a challenge. The observations and difficulties that were related to the Estonian e-health system were (and are) as follows:

- Physicians and other professionals must change the way they fill out medical files to some extent – the trend is towards more uniform language;
- Semantic interoperability of medical data is hard to achieve;
- Data quality and secondary usage of data is still challenging;
- General acceptance of hospital personnel to share medical data in patient portal with patient is problematic;
- Much attention must be paid to the security and electronic authentication of the users;
- User interface development must not be underestimated;
- Medical data is not what people are looking for – they are interested in services.

As an example, related to the last claim in the list above, e-health services that are crossing institutional and/or sectoral borders such as e-referral, e-consultation, e-prescription or filling in health declarations for a driving license application are the most popular services among the users. These types of services make healthcare processes more effective and save time for both healthcare professionals and individuals. The exchange of data and digital documents between institutions also puts high demands for data quality [18, 19] and has a clear potential to increase healthcare quality in general.

The aim of the Estonian e-health system was to develop a platform for health information exchange. However the solution had to provide some tangible services as well. During the first phase of the system, the scope to provide certain standardization and applications for most valuable documents and data was set, including outpatient summary notes, inpatient discharge letters, demographics, time-critical health data reports, and diagnostic image references.

Even though Estonia is considered an IT-mature society, it is important to understand that, similar to other European countries, Estonian society has members whose computer skills do not allow them to use e-services comfortably. This means that the digital society ecosystem should be accompanied by activities to

educate society members and to decrease the digital divide. New e-services must not replace ordinary services but should complement them to make processes more efficient and affordable for the whole society. This is the leading concept in the implementation of EHIS in Estonia, meaning that patients still have the right and the opportunity to receive services in conventional ways.

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