TALLINN UNIVERSITY OF TECHNOLOGY
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DEVELOPING AN EVALUATION FRAMEWORK FOR THE COUNTRY-WIDE ELECTRONIC PRESCRIBING SYSTEM IN ESTONIA

Master's thesis

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EESTI ÜLERIIGILISE DIGIRETSEPTI SÜSTEEMI HINDAMISE RAAMISTIKU ARENDAMINE

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CONTENTS

ABBREVIATIONS

ADE – Adverse Drug Event

CDSS – Clinical Decision Support System

CPOE – Clinical Physician Order Entry

EHIF – Estonian Health Insurance Fund

EHR – Electronic Health Record

EISA – Estonian Information System's Authority

EPS – Electronic Prescribing System

HOT-fit – Human Organization Technology Fit

HTA – Health Technology Assessment

IT – Information Technology

IS – Information System

ME – Medicine Error

PRC – Prescription Center

RCT – Randomized Controlled Trial

SAM – State Agency of Medicines

SDLC – System Development Life Cycle

TCO – Total Cost of Ownership

WHO – World Health Organization

INTRODUCTION

Estonian health care system has seen many developments regarding health care information technology and e-Health during the past 10 years. Several large-scale projects have been implemented – for example electronic health record, digital picture archiving system and electronic prescribing system. To date, the most widely used e-Health service in Estonia is the country-wide electronic prescribing system (EPS). EPS has received positive feedback from the public and providers (Elanike hinnangud …, 2012; Haigekassa lepingupartneritega rahulolu 2012) and the usage level of the system is very high – more than 95% of reimbursable prescriptions are issued digitally. In this regard the system has potentially had a significant impact on different stakeholders in the Estonian health system.

There is a considerable gap in the practice of evaluating nation-wide health information systems in Estonia. The problem lies especially in the aspect that there is no formally implemented and mutually agreed framework for doing the evaluation. Although a few studies have been conducted, several relevant aspects about the impact of the system have not been evaluated. An analysis using both quantitative and qualitative methods in a systematic and complete manner while taking into account the context and specifics of the system is still yet to be done.

The current paper will start to fill that gap in terms of developing a framework for the Estonian country-wide EPS evaluation. Future research proposals and suggestions for using the framework will be an important result of this paper. The abovementioned gaps in research, as well as author's own interest towards the subject are the reasons for selecting the research subject.

The thesis project is an exploratory case study employing an inductive approach to develop an evaluation framework for Estonian electronic prescribing

system. The research question is thus ‘how to evaluate the country-wide electronic prescription system in Estonia?’ The thesis will propose a framework for facilitating evaluation and defining its focus and limits, which can be regarded as a first step in the evaluation process of a country-wide EPS.

The paper consists of four main chapters. The first chapter will focus on defining the research problem and describing the Estonian e-prescribing system case. The second chapter will give the reader a theoretical background on evaluating health information systems. An overview of existing research on evaluating the impact of e-prescribing and health information systems with examples of various evaluation frameworks will be presented. The third chapter will demonstrate the methodology and methods used in the thesis. Finally, in the fourth chapter an initial evaluation framework will be developed. Furthermore, the results of framework validation with experts will be outlined. A refined framework for EPS evaluation will be presented and conclusions with suggestions for policy makers for uses of the framework, as well as future evaluation needs will be discussed.

BACKGROUND AND CONTEXT OF THE E-PRESCRIBING SYSTEM IN ESTONIA

1.1 Defining electronic prescribing systems

Electronic prescribing systems come in many forms and can be defined from different perspectives, depending on the specifics of the system and the context of implementation. In academic literature, Black *et al*. (2011, 7) define electronic prescribing as ‘any computerized system used by clinicians to enter, modify, review and communicate information on medication prescriptions’. Ammenwerth *et al*. (2008, 585) see electronic prescribing as a system supported by Computerized Physician Order Entry (CPOE) systems, which denotes to ‘a variety of computer-based systems for ordering medications, which share the common features of automating the medication ordering process'. The CPOEs include various systems from just a list of available medications that the provider can choose to prescribe to complex systems with different forms of decision support, which include alerts or reminders for the doctor, regarding different aspects in the prescribing process. (*Ibid.*)

The abovementioned definition of CPOE can be used to define the Estonian EPS (to be described in chapters 1.2 and 1.3) to some extent (excluding decision support functions), but the existing concepts do not grasp the scope of the Estonian system. However, Motulsky, Lamothe and Sicotte (2013) have differentiated between first- and second-generation electronic prescribing technologies. While the previously mentioned system definitions (electronic prescribing, CPOE) could be regarded as the first generation EPS, according to Motulsky *et al*. (2013) the second

generation e-prescribing system enables different counterparts to communicate electronically, including the possibility for physicians to see pharmaceutical profiles of the patients and to send prescriptions straight to pharmacy or pharmacies nationwide. The prescription information could be sent straight to a specific pharmacy by the doctor (push model) or it can be done through the third party or a data warehouse from where it is accessible by all approved pharmacies (pull model). In case of country-wide e-prescribing systems the pull model is mostly used. (*Ibid.*)

Deriving from the different definitions, the Estonian e-prescribing system can be regarded as a second generation system. As the system is unique in the world context, there are no broad research evaluations made, yet similar systems have been evaluated to a limited extent (Motulsky *et al*. 2013). EPS is essentially a health information system (HIS)[1] hence evaluation methods and frameworks used broadly for different HISs are also relevant in seeking an answer to the research question of this paper. Yet before concentrating on issues regarding evaluation, the case of Estonian EPS will be described in detail – namely the development and the architecture of the system will be outlined.

1.2 Development of the e-prescribing system in the Estonian health care system

The pharmaceutical system and distribution have an impact on patients, doctors, pharmacies, state agencies, the pharmaceutical industry and other stakeholders. For example, the costs of prescription medicines accounted for 17% of total health care costs in 2011 in Estonia (Tervishoiu kogukulud 2011) and reimbursable drugs were used by 68% of the insured population in 2012

[1] According to the definition by Yusof *et al*. (2008a, 378) 'information system is a group of interrelated processes implemented to aid in enhancing the efficiency and effectiveness of an organiszation in performing its functions and attaining its objectives'; health information system is an information system used in healthcare settings.

(Majandusaasta aruanne …, 2013). There are 475 general outpatient pharmacies in Estonia (Ülevaade apteekide …, 2013) and 4372 certified doctors (Tervishoiutöötajad ja …, 2013). Thus any policy or broad IT-development in this sector can have an enormous impact on the system counterparts.

As far as the Estonian EPS is concerned, most of the abovementioned stakeholders have contributed in some way to the development and implementation of the system. The Estonian Health Insurance Fund (EHIF) has played one of the most important roles in the development of Estonian health system's IT-capacity as well as building the preconditions for e-prescribing system implementation in Estonia.

As Estonia has a social insurance system with one central purchaser (EHIF), data transmission between EHIF and health providers, pharmacists and also citizens has been important since the system has existed. For example, already in year 2000 it was possible for citizens to check their insurance status online by using commercial internet bank authentication systems (Internetipanga kasutajad …, 2000).

The strategic goals for IT (information technology) development at EHIF were set in 2001, when the whole information system was centralized. The goal was to implement standardized information transmission and develop a possibility for electronic transmission of medical bills and prescription data; the first developments were made in co-operation with the IT-department of one of the leading banks in Estonia – Eesti Ühispank (Majandusaasta aruanne …, 2002; Haigekassa alustab …, 2001). As of October 2002, all the pharmacies were obliged by law to transmit the prescriptions for reimbursement to EHIF electronically using the electronical data transmission service TORU, setting an important precondition for the development of the country-wide e-prescribing system. By the end of 2002, EHIF had signed electronic data-trasmission contracts with 76% of healthcare service providers and 54% of pharmacies. (Majandusaasta aruanne …, 2003) By 2003 the X-road framework (a secure data transmission service provided by the central government) was already used for some data transmissions between EHIF and its partners

(Majandusaasta aruanne …, 2004). The idea and the basic principles of the EPS were drafted already in 2003 (Digiretsepti realiseerimine …, 2007).

By 2005 100% of the medical bills and prescription data for reimbursement were submitted electronically (Majandusaasta aruanne …, 2006). In 2006, using ID-card (a secure authentication measure provided by the central government) was made compulsory for healthcare service providers sending medical bills and pharmacies sending prescription data for reimbursement (Homsest peavad …, 2006), thus supporting the diffusion of ID-card usage among health providers and pharmacists.

Thus many basic requirements for e-prescribing system were existent by 2006. Also a development project was launched in co-operation between EHIF and the Ministry of Social Affairs with the aim to implement an e-prescribing system, where a patient can buy the prescription drug from a freely chosen pharmacy without the need for having a paper prescription. The intention was to make it more convenient and secure to write prescriptions, save time for pharmacists, enhance feedback and analytic capabilities and save costs on paper prescriptions. (Majandusaasta aruanne …, 2006; Majandusaasta aruanne …, 2007).

The development of the Estonian health information system (EHIS) could be considered as the second phase of e-health development in Estonia. EHIS is regarded as the fundamental platform for ensuring standardized and fluent data transmission among relevant stakeholders: healthcare service providers, patients, state registries, insurance foundation, pharmacists etc (Eesti terviseinfosüsteemi …, 2010, 9). By 2005 the level of IT-usage in the Estonian health system was quite diverse. Most care providers had already implemented different IT systems: e.g the Tartu University Hospital health care image database, IT-solutions by EHIF and information systems of different health providers and pharmacies. Yet the systems were not interoperable to exchange information. (Koppel *et al*. 2008) EHIS was seen as a solution to that problem and a possibility to connect the relevant data to support health services contracting, ensuring quality and protection of patient rights and public health, as well as make it feasible to manage relevant registries and health care on the whole. (Tervise infosüsteemi põhimäärus 2010)

The concept of EHIS was presented in 2005 by The Ministry of Social Affairs of Estonia as the main regulatory institution for health policy development and health system stewardship (Koppel *et al*. 2008). The aim of the concept was to implement four e-health projects: electronic health record (EHR), digital image, digital registry and digital prescription (EPS). In order to manage the projects, an independent administrative institution, the Estonian E-health Foundation was formed. The founding institutions were the three largest hospitals in Estonia, Ministry of Social Affairs, Association of Family Doctors, Estonian Hospitals Association and the Union of Estonian Medical Emergency. Thus important stakeholders were gathered for ensuring co-operation and requirement fit. Estonian E-health Foundation is mainly responsible for standardization and development of digital medical documents and managing EHIS. (Eesti terviseinfosüsteemi …, 2010, 9)

Relevant legal foundations of the system were set in 2007, when the Parliament of Estonia adopted the essential acts. EHIS was activated in 2008, while development of the system continued. In essence EHIS is a state provided framework with the aim of transmitting data through a central server. The system does not substitute internal IT systems of healthcare service providers or pharmacies, but provides the possibility to connect the internal IT systems to EHIS and exchange medical data across the entire health system. (Eesti terviseinfosüsteemi …, 2010, 8) Thus EHIS made it also possible to link prescription data (then solely in the EHIF system) to the country-wide EHR, to bring together personal data and medical records, digital pictures and other important health related data.

At the same time, the development of the e-prescribing system was still to be co-ordinated by the EHIF, although the Ministry of Social Affairs also had an important role (Eesti terviseinfosüsteemi …, 2010): a contract for the procurement of necessary software and hardware was signed in 2007 (Majandusaasta aruanne …, 2008) in order to build the central database: the prescription centre (PRC). As defined by law (Retseptikeskuse asutamine …, 2013), PRC is a database established to make it feasible to prescribe and process prescriptions and medical device cards and make reimbursements to insured individuals. PRC has the aim of protecting the

health of patients using prescription drugs and provide supervision, whether the pharmaceuticals provided are justified and appropriate, also to make it feasible to conduct pharmaceutical statistics. Simply put, PRC is a system, which makes it possible to gather data from different national registries and users of the system and use the data to organize the provision of digital prescription service to the various stakeholders.

Several important developments were made in 2008-2009: a module was developed to enable to integrate the information systems of healthcare service providers and pharmacies to the PRC, a module for writing a digital prescription and dispensing the drug was developed and a module for patient authentication was developed in the pharmacies (E-teenuste kasutamise …, 2013, 46). All the costs regarding integrating the health care service providers' and pharmacies' information systems (IS) to the PRC had to be covered by themselves. Also a Mini Information System Portal (MISP) was developed by EHIF in order to make it possible for doctors and pharmacies to use the service online in case of no local IS. (*Ibid.;* MISP portal 2013)

As part of the overall health information system implementation process, several broad campaigns were organized and also user traingings were prepared for health care workers during the period of 11.2007 – 12.2008. The trainings centered on filling and transmitting digital documents. Several trainings were also conducted by healthcare service providers and related software development companies. (Eesti terviseinfosüsteemi …, 2010, 15)

EPS was activated on January 1, 2010, when pharmacies were obliged by law to process prescriptions through the PRC (unless a few objective reasons were met). Due to the fact that many doctors were still writing paper prescriptions, processing prescriptions through a former data transmission service TORU was still active until January 2011. From that point onwards, doctors were also obliged to write digital prescriptions. As of July 2011 all data transmission started to go through PRC. As of January 2012 all of the non-reimbursable prescriptions were also digitalized. (Digiretseptist apteekrile 2012) By 2012 almost all doctors and

pharmacies had joined the system (E-teenuste kasutamise …, 2013, 47). The usage level of the system can be characterized by figure 1[2], showing a clear positive trend since the implementation of the system.

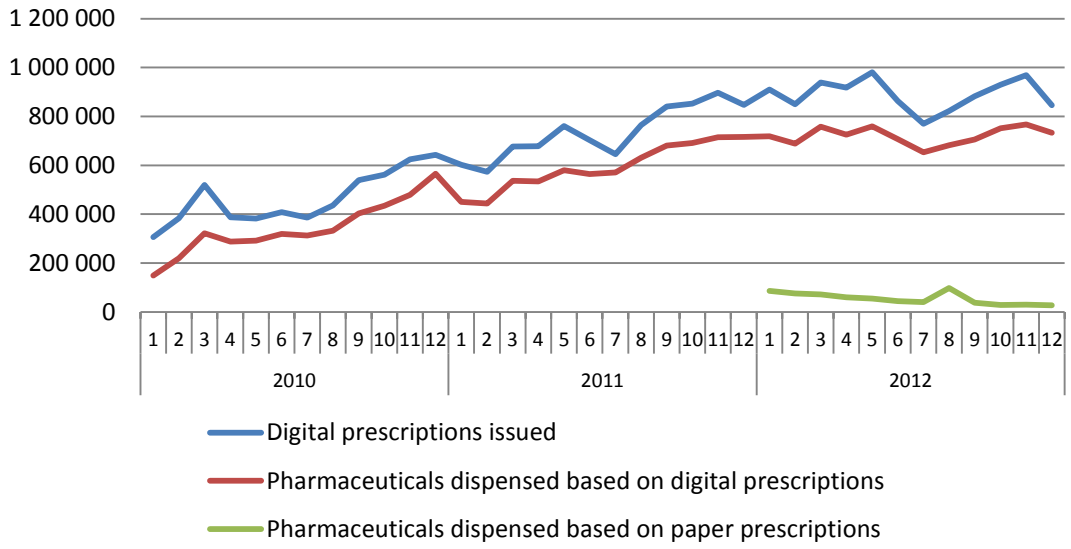

Figure 1. Digital prescriptions issued, pharmaceuticals dispensed based on paper prescription, pharmaceuticals dispensed based on digital prescription (includes only prescriptions processed through PRC). Source: Data inquiry from EHIF 02.04.2013.

In sum, the long development path of the system characterizes the importance of EPS as a research subject. It is clear that there are several important stakeholders to be kept in mind when thinking about how to evaluate a nation-wide system.To better outline the roles of various countrerparts, the architecture and functional process steps of EPS should be more thoroughly discussed.

[2] The figure does not cover the durg dispensed based on paper prescriptions 2010 and 2011, as they were not processed through prescription centre. In 2010 3,1 million and in 2011 1,3 million reimbursable pharmaceutical hand-written prescriptions were issued. There is no exact data about prescriptions whithout reimbursement. (E-teenuste kasutamise …, 2013)

1.3 The e-prescribing system in Estonia – architecture and process

The intricate architecture of the e-prescribing system in Estonia can be described by figure 2 below, which shows the integral role of the prescription centre (managed by EHIF) in providing the service, yet also the importance of other counterparts in doing that (pharmacies, physicians, state insitutions and national registries).

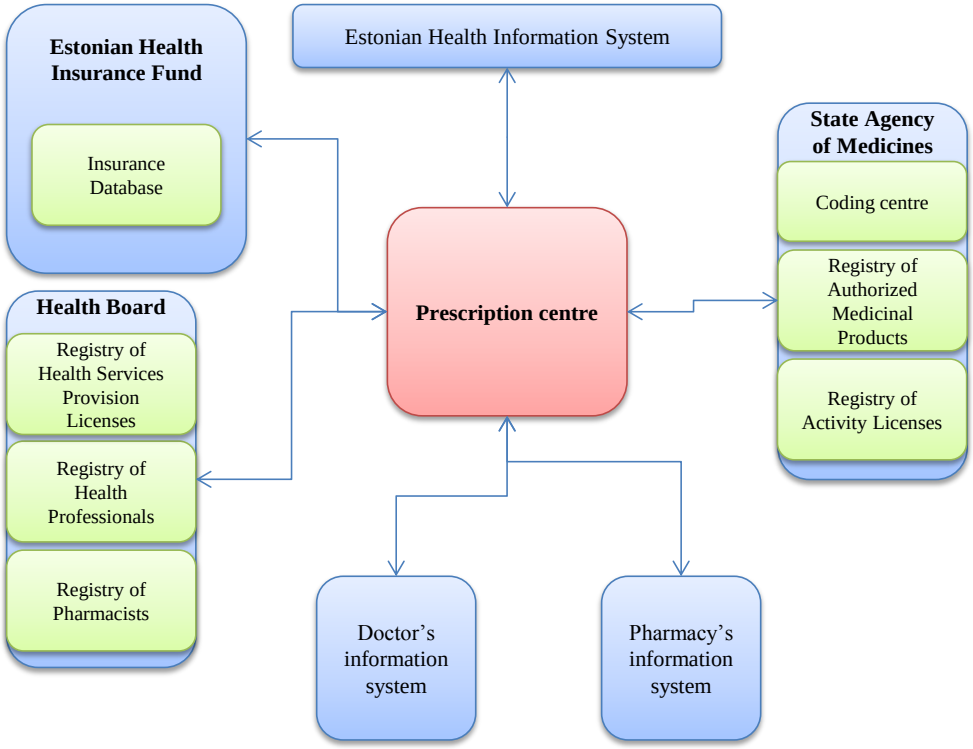

Figure 2. Indicative figure of the architecture of Estonian EPS. Source: author (based on Retseptikeskuse asutamine …, 2013; Digiretsepti realiseerimine …, 2007).

In addition to doctors, patients and pharmacies, the different national registrars are also involved in the system, as PRC gathers and checks the relevant data from different registeries. The following registries transmitting data were involved (Retseptikeskuse asutamine …, 2013):

- National Registry of Health Professionals, National Registry of Health Services Provision Licenses, National Registry of Pharmacists (registrar: Health Board)
- Insurance database (registrar: EHIF)
- Coding centre, Registry of Activity Licenses, Registry of Authorized Medicinal Products (registrar: State Agency of Medicines).

The Estonian e-prescribing process is described using the framework by Bell *et al*. (2004) as well as other relevant documentation (Majandusaasta aruanne…, 2009; Eesti üleriigilised e-tervise …, 2007; Digiretsepti eelised ja võimalused 2012; Koppel *et al*. 2008, Digiretsepti realiseerimine …, 2007; Retseptikeskuse asutamine …, 2013; E-teenuste kasutamise …, 2013) and is divided into 6 broader steps. Compared to the framework by Bell *et al*. (2004) an additional step of re-prescribing is added in order to grasp the possibility of prescribing by telephone in case of chronic diseases. The steps are presented and then described below in the following sequence: prescribing, transmitting, dispensing, administering, monitoring and re-prescribing.

1. Prescribing – doctor issuing the prescription:
    a. Selecting the patient or patient identification.
    b. Diagnosis selection.
    c. Active substance selection from a list.
    d. Reimbursement rate selection.
    e. Other relevant data.
2. Transmitting – instead of printing or paper based documentation, the prescription data is sent to the PRC using X-road.
3. Dispensing – pharmacist dispensing the drug based on the prescription:
    a. Patient has to identify himself/herself at the pharmacy (based on the ID-number of the person).

b. Pharmacist ‘pulls’ and selects the right prescription(s) from the PRC database, based on the ID-number of the person. The relevant data about the patient, doctor and drug is automatically generated for the pharmacist.
c. In case of problems with understanding the prescription the pharmacist contacts the doctor by telephone.
d. When the drug is dispensed, a notice is sent back to the PRC.

4. Administering – no changes regarding e-prescribing have been detected during the phase of administering the drug.
5. Monitoring – monitoring can be conducted at different levels – patient-specific prescription data can be seen by the doctor and the patient, statistical monitoring can be done by relevant institutions such as Ministry of Social Affairs, EHIF, Health Board, State Agency of Medicines:
    a. The patient can access his/her outstanding prescriptions online from the patient portal or citizen portal[3] and can also see whether doctors or pharmacists have accessed their data. The patient can also authorize other people (e.g relatives) to buy the drugs for them.
    b. The doctors can receive information, whether the prescribed medicine has been dispensed and also see other prescriptions issued for the patient.
    c. Ministry of Social Affairs, Health Board, State Agency of Medicines, EHIF, and Estonian Data Protection Inspectorate can obtain statistics and reporting of prescribing data.
    d. Monitoring is also done at EHIF, where an administrator is checking the flow of the system and conducts changes to base-data (e.g. reimbursement rates, classifications of drugs). An operator provides a support service in case of technical errors.

[3] In 2012, there were on average 17611 pageviews of prescription information per month from the Citizen Portal (based on the data inquiry to the Estonian Information Systems’ Authority conducted by the author, 07.07.2013).

6. Re-prescribing – in case the patient's disease is of long-term nature and easily controllable, due to what a specific drug is used under a constant treatment plan, a new prescription can be issued by a phone consultation.

The presentation of general architecture of EPS and the e-prescribing process above, show that the roles of different stakeholders (e.g. doctors, state institutions) are varying in different circumstances and therefore evaluation focus from different perspectives is of high relevance and should be kept in mind when answering the research question.

1.4 Defining the research problem

The extent of previous evaluations regarding EPS in Estonia is low. The relevant evaluation research consists mainly of qualitative studies with emphasis on some specific aspects of the system.

The most evaluated measure has so far been user satisfaction with the system. EHIF has conducted satisfaction surveys among its partners (care providers and pharmacies) and also acquired information about the perceptions towards electronic prescriptions since 2010 (Haigekassa lepingupartneritega rahulolu, 2009, 2012). The Ministry of Social Affairs (Elanike hinnangud …, 2011) has carried out surveys among citizens, which have also included questions regarding the use of digital prescriptions and satisfaction with the dispensing of the drugs based on the digital prescription. Both abovementioned surveys have incorporated some free-text answers regarding e-prescribing.

No quantitative quality measurements have been made, although a survey about the estimated error reduction has been conducted among family doctors and pharmacists and concluded that there has been a decrease in errors. Nevertheless the retrospective survey did not cover the aspect in great depth: no distinction of different types of errors was presented in the questions. The survey also covered time

use measures in a subjectivist manner, but the method had several methodological limitations (E-teenuste kasutamise …, 2013, 52) regarding time measurement.

There is no research concerning monitoring phase (described above) – the number of pageviews by patients in the Citizen Portal is accessible upon data request, but the characteristics of the viwers are unknown. EHIF database data about prescriptions written and drugs sold is also quite narrow, although an extensive statistics module is being developed, which can be used by other institutions (E-teenuste kasutamise …, 2013, 47).

Also, there is no public research on the development of different local IT-systems at healthcare service providers or pharmacies, although such systems play an important role in the quality of the system, especially on aspects regarding user-interface and connection to other HISs.

Furthermore the overall costs and benefits of the system for different counterparts are yet to be identified. A general mapping of different possible cost has been conduced (E-teenuste kasutamise …, 2013), showing that there is no information about the costs for development and adjustments of integrated registries or development and integration costs carried by healthcare service providers and pharmacies.

It is important to discuss the reference period of the cost/investment evaluations. Many incorporated systems (TORU, X-road, ID-card, state registries) have been developed for a long period by different institutions and consequently provided important prerequisites for the implementation of other e-services/systems. Thus, as far as *ex-post* evaluation is concerned, the setting of the reference point and distinction of the service itself and its prerequisites is very important. This aspect is connected to future developments of the system – a comprehensive evaluation would be a good input for next development phases of the Estonian EPS.

The author hereby argues that there is a considerable gap in the practice of evaluating EPS in Estonia. There is no mutually agreed and formally implemented framework for evaluation, which could give a clearer startingpoint for answering the question – how to evaluate the EPS in Estonia in a comprehensive and exhaustive

manner? Although a few evaluations have been conducted, different relevant aspects have not been covered. The paper will start to fill that gap by developing a framework for Estonian EPS evaluation. The next chapter will give an overview of general evaluation background and will then concentrate specifically on electronic prescribing systems and alike.

2 THEORETICAL BACKGROUND, EVALUATION APPROCHES AND FRAMEWORKS

2.1 Evaluation of health information systems

Evaluating the impact of broad information systems is not a simple task as information technology is nowadays used in very different settings in very varying extent. Several important questions arise when choosing a suitable evaluation approach for the electronic prescription system in Estonia. Yusof *et al*. (2008a) point out the questions of *why?, who?, when?, what?* and *how?* to be asked about information systems evaluation. The following paragraphs will cover the questions in order to provide a theoretical input for the paper in developing a specific evaluation framework for the Estonian EPS.

The reason for conducting an evaluation is of high significance and the '*why'* question stands for the objective of the evaluation (Yusof *et al*. 2008a). There can be several reasons for conducting an evaluation. For example, in case of systems already in use, the aim of the evaluation can be to find improvement possibilities and provide knowledge to other implementers. However, when the system is still in the planning phase, it can provide valuable information for decision-making, whether to adopt the system or not. Evaluation is especially important in learning from past experiences to identify more effective techniques or methods. (*Ibid.*) Evaluation objectives can be also connected to the final goal for implementing such systems, for example quality or improved performance (Shekelle and Goldzweig 2009, 2) or in case of Estonia: better health protection and better supervision over the pharmaceutical system (Retseptikeskuse asutamine …, 2013). Hence the reason for

evaluation has several dimensions – it could try to evaluate whether the implementation of the system has produced desired outcomes, evaluate the overall impact, but also give input for improving a current system.

The '*who'* question defines, which stakeholders' view is evaluated, as large IT projects can affect several stakeholders in a system (Yusof *et al*., 2008). As seen above, many stakeholders are involved in the Estonian EPS during different process phases – including patients, clinicians, purchaser, pharmacies, commercial IT-system providers and different state institutions. The number of stakeholders can make the implementation and possible outcomes more diverse and thus the evaluation more difficult (Motulsky *et al*. 2013). It is important to make the distinction between the context and the subjects under evaluation, as the bounadries between the subject and the context are often hard to define (Yin 2009, 18), as can be also seen based on the long development path of the Estonian EPS.

The '*when'* question is also relevant with regard to the current study, as it should be asked in what phase of development (Yusof *et al*. 2008a) the information system is. This is also connected to the notion, whether we are viewing the system as a ready one or we see it in an intermediate phase, as IS evaluation can be done during the four main phases of the classical system development life cycle (SDLC) – pre-implementation (development), during implementation, post-implementation or routine operation (*Ibid.*). Kaplan (1997) asserts that depending on the phase, evaluation can be regarded as formative or summative – the former having the aim of improving the system in development/implementation, the latter providing assessment of a system already implemented. A summative evaluation studies the impact and outcomes emerged during the use of the system (Currie 2005, 909).

The fourth question '*what'*, as postulated by Yusof *et al*. (2008a) can be regarded as the focus of the evaluation. There are innumerable aspects that can be measured and evaluated regarding a health information system (HIS). Evaluation can include 'technical, professional, organizational, economic, ethical and legal domains' (*Ibid.*). Shekelle and Goldzweig (2009) also discuss the broad nature of organizational interventions, which interact with many of the system components.

Thus IT-interventions can also be difficult to generalize, for example compared to more specific interventions like pharmaceuticals (*Ibid.*, 6). Hence, in many cases it is not easy to draw the line between different systems or sub-systems (e.g. prescription system and electronic health record) and ideally the evaluation framework should seek to address such a difficulty.

The final broad question of evaluation: '*how'* represents the choice in the research approach of the evaluation (Yusof *et al*. 2008a). Evaluation could be supported by a broader framework and entail objectivist or subjectivist approaches. The former relies on the assumption that there is a possible common understanding, what constitutes a good system: for example, randomized controlled trials (RCTs) are important in the objectivist approach. The latter on the other hand assumes that there are many stakeholders involved in a complex system, thus there is no one and only way to say, what is right for them. (*Ibid.*) Yusof *et al*. (2008a, 381) clarify that 'in subjectivist studies, research is conducted based on the judgements of expert evaluators or system stakeholders in the natural environment of the subjects'. The subjectivist studies can be more efficient and holistic (e.g. use of semi-structured interviews), while objectivist approach could be more costly and sometimes difficult to produce (*Ibid.*).

Hence a right balance between subjectivist and objectivist approaches and qualitative and quantitative methods should be seeked, although integrating qualitative and quantitative research can be difficult (Bryman 2007, 21), while it could be also challenging to provide a comprehensive evaluation with just a few methods in case of systems with many related counterparts, users, dimensions, functions and development phases. Thus an arsenal of research approaches should be considered beforehand, whereas taking into account the cost and suitability of different methods.

2.2 Relevant approaches for evaluating e-prescribing systems

As the scope of the current paper is limited, a broader discussion with author's selection of relevant examples concerning research design, methods and measures of EPS evaluation will be presented below. Also important limitations of previous research about EPSs will be discussed.

With regard to second generation e-prescribing systems (as the EPS in Estonia) the research base is still quite low (Motulsky *et al*. 2013). The study designs are mainly observational, with or without a control group – hence level III and IV designs (see Appendix 1 on hierarchy of study designs). No experimental or quasi-experimental studies were detected in the systematic review of second generation e-prescribing systems (*Ibid.*).

On the other hand several reviews have been conducted, which concentrate on first generation electronic prescribing systems (CPOEs, with or without clinical decision support systems – CDSSs) that could also be a functional part of a hypothetical second generation e-prescribing system. In numerous cases (as discussed in systematic reviews by Ammenwerth *et al*. 2008, Eslami *et al*. 2007) experimental (RCTs) and quasi-experimental (non-RCTs) studies have been conducted. Evaluation articles in these reviews were using randomized controlled trials, non-randomized controlled trials, before-after trials, as well as time-series analysis with multiple measurements and also evaluations with observational study designs. As far as quantitative studies are concerned, two important and often evaluated subjects emerge: quality and time.

One of the main drivers of IT implementation has been the argument of the possibility for improving quality and safety of health care. In case of EPSs, quality can be measured at different levels, yet a common indicator used has been the rate of medication errors and potential adverse drug affects. The review study by Ammenwerth *et al*. (2008) covered articles evaluating the effect of electronic

prescribing on medication errors (ME[4]), potential adverse drug affects (potential ADEs)[5] and ADEs[6]. With regard to different measures of safety, there are several aspects to consider, as there can be a number of different causes[7] of MEs and ADEs. Based on the research by Bell *et al*. (2004) it could be argued that the causes and types of errors should not be looked from only the pharmacists point of view but also other functional steps (prescribing, monitoring) and stakeholders (doctors, administrators) should be taken into account in dealing with error reduction, this posing question, whether it is possible and efficient to evaluate EPS with objective measures of quality.

Furthermore, Eslami *et al*. (2007) also concluded that outcome indicators regarding quality and safety need attention, although this is hard to do due to the dispersed patient information and the non-controllable environment in outpatient area. This also makes it difficult to produce RCT-s in outpatient settings. Rosse *et al*. (2009, 1189) point out that conducting RCT-s is close to impossible due to the specifics of the intervention and before/after designs in multicentre settings would be more suitable.

Similar issuese emerge regarding the impact of EPS to time usage and work-patterns. For example Clamp and Keen (2005) show (similarly to Eslami *et al*. 2007) that the time taken by physicians to write prescriptions might rise at first, but it decreases with time as doctors become more accustomed to the system. There can be also variations in work-pattern changes for professionals, as less time could be spent

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[4] MEs defined as 'medication error as all errors in the process of ordering, transcribing, dispensing, administering, and monitoring medication. This included an inappropriate drug, dosing, frequency, route, or timing (when related to patient safety), involving problems such as illegible or unsigned orders, and problems related to drug-allergy, drug-drug, drug-lab, and other interactions." (Ammenwerth et al. 2008, 592)

[5] Potential ADEs were defined as 'a medication error with significant potential to harm a patient that may or may not actually reach a patient". (Ammenwerth *et al.* 2008, 592)

[6] Adverse drug events (ADE) were defined as 'patient injuries resulting from drug use". (*Ibid.*)

[7] Bell *et al.* (2004) list the root causes as: lack of knowledge about the drug or the patient, calculation and decimal point errors, nomenclature errors, faulty administrative processes, rule violations, slips and memory lapses, drug stocking and delivery problems, faulty interaction with other services and faulty drug identity checking; while as the main error types are wrong dosage, wrong drug choice, known allergy, wrong route of administration.

on filling prescriptions and more time on actual pharmacy work (Clamp and Keen 2005), but extra time could also be needed for problem-solving activities (Murray *et al*. 1998).

Several studies have observed the effect of EPS on time-usage and work patterns of professionals (Murray *et al*. 1998; Overhage *et al*. 2001; Stone *et al.* 2009). Murray *et al*. (1998) measured the effect of computer-based outpatient prescription writing on pharmacist work patterns by using multidimensional work sampling method, seeking to find out the percentage of time spent on different activities, reasons for each activity ('function'), and people contacted by the pharmacists[8]. Recording these activities made it possible to describe pharmacists' work patterns before and after the implementation of computer-based outpatient prescripition writing. Also an RCT with similar aims has been conducted (Overhage *et al*. 2001) to study the impact of CPOE implementation in primary care internal medicine practices using time-motion measurement technique[9].

Many of the studies (*incl.* Ammenwerth *et al*. 2008; Overhage *et al*. 2001; Stone *et al.* 2009) included also a qualitative component regarding different subjective measures such as ease of use, work-flow improvement, organizational aspects). Surveys, structured and semi-structured interviews, focus-groups and desk-research based on secondary data are of high relevance with regard to qualitative studies (Tan *et al*. 2009, Duffy *et al*. 2010, Bell *et al*. 2004, Yusof *et al*. 2008b, DeLone and McLean 2003), but also other qualitative approaches have been developed, which could be useful in case of EPS evaluation: simulation, usability testing, cognitive studies and social interactionism among others (Kaplan 2001, 40).

It has been demonstrated that the attitude towards adoption of an EPS system could be connected to the quality changes perceived by users. In a study by Schectman *et al.* (2005) a survey was conducted assessing the determinants whether

[8] The pharmacists were prompted by a technical device at random intervals (4-8 signals per hour) to mark their current activity during their work day.
[9] For example time for activities such as 'calling to a patient' or 'writing an order' or looking a reference for a drug on computer was recorded.

physician experience with and attitude towards computers is associated with adoption of a voluntary ambulatory prescription writing expert system. They discovered that variation in use of the system was strongly related with physician attitude toward aspects regarding the system's efficiency and effect on quality, but not with former computer experience or level of training. The importance of measuring organizational aspects was also acknowledged by Ammenwerth *et al.* (2008) when showing that home-grown systems show a higher relative risk reduction than commercial systems. The authors assume that this due to the fact that home-grown systems can be modified and adapted easier and more quickly to the local organization needs. This aspect is important with regard to the current study, as the Estonian landscape of different commercial systems is rather diverse[10].

Bell *et al*. (2004) acknowledge that the high cost of controlled trials should be considered when accepting or declining less rigorous evidence. With regard to that statement, Shekelle and Goldzweig (2009, 16) argue that randomised controlled trials (RCTs) are not always suitable for evaluating organizational change and relying on RCTs may result in the focus being to narrow; multifaceted structural interventions are executed as a series of phases, whereas each phase depends on the organizational reaction to the prior phase. There has been a rise in focus on organizational cultural, political issues connected to the systems and the need for accompanying users to the design process of IS development has been proposed (Kaplan 1998, 327).

In a systematic review, which included EPS evaluation studies, Black *et al*. (2011) highlight the absence of sufficient research on patient-level benefits, but similarly to Shekelle and Goldzweig (2009, 20), also on the cost-efficiency of that kind of systems. Supporting the notion by Shekelle and Goldzweig (2009, 20) and Eslami *et al*. (2009) that not enough attention is paid on the technical aspects in HIS evaluations on the whole, Eslami *et al*. (2007) also state that none of the selected papers in their study assessed the technical aspects (data security, reliability of data

[10] Including companies: 5D Vision OÜ, AS GennetLab, Connected OÜ, AS Medisoft, AS Helmes. Several big providers (Tartu University Hospital, Medicum, East-Tallinn Central Hospital) have home-grown systems (Tarkvara 2013, Leego 2004, I-patsient 2013, Medicum 2013).

transfer system, user interface, technical functionality), although they are very important and thus should be considered in assessing the EPSs. Schledbauer *et al*. (2009) mark also that different design features should be studied in order to determine what kind of design elements are connected with better prescribing and clinical outcomes. On the other hand it should be kept in mind that concentrating merely on technical and clinical aspects could not adequately describe the success of a system within specific settings and users (Yusof *et al*. 2008b).

In sum, it can be seen that the evaluation approaches and extent of evaluation of EPSs vary in complexity and rigour. Choosing the questions to be asked or indicators to be measured in an evaluation can be difficult without a systematic framework. The author hereby argues that different approaches should be considered when evaluating extensive e-prescribing systems. When choosing the evaluation framework, it should be asked what kind of a framework supports setting a focus on evaluation and using different methods, measures and study designs (quantitative and qualitative), but also address different dimensions, aspects and problems of an EPS.

2.3 Relevant evaluation frameworks

A framework is hereby described as a plan or a structure with relevant aspects or attributes that an evaluation will focus on: an evaluation framework can comprise different study designs, measures and analytic methods. (Eisenstein *et al*. 2011, Yusof *et al*. 2008b). In other words, an evaluation framework facilitates a mapping exercise for evaluation (Black *et al*. 2011) and necessary dimensions before conducting specific assessments with qualitative, quantitative or mixed methods (Yusof *et al*. 2008b). Evaluation frameworks should be also able to capture the central processes of systems, but also the user and the context where the system is used (Currie 2005, 909).

Different frameworks address different evaluation needs – some focus on specific development stages of a HIS (Stead *et al*., 1994), some look at different

process steps (Bell *et al*., 2004) and distinguish different evaluation dimensions (Yusof *et al*., 2008b, DeLone and McLean, 2003), there are also several frameworks for health technology assessment (Lehoux and William-Jones, 2007) that could be effectively used for evaluating information technologies (Kazanjian and Green, 2002).

Some framework approaches take the cost and investment perspective for evaluation. Saluse *et al.* used an interdisciplinary approach (the PENG method) to analyse the costs and benefits of the implementation of an EHR, by using both numerical and non-numerical data. The PENG approach made it possible to assess the financial, direct, indirect and immaterial benefits and costs by a mapping exercise, while taking into account the different stakeholders: patients, providers, society. (Eesti terviseinfosüsteemi …, 2010) Although due to its numerous dimensions the approach could be used as a broader framework for evaluation, the final result is the assessment of net benefits / economic impact and thus the method is more suitable for investment evaluation. The PENG approach is similar to the Total Cost of Ownership method, wich aims to to quantify the short and long term (direct and indirect) costs of an IT solution during the total life-cycle of the system, but TCO model does not usually assess how the system meets the needs of the user or fits with the organization's strategic aims (Total Cost …, 2013, West and Daigle 2004), which can be seen as an significant limitation to the approach.

Several frameworks address the system development life-cycle in the framework (Currie 2005, 912). For example, Stead et al. (1994) juxtaposed the system development level to the evaluation level, showing what should be the extent of evaluation during a specific stage of system development. Stead *et al*. (1994) stress (similarly to Currie 2005, 909) the importance of subjective evaluation techniques during implementation, as quantitative studies can be impractical. Again the relevance of such a framework in the current study is low, as it has a focus on evaluating an already implemented system (post-implementation evaluation).

Shekelle and Goldzweig (2009, 7) on the other hand have separated the following dimensional evaluation components: technical factors, human factors, project management and organizational and cultural change (see table 1 below).

Table 1. Evaluation components

Technical factors	System components, previous and existing IT/technical infrastructure and interfaces.
Human factors ('machine-person interface')	The user-friendliness of the system including system response time, intuitiveness, support for workflow processes and other context-specific aspects.
Project management	Managing the socio-technical change of the process during HIS implementation.
Organizational and cultural change	Aligning incentives of different counterparts (doctors, administrative staff) and using organizational inertia to achieve stated goals.

Source: Shekelle and Goldzweig 2009

The framework of evaluation components by Shekelle and Goldzweig (2009) has similar characteristics to the framework developed by Yusof *et al*. (2008b). Yusof *et al*. (2008a) conducted a broad literature review on different evaluation frameworks of health information systems, investigating whether the existing frameworks are sufficient in supporting health service delivery; they do that (similarly to Shekelle and Goldzweig, 2009, 7) in the dimensions of human, organizational and technological factors. As organizations and technology become more inter-connected while implementing technological solutions, it is important to consider the organizational structure, human communication patterns and the changes the technology poses in a comprehensive manner (Turner 2003, 530).

The HOT-fit framework (developed by Yusof *et al*. 2008b) is based on previous work on the review of HIS evaluation and makes use of two models of IS evaluation: the IS Success Model (initially developed by DeLone and McLean, 2003) and the IT-Organization Fit Model (initially developed by M.S. Scott Morton). The graphical depiction of the HOT-fit framework is presented below (see figure 3).

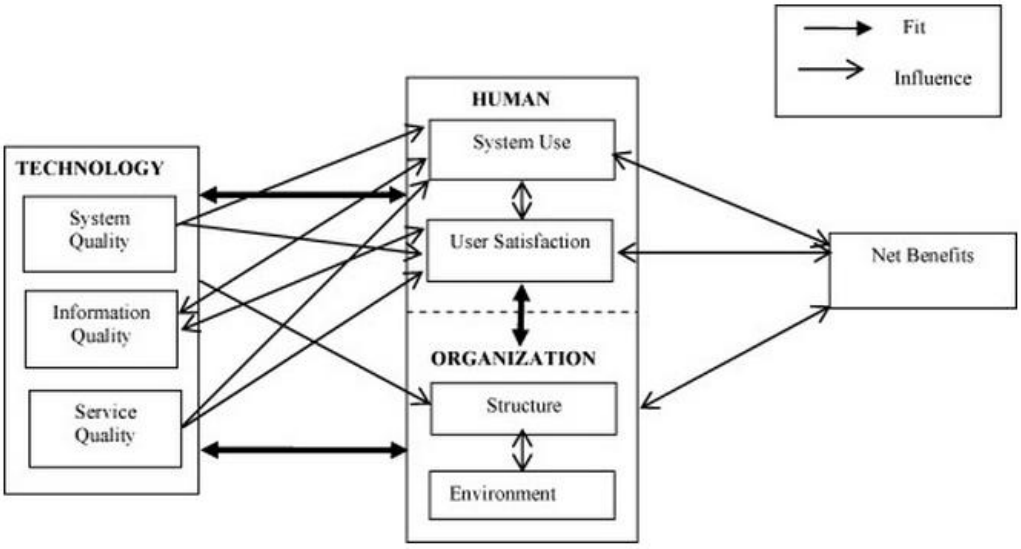

Figure 3. Human-organization-technology fit (HOT-fit) framework. Source: Yusof *et al*. 2008b, 389.

Yusof *et al*. (2008b) regard the HOT-fit framework suitable for HIS evaluation for several reasons. The framework ties 8 dimensions of HIS success: system quality, information quality, service quality[11], system use, user satisfaction, organizational structure, organizational environment and net benefits. All of these dimensions are interconnected and have an impact on each other either jointly or on its own. This concept is also described by Kaplan (2001): fit can be seen as system's coherence with the work-flow and work-patterns, professional expertise and culture, user or organizational life. Yusof *et al*. (2008b) see the concept of fit in their framework as 'as complex, abstract and subjective' (making it suitably loose for a basis of a new framework development). Fit between human, organization and technology can be analyzed by different measures, keeping in mind that the extent of human, technology, human and organization fit increases the success of HIS (*Ibid.*).

Due to the limited scope of the current study, it will mainly focus on the relevance of different dimensions for framework development rather than the exact

[11] From here on referred to as 'support service quality'.

relations between different dimensions and measures, although the relationships with different dimensions are a matter of future research in case of EPS-s especially.

As the framework presented above has been developed for general HIS analysis, frameworks for specifically EPS assessment should be also considered. The described HOT-fit framework could be supported with the work of Bell *et al*. (2004), who have taken a very different approach in assessing the risks and benefits of e-prescripition systems.

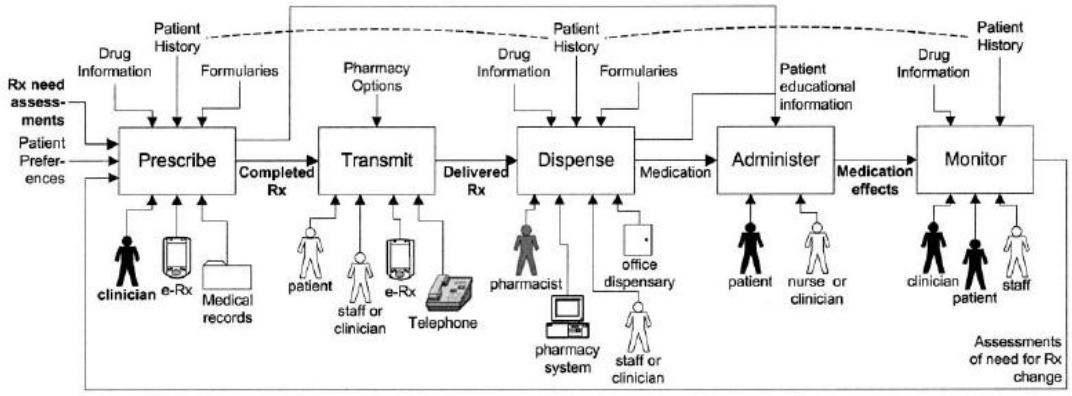

Figure 4. Conceptual Framework for Electronic Prescribing. Source: Bell *et al*. 2004, 64.

Bell *et al*. (2004) have developed a conceptual framework (see figure 4) for comparing e-prescribing systems based on their components' functional abilities (prescribe, transmit, dispense, administer, monitor), where potential effects of each capability or sub-capability were mapped. The functional approach was also used in describing the current EPS in Estonia in chapter 1.3. The approach could give a better stakeholder view on the system, but at the same time making it able to cover the different relationships in each of the functions/phases.

Based on the literature review, it can be concluded that there are a number of different evaluation approaches and evaluation frameworks for HIS evaluation, but there are no comprehensive evaluation frameworks specifically for country-wide EPS systems, which could fully address the needs of the Estonian EPS. Hence,

relying on the selection of frameworks above and the relevant evaluation approaches, a framework should be developed for facilitating the evaluation of the country-wide electronic prescribing system in Estonia. The techniques for doing that are presented in the next chapter, which covers the methodology and methods of the current paper.

3 METHODOLOGY AND METHODS

The master thesis is based on an exploratory case study employing an inductive approach. A case study method was selected due to the nature of the problem to be solved. The main reasearch question was '*how'* to evaluate the country-wide electronic prescribing system in Estonia. As Yin (2009, 18) puts it: 'a case-study is an empirical inquiry that investigates a contemporary phenomenon in depth within its real-life context, especially when the boundaries between the phenomenon and the context are not clearly evident'. Hence the method is relevant, as electronic prescribing systems evaluation can be described as a contemporaty phenomenon and the context is the Estonian country-wide electronic prescribing system is the general health care environment, with loose boundaries amid the phenomenon itself.

The paper is a case-study research with the unit of analysis being the electronic prescribing system evaluation. It should be stressed that the unit of analysis is not the system itself, but evaluation of the system as such. Due to the fact that case-study methods have not been codified (Yin 2009, 25), the selection of such a method for framework development should be approached cautiously and every phase of the research thoroughly specified.

Several sources for qualitative data collection were used in order to gather relevant and comprehensive information about EPS and its evaluation in Estonia. Previous literature on EPS and HIS evaluation in Estonia was incorporated, also public databases studied on relevant background data. Data inquiries to EHIF and Estonian Information System's Authority (EISA) were made in order to aquire information on EPS usage levels.

Academic literature regarding electronic prescribing system evaluation was searched from international and university databases (Google Scholar, PubMed, National University of Singapore Libraries). The search words included: electronic prescribing system, prescription system, evaluation, e-prescribing evaluation, e-prescribing systems, impact evaluation, evaluation framework, CPOE evaluation, HIS evaluation framework, drug order entry evaluation. Same keywords were searched from the references of the articles found. Several systematic reviews were identified and the articles in those studied and, if found relevant regarding the research question, incorporated into the study.

The strategy for development of the initial framework included selecting a broad preliminary framework (based on literature review) as a benchmark and analyzing its suitability for the Estonian EPS evaluation case context. A deductive directed qualitative content analysis technique was used (Wildemuth 2009, 311; Hsieh and Shannon, 2005, 1281), where the initial coding starts with an existing conceptual framework (preliminary model) and research findings in order to extend or modify the existing framework (Wildemuth 2009, 311). Initially a new framework for the evaluation of the subject under research is developed, thus the method consist also an inductive element. The framework was further developed and modified by incorporating dimensions from other frameworks and evaluation approaches and connecting the dimensions with the context of Estonian EPS.

The initial framework was validated by five experts. Experts were selected based on their competencies and background regarding HIS and e-prescribing system evaluation and familiarity with the overall health care and electronic prescribing context in Estonia. Of the five experts three had active experience in developing the EPS in Estonia, two experts had general e-health evaluation and implementation experience, two experts have evaluated other health programmes and two experts had been trained as medical doctors (see table 2 below).

Table 2. Competencies of participants in the validation exercise

Validation participants' experience	Active experience in developing/implementing EPS in Estonia	Experience in using evaluation frameworks for HIS or health programs evaluation	Trained as a medical doctor
Expert 1		x	
Expert 2	x	x	
Expert 3	x		
Expert 4	x	x	x
Expert 5		x	x

Source: author

The validation exercise was conducted in the form of semi-structured interviews with open-ended questions, while keeping in mind the guidlines presented by Meho (2006); (see Appendix 2 for the interview guide). A .doc file with the validation questions and initial framework was sent by e-mail to the experts. The selection of a .doc file based e-mail interview (not an online form or face-to-face interview) was made in order to make it easy for the experts to write comments into the framework itself, which was presented in the structured interview form. Using an e-mailed document for colleting answers made it possible for the experts to create additional figures in order to present their answers and own experience more thoroughly and thus allowing more information rich and thought out results (Meho 2006, 1292).

In sum, the research can be divided into 5 phases:

1. Describing the Estonian EPS background.
2. Describing relevant evaluation approaches and frameworks.
3. Developing an initial evaluation framework applicable to the context of the country-wide electronic prescribing system evaluation in Estonia.
4. Validation of the framework by experts.
5. Making refinements to the framework and outlining uses of the framework and future evaluation needs.

The research approach can be described by figure 5 below.

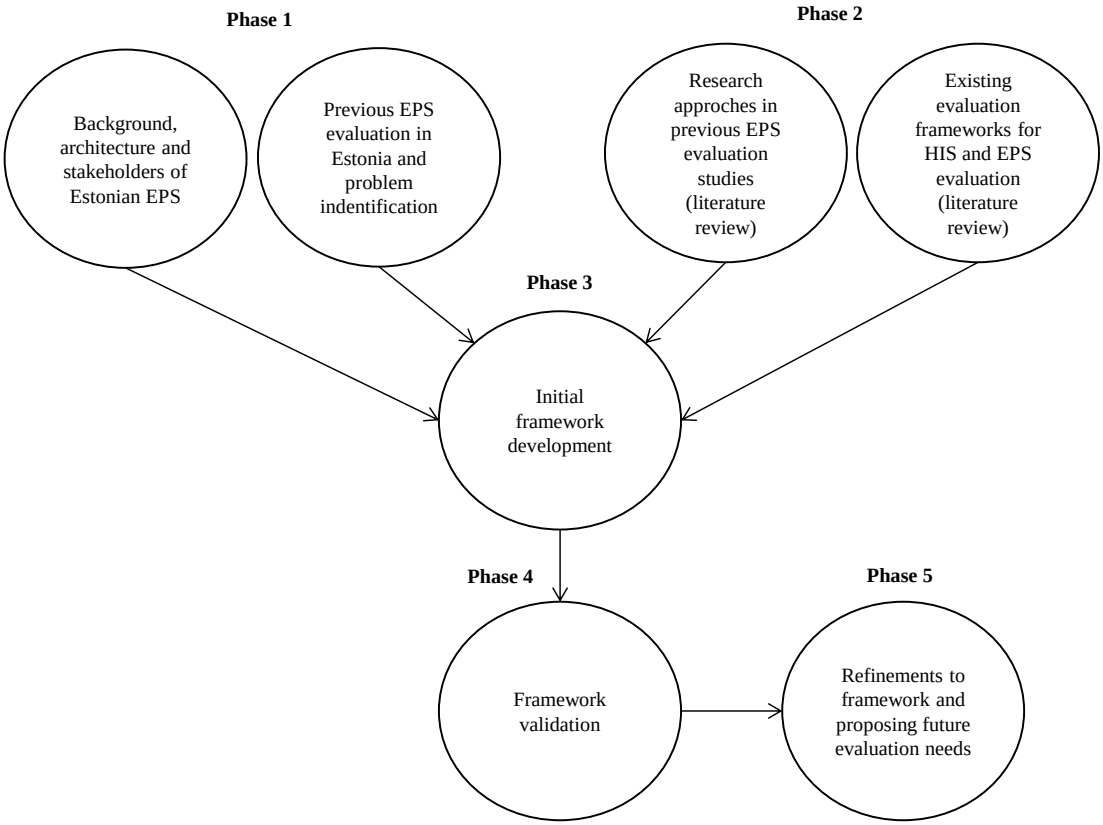

Figure 5**.** Research approach. Source: author, adapted from Yusof *et al*. (2008b)

The selected case-study approach has several strengths, but also important weaknesses. Case-study method gives an adaptive and holistic approach towards a complex problem. On the other hand, case-study designs as such have not been thoroughly codified (Yin 2009) and not widely used for framework development. Thus it was important to judge the quality of the research design.

Construct validity was achieved by identifying correct operational measures for the concepts being studied. The data collection questions were connected to the research question and specific operational measures (e.g. system architecture, development path, stakeholders and evaluation approaches). Multiple sources of evidence were used, although the extent of different data collection sources could be increased in future research. Construct validity was also increased by conducting a

validation exercise (in order to review the initial case-study results). Potential bias was decreased by selecting participants from different backgrounds with regard to the context of Estonian EPS and evaluation of HIS.

Reliability was achieved by describing the operational phases of the study and outlining the specific analytical steps of moving towards the initial and refined framework. Literature review was conducted in a logical sequence and the covered articles were systematized in a separate database.

Internal validity is not pertinent in case of the current study, as it is an exploratory research (Yin 2008, 40). With regard to external validity, the paper can be criticized, as there is no broad and clear theory and neither a systematic taxonomy existing for HIS evaluation (Black *et al*. 2011). Nevertheless possible external uses of the results of the case study emerged and were listed in chapter 4 and also discussed in the validation exercise.

4 EVALUATION FRAMEWORK DEVELOPMENT FOR THE E-PRESCRIBING SYSTEM IN ESTONIA

4.1 Initial framework development

The method for framework development, as described in chapter 3, was a directed qualitative content analysis technique (Zhang and Wildemuth 2009; Hsieh and Shannon 2005), where initial coding starts with an existing framework and research findings with the aim to modify the framework. In the current case, the HOT-fit framework (by Yusof *et al*. 2008b) was selected as a base model. The reason for selecting the HOT-fit framework as a benchmark was its multi-facated nature and wide range of covered dimensions and measures.

Based on the five framework critique characteristics outlined by Currie (2005, 912): user-centricity (1), context-centricity (2), functionality-centricity (3), recognition of SDLC (4) and presence of theoretical foundation (5), the HOT-fit framework can be regarded a good basis for framework development. HOT-fit addresses all of those charactersitics to a sufficient extent[12]. The framework supports also post-implementation evaluation and can be applied using both qualitative and quantitative or mixed methods (Yusof *et al.* 2008b).

Hence the HOT-fit framework's dimensions were incorporated into the initial framework of this paper (Zhang and Wildemuth, 2009) based on the context of Estonian EPS and evaluation research. The technology, human, organization and net

[12] There are user-centric and context-centric dimensions and also SDLC is recognized. The functionality dimensions are not very clearly defined, yet still existent (Yusof *et al.* 2008b), the previous frameworks, on which HOT-fit is based on, have considerable theoretical foundation (DeLone and McLean 2003).

benefits dimensions (see figure 3 above for distinction) incorporated to the framework are described as follows (Yusof *et al*. 2008b):

- System quality – The inherent features, such as user-interface and performance. Focuses on the questions of whether the system fits with user needs and work patterns and is simple to use.
- Information quality – The different information (e.g. prescription data or patient profiles) produced by the system by mostly using subjective methods.
- Support service quality – The support provided by the provider of the technology (internal or external).
- System use – The usage level (e.g. frequency) and extent of usage of the information system's different requests and functions. The dimension is also connected to the characteristics of the person who uses it (incl. computer skills, knowledge and acceptance/resistance).
- User satisfaction – A subjective measurement, as it depends on whose satisfaction is measured.
- Organization structure – The characteristics of the various stakeholder organizations.
- The environment – The external conditions surrounding the system including the legal, financing or political environment.
- Net benefits – The net benefits dimension characterizes the balance of different types of positive and negative impacts (e.g. time, quality, cost-efficiency) on all the relevant stakeholders in each phase.

The HOT-fit framework proposes a number of different measures for each dimension (*Ibid.*). In the current case, a content analysis technique will be used in

order to select the most relevant sub-dimensions[13] considering the Estonian EPS case. The selection of sub-dimensions and the rationale for their selection are presented in the 4 HOT-FIT dimension areas: technology, human, organization and net benefits. First, the technology dimensions and sub-dimensions and their relevance to the current context[14] are discussed (see Table 3).

Table 3. Selected technology dimensions and sub-dimensions and their relevance to the context of Estonian country-wide EPS

Evaluation dimensions	**Sub-dimensions**	**Relevance to context and data availability**
System quality (user-interface)	Ease of use	There are no studies available evaluating the intrinsic features of the system regarding ease of use of the EPS's interface or the information systems (IS) connected to EPS. Different care providers and pharmacists use different systems (either commercial or home-grown), but there are no comparative evaluations regarding which of the systems are easier to use. There are some questions in previous surveys (Elanike hinnangud …, 2011) about the ease of use of drug dispensing from the patient's perspective, yet no srudies about the ease of use of the system's digital aspects (e.g. viewing outstanding prescriptions) were detected during the data collection phase.
	Flexibility	Flexibility can be characterized as the systems' ability to be modified for specific user needs. The Estonian EPS can be integrated with commercial or home-grown IT-systems – there were no studies detected regarding the ease and cost of integration of the two technologies or flexibility of integrated systems.
	Security	There is a gap in evaluation about security issues in HISs (Eslami *et al.* 2007) and no public research discussing the security level of Estonian EPS specifically was identified. The role of different stakeholders (eg. EHIF, EISA, commercial IT-system providers) in ensuring the security has not been studied. There has been a claim by a state institution (Digiretsept – E-tervise Sihtasutus 2012) of increased security, yet there is no evaluation to prove the claim about EPS.
Information quality	Relevance	Information quality is important regarding different registries incorporated to the system. Pharmacists and doctors have come across data which is out of date and not relevant (E-teenuste kasutamise …, 2013, 52). There are no studies in Estonia concentrating specifically on information relevance.
	Format	There are problems regarding the data format (type and presentation of

[13] The sub-dimensions should be regarded as an aggregate measurement of different specific variables and measurses. The list of specific measures, indicators or variables is not provided in this paper and should be separately approached by every researcher evaluating EPS.

[14] The discussion provides some examples for relevance of the sub-dimension, but should not be considered an exhaustive list due to the limitedscope of the paper.

		the data) concerning different aspects of the systems from the perspective of family doctors and pharmacists (E-teenuste kasutamise …, 2013), yet no specific studies regarding the format were identified during the data collection phase.
Support service quality	Problem solving	In case of the Estonian EPS, it is very difficult to distinct only one service provider for problem solving, as the system is a complex network with several support service providers. With regard to the PRC, the support service provider is EHIF, as it provides support for healthcare service providers and pharmacies (Digiretsepti realiseerimine …, 2007, EHIF veeb 2013); at the same time the support level of commercial IT-system providers for healthcare service providers and pharmacists is also important. Also EISA and E-Health Foundation are support service providers, as far as the possibility for patients to check their outstanding prescriptions in the citizen portal or patient portal is concerned. There is little available research about the quality of support service, no specific questions have been asked about it in the surveys conducted (Haigekassa lepingupartneritega rahulolu 2012).
	Response time	There are no evaluations regarding the response time of different support service providers detected, yet it is an important indicator and could impact the service provision.

Source: author

The following table 4 will explain the relevance of the sub-dimensions regarding the human aspects of the system: system use and user satisfaction.

Table 4. Selected human dimensions and sub-dimensions and their relevance to the context of Estonian country-wide EPS

Evaluation dimensions	**Sub-dimensions**	**Relevance to context and data availability**
System use	Frequency of use	The frequency of use has not been evaluated thoroughly, yet there is data available upon request from EHIF and EISA regarding the usage level of the system (number of prescriptions issued and drugs sold), also the views of outstanding prescription by patients. As the dimension is also connected to the characteristics of the person who uses it (incl computer skills, knowledge and acceptance), there should be more evaluation regarding the characteristics of the stakeholders who are using the system to analyse the reasons, if there is resistance from users towards the system.
	Extent of use	The extent of use is relevant regarding the different functions and possibilities of the system. There was no evaluation research detected answering the questions, what kind of functions and information fields are used by different stakholders and to what extent.
User satisfaction	User satisfaction	As pointed out in chapter 1.4, user satisfaction with the EPS has been evaluated the most in Estonia, although satisfaction with different kinds of integrated IT-systems and use of different kinds of functions is still unknown.

Source: author

The following table 5 will discuss the relevance of organizational context regarding evaluation.

Table 5. Selected organization dimensions and sub-dimensions and their relevance to the context of Estonian country-wide EPS

Evaluation dimensions	**Sub-dimensions**	**Relevance to context and data availability**
Organi-zation structure	Nature (type, size)	Organizations play an important role in the context of HIS and IT-systems implementation (Yusof *et al*. 2008b, Shekelle and Goldzweig 2009, DeLone and McLean, 2003). The Estonian EPS might have a potentially large impact to all of the organizations connected to the prescription process. As seen from chapter 1.2 the development path of the system has been long and concerned different organizations. There was no evaluation research regarding organizational change detected – it is still yet to be defined what has the impact been to the nature, culture, communication, work-processes and management of different organizations affected by the system. As EPS is part of EHIS, the goals of EHIS (stated by law) are also relevant. One of the aims of EHIS was management of relevant registries and health care on the whole and also to support health services contracting (Tervise infosüsteemi põhimäärus 2013) – those aims are important with regards to the sub-dimensions of management, work-processes, but also the political and legal dimensions (see below).
	Culture	
	Communi-cation	
	Work-process	
	Management	
Environ-ment	Political	The environment could be defined as health system of Estonia. The political sub-dimension is here of high relevance, as the system is country-wide and was implemented by law (Retseptikeskuse asutamine …, 2013). The original aims defined by law (*Ibid*.) of PRC are also important, as one of the goals was to make it feasible to conduct pharmaceutical statistics and provide supervision (legal obligation). Inter-organizational relationships are also a matter of research, as seen complex and broad based on the development path description (chapter 1.2) of the system – different stakholders were involved in the development.
	Legal	
	Inter-organizational relationships	
	Financing	

Source: author

Table 6 will show the sub-dimensions of net-benefits. Net benefits have been defined as the balance of different types of positive and negative impacts on all of the relevant stakeholders in each phase (Yusof *et al*. 2008b). There can be a number of different benefits and negative impacts to be measured, nevertheless based on the

'control knobs concept of health-Sector reform' (Roberts *et al.* 2008, 27) [15] and previous research regarding EPS evaluation (see chapter 2.2), the author concludes that special attention should be put on the three sub-dimensions of quality and safety (1), time-usage and work-patterns (2) and cost-effectiveness (3).

Table 6. Selected net benefits sub-dimensions and their relevance to the context of Estonian country-wide EPS

Evaluation dimensions	**Sub-dimensions**	**Relevance to context and data availability**
Net benefits	Quality and safety	A considerable amount of evaluation articles regarding EPS focus on the reduction of medication errors (ME) or adverse drug reactions (ADE), which is deriving from the fact that MEs account for a high number of deaths in health care (Durieux *et al.* 2012). In Estonia there has been no such evaluation made, although a retrospective survey inquiring about the estimated error reduction has been conducted, the survey did not cover the aspect in great depth: no distinciton of different types of errors was presented in the questions (E-teenuste kasutamise …, 2013). Altough RCTs on error reduction would be important in case of Estonia there are several limitations which make it hard to conduct such studies: there is no possibility to do before-after studies, as the system is already in use. Furthermore there is no official practice in Estonia nor a functionality in EPS to conduct quality measurements, where MEs and ADEs can be systematically connected to different aspects of pharmaceutical management work-flow (Tervishoiteenuste kvaliteedi tagamise … 2013; Retseptikeskuse asutamine …,2013). As one of the aims of PRC was to protect the health of patients and ensure that the drugs provided are appropriate and justified (Retseptikeskuse asutamine …, 2013), it could be regarded as a matter of quality and safety dimension. As EPS is part of EHIS the goals of EHIS (stated by law) are also relevant. By law EHIS was seen as a possibility for ensuring quality and protection of public health, among other aims. (Tervise infosüsteemi põhimäärus 2013)
	Time and work-patterns	Previous studies have shown that EPS can have diverse impact on time and work-patterns, as discussed in chapter 2.2. This has been also the claim by the state institution (Digiretsept – E-tervise Sihtasutus 2012), yet the question remains, what is the best method for evaluating time efficiency and whether the promises have materialized. Thus far the time measurement practices have been methodologically weak (E-teenuste kasutasmise …, 2013). There have been no rigorous evaluations of time

[15] The control knobs concept is a framework to 'facilitate the diagnostic and policy development processes of health care reform', consisting of control knobs, intermediate and final performace goals of the health system. (Roberts *et al.* 2008, 26)

		and work-patterns. Time and work-patterns can be also connected to the 'accessibility performance measure' posed by Roberts *et al.* (2008, 27), as time-savings from prescribing activities can save time and thus make more time for other services for patients.
	Cost-effective-ness	No evaluation on cost-effectiveness has been conducted in Estonia, although there could be time savings and cost-reductions on different levels of the system. As mentioned in chapter 1.4 there is no comprehensive calculation of the system's overall cost-effectiveness and whether the investment has produced positive results.

Source: author

The framework developed thus far does not fully incorporate the views of different stakeholders in the evaluation or different functional process steps regarding EPS. This is also important in connection to evaluation frameworks critique (Currie *et al.* 2005, 911): a good framework should be able to capture the functions of the system available for the end-users. With this regard the author incorporates the functional process steps, originally developed by Bell *et al*. (2004) to the framework with modifications regarding the Estonian context (based on the architecture and process description in chapter 1.3):

1. Prescribing – doctor issuing the prescription;
2. Transmitting – instead of printing the prescription, the prescription data is transmitted electronically by the system;
3. Dispensing – pharmacist dispensing the drug based on the electronic prescription;
4. Administering – patient is administering the drug;
5. Monitoring – monitoring can be conducted at different levels – patient-specific prescription data can be seen by the doctor and the patient, statistical monitoring can be done by relevant state institutions;
6. Re-prescribing – in case the patient's disease is of chronic nature and easily controllable and a specific drug is used under a constant treatment plan, a new prescription can be issued by a phone consultation;

Bell *et al*. (2004) proposed a process model for organizing prescribing system evaluations. Based on the Estonian context a 6th stage was added to the process model originally developed by Bell *et al*. (2004), namely Estonian context specific (Majandusaasta aruanne…, 2009) re-prescribing (see definition above). As a result of adding the functional process phases of the prescribing system, a matrix framework is formed which covers the relevant evaluation dimensions and sub-dimensions in every stage. The resulting framework makes it possible to both concentrate on a specific aspect of EPS evaluation and generalize the results of a specific evaluation to a wider framework context. A framework as such (see Table 7 below) can be used for facilitating the evaluation of the Estonian country-wide EPS system by giving a basis for selecting the focus of evaluation and supporting the mapping exercise of evaluation. Furthermore, the framework does not restrict the use of different evaluation methods and can incorporate qualitative, quantitative as well as mixed methods in the evaluation.

Table 7. Initial evaluation framework of the countrywide electronic prescribing system in Estonia

Evaluation dimensions	**Sub-dimensions**	**Relevant electronic prescribing process steps**					
		Prescribing by doctor	**Transmitting** through EPS	**Dispensing** at pharmacy	**Administering** by patient	**Monitoring** by doctors, patients or state institutions	**Re-Prescribing** by doctor through phone-call
System quality (user-interface)	Ease of use						
	Flexibility						
	Security						
Information quality	Relevance						
	Format						
Support service quality	Problem solving						
	Response time				N/A		
System use	Frequency of use						
	Extent of use						
User satisfaction	User satisfaction		N/A				
Organization structure	Nature (type, size)						
	Culture						
	Communication				N/A		

	Work-process						
	Management						
Environment	Political						
	Legal						
	Inter-organizational relationships						
	Financing						
Net benefits	Quality and safety						
	Time and work-patterns						
	Cost-effectiveness						

4.2 Validation and refinements to the framework

As a result of the validation exercise (methods described in chapter 3) the validation results can be outlined. All of the experts agree that there has not been enough evaluation of EPS thus far. The following aspects were pointed out as not been evaluated enough:

- cost-effectiveness,
- time-savings,
- quality,
- rational drug use,
- pharmacy's work-patterns,
- economic benefits for different stakeholders,
- impact of prescribing and dispensing of different medicines (e.g. originals vs. generics),
- organizational indicators,
- work-processes.

Most experts agreed that the framework facilitates the evaluation of the Estonian electronic prescribing system, especially in defining the evaluation scope and limits. It was also pointed out that the usability of the framework depends on what specific methods and data are used for evaluation in case of each dimension/phase and there should be a clear technique for making generalizations to the evaluations based on the framework. Furthermore, one of the experts pointed out that the evaluation framework needs a causal evaluation concept within the framework itself – meaning that interconnections between different dimensions should be clearly outlined. Also piloting the framework was suggested by one of the experts.

Regarding the aspect whether the list of dimensions and sub-dimensions of the framework are sufficient enough, several comments were made. Some experts

found that more specific dimensions are needed, while others found the number and extent of different dimensions suitable. It was pointed out that the net benefits dimension should be more explicit and quality and safety sub-dimension more thoroughly described. Several experts noted that there might be a need for incorporating stakeholder views into the framework, although one expert found the process view more inclusive, as incorporating several stakeholders (in a process phase) is more significant than a stakeholder on its own. Nevertheless it was found that stakeholders should be more explicitly incorporated into the framework.

An observation was made with regard to the re-prescribing process step that it should not be only limited to re-prescribing by a phone-call, but in light of future developments other forms of re-prescribing should be possible to acknowledge. One of the experts pointed out that the reimbursement stage is missing from the process stages. The author agrees with the concept that reimbursement is an important stage in the process, as discussed in chapter 1.2 on development of the system and chapter 1.3 regarding the initial prescribing phase, but also pointed out by McMullin *et al*. (2004) with e-prescribing having a possible impact on reimbursement claims level[16].

It was also pointed out that the framework should try to address the possible future developments of the system and additional services (for example, during the administering phase: patient notifications; or prescribing phase: CDSSs). The importance of statistical capabilities (the monitoring phase) was also emphasized.

Most experts saw other uses for the framework. In several cases the possible use for evaluating other e-services in health and social care was noted, provided the process phases were modified for other services. Also the possibility for comparing different electronic prescribing systems in different countries is a possible additional use of the framework according to one of the experts.

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[16] McMullin *et al*. (2004) assessed the impact of a CDSS with evidence-based messages on prescription costs by conducting a retrospective, cohort study on the basis of pharmacy reimbursement data with the result of the difference in prescription costs – physicians using CDSS had significantly lower prescription costs between 2 groups under research. Although the current study does not cover CDSS, the method of comparing reimbursement claims of physicians would be an important assement tool to see if and to what extent similar results could be obtained (comparisons with different IT-systems) in case of Estonian EPS.

Based on the validation results the author hereby refines the framework by introducing a more explicit stakeholder view. Furthermore some causal relationships are incorporated into the framework.

In order to develop a clearer perspective of the case of EPS in Estonia, several approaches should be used in approaching the unit of analysis – thus a 2-dimensional matrix may not be sufficient and a third dimension of stakeholders should be added. Hence the process view of the framework matrix is enhanced with relevant stakeholders in case of every process stage, giving a better view of possible impact on different stakeholders (see Table 8 below – the refined process view).

Table 8. Addition of relevant stakeholders to the functional process stages

Prescri-bing	**Transmit-ting**	**Dispen-sing**	**Administe-ring**	**Monito-ring**	**Re-imbursement**	**Re-prescribing**
Doctor	State, insurance	Pharmacist		State, insurance	State, insurance	Doctor
Patient		Patient	Patient	Patient	Pharmacist	Patient
		Doctor		Doctor	Doctor	
IT-system providers	IT-system providers	IT-system providers		IT-system providers	IT-system providers	IT-system providers
State registries	State registries	State registries		State registries	State registries	State registries

Source: author

In the refined process view, every stage of prescribing process includes the relevant stakeholders. For example, in case of dispensing the drug, both doctor and the patient, but also the pharmacist and IT-system providers are of high importance with regard to the impact of the system.

Furthermore, the causal interferences were discarded in initial framework development due to scope limitations, but based on the validation exercise the

importance of showing the causal relationships of different dimensions re-emerged. Several articles have also discussed and previous frameworks included causal connections between different variables regarding HISs and EPSs. For example, Schledbauer *et al*. (2009) has stressed the need for connecting design features and outcome measures, Ammenwerth *et al*. (2008) viewed the connection between error reduction and organizational aspects. Also the attitude towards adoption could be linked to perceived quality changes (Schectman *et al.* 2005) and impact on work-patterns could subsequently have influence on quality and other indicators (Overhage *et al.* 2001).

Furthermore, Yusof *et al.* (2008b) emphasized fit between human, organization and technology in their framework. There is also a need to connect the targets/goals to different dimensions (Kazanjian and Green 2002, 173) and acknowledge that different dimensions are interrelated rather than independent (DeLone and McLean 2003).

Based on the initial framework developed and refined and the causal relationship aspects from IS-Success Model and HOT-fit frameworks (DeLone and McLean 2003; Yusof *et al.* 2008b) a supplementary figure (see figure 6 below) for the framework was developed by the author, incorporating causal relationships and also acknowledging the different stakeholders of EPS. The addition to the framework incorporates the technology, human, organization and net benefits dimensions, while pointing out the relevant stakeholders in each part. The figure shows the possible interconnections between dimensions. It can be seen that the importance of evaluating the human dimensions is high for all the process stages where patients, pharmacists and doctors are incorporated. Furthermore, when evaluating net benefits, the benefits of the state institutions and health insurance providers are also relevant. The logic of different interconnections can be linear – a good EPS increases acceptance (e.g. high level of use) and positive organizational development (e.g. development of work-processes) and result in positive net benefits, but at the same time perceived or initial net benefits (e.g. rise in quality or time-savings) could influence organizational changes and rise usage levels (DeLone and McLean 2003,

24) of EPS. The two-way relationship with regard to technology and organization and human dimensions shows the need for 'fit' in the system (Yusof *et al*. 2008b; Kaplan 2001). For example, fit can be seen as EPS's coherence with the work-processes of the organizations using EPS (e.g. pharmacies, care providers, state institutions and EHIF), but also professional culture of pharmacists and doctors.

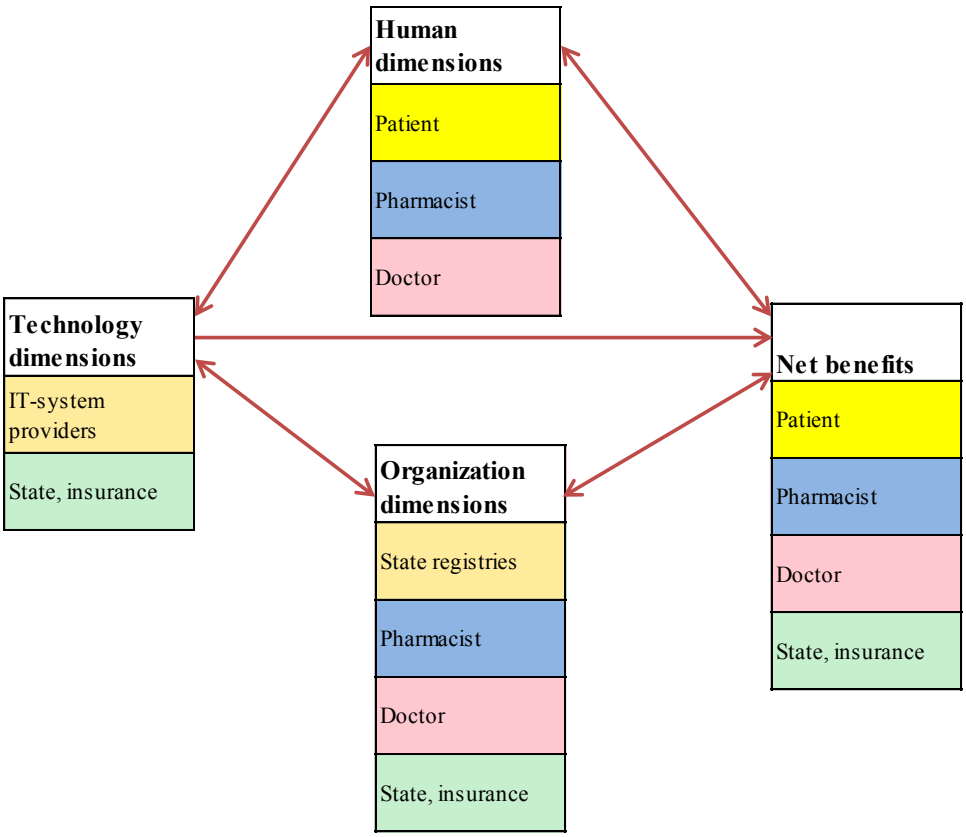

Figure 6. Supplementary figure to EPS evaluation framework
Source: author, adapted from DeLone and McLean 2003; Yusof *et al.* 2008b.

In sum, the validation exercise was relevant for the framework development. Important revisions were made to the initially developed framework: addition of an improved stakeholder view and the interconnections of different dimensions.

4.3 Limitations of the framework

The current paper was an exploratory inductive research. It did not conduct a comprehensive evaluation *per se*; instead a framework was developed, suitable for defining the scope and limits of EPS evaluation and helping to facilitate the mapping exercise of the evaluation.

As a result of the validation it was pointed out that the causal relationships between different dimensions are important and should be presented in greater detail. The author agreed with this notion and refinements were made to the framework. To certain extent potential causal relationships were outlined in a supplementary figure for the framework. The actual context-specific causal relationships are still yet to be evaluated in case of the Estonian EPS specifically.

The scope of evaluation was also seen problematic – making a distinction between the central system and the integrated local IT-systems emerged as an important topic during the validation exercise and background research. Yet the current refined framework should be able to address this problem, as it provides a perspective for acknowledging relevant stakeholders and process phases of EPS (see Table 8 and figure 6 above).

The framework does not prescribe the use of specific methods – this could be regarded both as a limitation and a strength, as there is still a considerable research gap in Estonian EPS evaluation and limiting the future evaluations to specific methods would make the framework too rigid.

In sum, the framework has limitations, but taking into account the broad and comprehensive nature of the system under research and the diverse context, it provides relevant information in answering the research question: how to evaluate the country-wide EPS in Estonia?

4.4 Suggestions for framework use and future evaluation needs

The developed, validated and refined framework gives input for policy-makers and researchers active in developing, modifying or evaluating the EPS in Estonia. The framework can be used for mapping the different aspects needing evaluation, or determining aspects to be improved in the current system based on post-implementation evaluation. Thus the framework can be used for the first phase of evaluation – mapping, generalizing, and defining focus and limits of evaluation.

The users of the framework should utilise different types of methods. The appropriateness of different qualitative, quantitative and mixed methods should be assessed before conducting an evaluation. In many cases the use of I and II level designs and quantitative evaluations is limited due to the fact that the system has been already implemented. Furthermore, defining the reference point for evaluation could prove difficult due to the lengthy development path of the system. The framework helps by allowing generalizing and combining data from different individual evaluations. As a result, the framework can guide the evaluation of the system as a whole and the achievement of goals stipulated by law.

There are also possibilities regarding transferability of the framework – the validation exercise indicated that the framework could be used for evaluating other e-services in health and social care, provided the process stages are sufficiently modified for other services. It could be also used in international context. For example comparing country-wide electronic prescribing systems is a possible additional use or employing the framework in the initial implementing phase of EPS in other countries. Nevertheless, the framework should be specifically adjusted for such uses.

Several aspects need future evaluation. The author concludes that the main attention should be put on the dimensions, which are connected to the pre-defined goals of the system and where there has been little discussion thus far. The author argues that organizational impact and net benefits are the dimensions needing the

most attention in future research, while taking into account the whole e-prescribing process.

Due to the scope of the current study, it focused on the relevance of different dimensions rather than the exact relations between different measures, which hence should be a matter of future research. Furthermore, the need for fit between different dimensions should not be overlooked and an evaluation concentrating on a specific aspect ought to acknowledge also other dimensions, process stages or stakeholders, which influence or are influenced by the variables under evaluation. Further evaluation is useful only when it is understood, what the exact focus and limits of evaluation are and what questions the evaluation does and does not seek to answer.

CONCLUSION

The aim of the master thesis was to develop an evaluation framework for the country-wide electronic prescribing system in Estonia. The aim was achieved through an exploratory case-study employing an inductive framework development approach.

The main results of the paper are three-fold. Firstly, the case of Estonian EPS was presented. The development path, architecture and functional process phases, as well as the current state of evaluation of the system were outlined. This was an important outcome, as there has been no thorough description of the development and essential components of the Estonian EPS conducted thus far.

Secondly, the literature review regarding evaluation approaches and frameworks identified a number of evaluation approaches and frameworks but also demonstrated that EPS evaluation is still lacking systematic approach. Moreover, the the range of research projects comprehensively addressing country-wide electronic prescribing systems is low.

Finally, a framework for evaluating country-wide EPS in Estonia was developed, based on the case context and international experience in EPS and HIS evaluation. A content analysis technique was used in order to develop the initial framework to be validated and refined. As a result a refined framework was presented as a matrix consisting of 8 evaluation dimensions, 22 sub-dimensions and 7 relevant e-precribing process phases. The framework included the interconnections of different evaluation dimensions, as well as incorporated different stakeholders into the evaluation (the final revised framework is presented in Appendix 3).

The framework can be used by policy-makers and evaluators for defining the scope and limits of EPS evaluation and facilitating the mapping exercise of the evaluation. Furthermore, it provides a tool for generalizing specific evaluation results into the wider context of the whole EPS.

Additionally the framework can be useful in evaluating the success of EPS in Estonia by helping to answer the question, whether the system has achieved the goals stipulated by law. It could be also used for evaluating the future development needs of the system in a comprehensive and systematic manner.

The paper showed a specific necessity for more research in the area, namely aspects regarding organizational impact and net benefits of EPS, but also different interconnections of human-, organization- and technology-related measures. Furthermore, the whole electronic prescribing system in Estonia needs constant attention and carefully reasoned evaluation in order to achieve full benefits for the health system and the whole society.

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RESÜMEE

EESTI ÜLERIIGILISE DIGIRETSEPTI SÜSTEEMI HINDAMISE RAAMISTIKU ARENDAMINE

Käesoleva magistritöö eesmärk oli arendada välja raamistik Eesti üleriigilise digiretseptisüsteemi hindamiseks. Töös kasutatavaks meetodiks on juhtumianalüüs ning kasutati induktiivset lähemist hindamisraamistiku loomisel.

Töö koosneb neljast peatükist. Esimeses peatükis on välja toodud Eesti digiretsepti süsteemi arengutee, süsteemi arhitektuur ja süsteemi protsessi etapid. Samuti on antud ülevaade senisest hindamispraktikast ning selle puudustest.

Teine peatükk toob lugejani kirjandusülevaate erinevatest digiretsepti süsteemide hindamise praktikatest. Samuti tuuakse välja senised hindamisraamistikud, mis võimaldavad digiretseptiga sarnaste süsteemide hindamist. Järgnev kolmas peatükk annab aga ülevaate töö metoodikast ja kasutatavatest meetoditest.

Viimases peatükis on toodud kontentanalüüsi käigus hindamisraamistiku arendamise protsess ning esialgne hindamisraamistik, selle valideerimise protsess ning parandatud ja lõplik hindamisraamistik. Töö tulemusena valminud raamistikku on võimalik kasutada poliitikategijatel digiretsepti edukuse hindamisel, samuti edasise hindamise ning analüüside fookuse ja piirtluse tegemisel aga ka hindamistulemuste üldistamisel ja laiemasse konteksti asetamisel.

APPENDICES

Appendix 1: Hierarchy of Study Designs by Eslami *et al*. 2007

Study design	Description
Level I: Randomized Controlled Trial (RCT)	A study in which people are allocated at random (by chance alone) to receive one of several clinical interventions. One of these interventions is the standard of comparison or control. The investigator controls the exposure to the intervention.
Level II: Non-Randomized Controlled Trial	A study in which people are allocated to receive one of several clinical interventions. One of these interventions is the standard of comparison or control. The investigator controls the exposure to the intervention but allocation of people is not based on chance. It includes interrupted time series and before-after studies.
Level III: Observational study with controls	A study in which individuals are observed or certain outcomes are measured without a specific attempt to affect the outcome (the investigator does not control the exposure to the intervention, e.g., the use of a CPOE). The intent is to observe how exposure to risk factors (implemented CPOE) influences the outcome of interest. Includes cross-sectional studies to estimate the prevalence of the outcome of interest or the prevalence of exposure to intervention or both; cohort (longitudinal) studies with control in which individuals who are exposed to the intervention are followed for a defined length of time and the effects of the intervention on the exposed group is compared to a group that was not exposed; and case control studies in which a comparison of exposure to the CPOE in a group of individuals with the outcome of interest (cases) is compared to those without the outcome of interest (controls).
Level IV: Observational study without controls	Includes cohort studies without controls or case series.

Appendix 2: Validation questionnaire

The master thesis project is an exploratory case study employing an inductive approach to develop an evaluation framework for Estonian electronic prescribing system (EPS). The main aim of the project is to develop an approach for evaluating the EPS in Estonia. The research project encompasses broadly three phases:

1) theory and literature review of EPS evaluation approaches;
2) development of draft evaluation framework;
3) validating the framework and producing suggestions for piloting the framework in a practical setting.

The case of Estonian EPS system was chosen because it is the largest healthcare IT initiative that has had a potentially great impact on different stakeholders at once. EPS has received positive feedback from the public and providers, moreover, the usage level is very high – more than 95% of reimbursable prescriptions are issued digitally. Yet there is a considerable gap in the practice of evaluating health information systems (including EPS) in Estonia. There is no formally implemented and mutually agreed framework for doing the evaluation. Although few assessment studies have been composed, different relevant aspects have not been evaluated at all. The master thesis paper will start to fill that gap in terms of developing a framework for Estonian EPS evaluation.

The aim of the validation exercise is to find out whether the proposed draft evaluation framework is applicable to Estonian EPS. Thus, I kindly ask you to answer the following questions regarding the general background of electronic prescribing systems evaluation and the specific draft evaluation framework compiled by the author (see below).

Please answer in the .doc file below. There are altogether 9 open-ended questions. Answering will take approximately 30 minutes. Answers can be both, in English or in Estonian.

1. To what extent are you familiar with the electronic prescribing system in Estonia? In what instances have you been in contact with the electronic prescribing system? *(ehk kuidas olete digiretsepti süsteemiga kokku puutunud, a la kasutamine, väljatöötamine, hindamine vms)*

[answer]

2. Have you used evaluation frameworks when evaluating different IT-systems, e-services or health programmes?

[answer]

3. In your opinion has the impact and success of the Estonian electronic prescribing system been evaluated (*ex-post*) enough? If not, what aspects (eg. user-interface, quality, impact on clinical processes etc) should be evaluated more?

[answer]

Next the draft evaluation framework will be presented for validation. The framework is a matrix and consists of evaluation dimensions (eg system use) with sub-dimensions (eg work-process) representing the aspects of evaluation to be considered. Every dimension can be evaluated in different process steps (prescribing, transmitting, dispensing etc).

The dimensions (left column) are hereby defined as:

System quality – Evaluates the intrinsic features, such as user-interface and performance. Focuses on the questions of whether the system fits with user needs and work patterns and is simple to use.

Information Quality – Evaluates the different information (e.g prescription data or patient profiles) produced by the system by mostly using subjective methods.

Support Service Quality – The support provided by the provider of the technology (internal or external).

System use – Entails the usage level (e.g frequency) and extent of usage of the information system's HIS's different requests and functions. The dimension is also connected to the characteristics of the person who uses it (incl computer skills, knowledge and acceptance/resistance).

User satisfaction – A subjective measurement, as it depends on whose satisfaction is measured.

Organization structure – Organization structure entails the characteristics of the organization (e.g dispensing pharmacy, prescribing GP practice etc).

The environment – The environment consists of aspects regarding financing or political environment.

Net benefits – The Net benefits dimension represents the balance of different types of positive and negative impacts (e.g time, quality, efficiency) on all the relevant stakeholders in each phase.

The process steps (top row) are here defined as:

Prescribing – doctor issuing the prescription

Transmitting – instead of printing the prescription, the prescription data is transmitted electronically by the system

Dispensing – pharmacist dispensing the drug based on the electronic prescription

Administering – patient is administering the drug

Monitoring – monitoring can be conducted at different levels – patient-specific prescription data can be seen by the doctor and the patient, statistical monitoring can be done by relevant state institutions

Re-prescribing – in case the patient's disease is of chronic nature and easily controllable and a specific drug is used under a constant treatment plan, a new prescription can be issued by a phone consultation

Please study the framework and answer the questions following the framework.

Table 1. Draft evaluation framework of the country-wide electronic prescribing system in Estonia

Evaluation dimensions	**Sub-dimensions (measures)**	**Relevant electronic prescribing process steps** *(colored if existing evaluation research in Estonia available to some extent)*					
		Prescribing by doctor	**Transmitting** through EPS	**Dispensing** at pharmacy	**Administering** by patient	**Monitoring** by doctors, patients or state institutions	**Re-Prescribing** by doctor through phone-call
System quality (user-interface)	Ease of use						
	Flexibility						
	Security						
Information quality	Relevance						
	Format						
Support service quality	Problem solving						
	Response time						
System use	Frequency of use						
	Extent of use						
User satisfaction	User satisfaction						
Organization structure	Nature (type, size)						
	Culture						
	Communication						
	Work-process						
	Management						
Environment	Political						
	Legal						
	Inter-organizational relationships						
	Financing						
Net benefits	Quality and safety						
	Time and work-patterns						

	Cost effectiveness						

The evaluation framework has the purpose of facilitating the mapping exercise of an evaluation before conducting specific evaluations with qualitative, quantitative or mixed methods. A framework can comprise different study designs, measures and analytic methods. The framework described above should be able to fill that purpose with regard to the Estonian countrywide electronic prescribing system.
Please answer the questions regarding the framework presented above. Please do that in free-text and explain your answers.

4. In your opinion, does the framework facilitate the evaluation of the impact and success of the Estonian electronic prescribing system? Please explain.

[answer]

5. Is the list of dimensions and sub-dimensions in the framework sufficient for a comprehensive evaluation? Please explain.

[answer]

6. Are the relevant process steps sufficient to represent different phases in the process? Please explain.

[answer]

7. Should there be any new dimensions, sub-dimensions or process steps additionally incorporated into the framework? Which ones?

[answer]

8. Is the framework transferrable? Does the framework have any other (theoretical or practical) uses, besides the evaluation of the EPS in Estonia?

[answer]

9. Do you have any other comments regarding the framework?

[answer]

Appendix 3: Revised evaluation framework for the country-wide electronic prescribing system in Estonia*

Evaluation dimensions	Sub-dimensions	**Relevant electronic prescribing process steps**						
		Prescribing by doctor	**Transmitting** through EPS	**Dispensing** at pharmacy	**Administering** by patient	**Monitoring** by doctors, patients or state institutions	**Reimburse-ment** by insurance to pharmacy	**Re-Prescribing** by doctor
System quality (user-interface)	Ease of use							
	Flexibility							
	Security							
Information quality	Relevance							
	Format							
Support service quality	Problem solving							
	Response time				N/A			
System use	Frequency of use							
	Extent of use							
User satisfaction	User satisfaction		N/A					
Organization structure	Nature (type, size)				N/A			

	Culture							
	Communication							
	Work-process							
	Management							
Environment	Political							
	Legal							
	Inter-organizational relationships							
	Financing							
Net benefits	Quality and safety							
	Time and work-patterns							
	Cost-effectiveness							

*To be used together with figure 6