Assessing the Economic Impact/Net Benefits of the Estonian Electronic Health Record System

DIGIMPACT
Final Report

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Table of Contents

I. INTRODUCTION .......................................................................................6

II. ESTONIAN ELECTRONIC HEALTH RECORD SYSTEM ...........................8
   A. HISTORY OF THE ESTONIAN ELECTRONIC HEALTH RECORD SYSTEM ...........................................8
   B. OVERVIEW OF THE ESTONIAN ELECTRONIC HEALTH RECORD ..............................................10
      1. Governance ........................................................................................................................................10
      2. The Operating Principle ..................................................................................................................10
      3. Infrastructure .....................................................................................................................................10
      4. Access Rights ...................................................................................................................................11
      5. Services ..........................................................................................................................................12
   C. ENGAGING THE SOCIETY .........................................................................................14
   D. STANDARDIZATION ......................................................................................................................15
      1. Business Process of Digitization of Medical Documents (BPoDMD) ..................................................15
   E. MAINTENANCE OF ELECTRONIC HEALTH RECORD SYSTEM ..................................................17

III. METHODS OF EVALUATING IT INVESTMENTS .....................................18
   A. EVOLUTION OF IT/IS INVESTMENT METHODS ..............................................................................18
   B. AN ARRAY OF TAXONOMIES ........................................................................................................19
   C. THE PENG-MODEL ......................................................................................................................23
      1. Using the PENG Model in Health care Sector ................................................................................23
      2. Using PENG for Evaluating IT/IS Investments in E-health ............................................................25
   D. RESEARCH DESIGN ......................................................................................................................26
      1. Research Process ...........................................................................................................................26

IV. TYPE 2 DIABETES AS A MODEL DISEASE USED FOR ANALYZING ....28
   A. GROUPING OF DIABETES PATIENTS ............................................................................................30
      1. Examples of Management Changes of Group 1 and Group 2 Patient ...............................................31
         a) Group 1 – Patients with Compensated Diabetes ...........................................................................31
         b) Group 2- Patients with Uncompensated Disease and/or with Complications of Diabetes ..........31
   B. CHANGE OF DIABETES MANAGEMENT ........................................................................................32

V. RESULTS: DESCRIPTION OF BENEFITS AND COSTS, REFINED
   APPLICATION OF PENG-MODEL AND CALCULATIONS ......................35
   A. DESCRIPTION OF BENEFITS AND COSTS ...............................................................................35
      1. Benefits .........................................................................................................................................35
      2. Costs .............................................................................................................................................38
   B. REFINED APPLICATION OF PENG-MODEL ..................................................................................40
   C. CALCULATIONS AND RESULTS ..................................................................................................43
      1. Valuation of Benefits .....................................................................................................................43
      2. Results .........................................................................................................................................44
Abstract

This report reflects the results of the DIGIMPACT project, whose primary purpose was to develop adequate methodology to evaluate the impact of the implementation of a nationwide Electronic Health Record. The analysis of potential costs and benefits associated with the implementation of the EHR was carried out on the basis of the PENG method, specially designed to evaluate IT investments. This method was chosen primarily because of its integrated approach, enabling both numerical and non-numerical data to be compiled. Type II diabetes was used as the model disease in calculating the benefits for patients, health care providers and citizens/society. Chapter VII of the report sets out the policy recommendations that were made during the last phase of the project.
I. INTRODUCTION

Why was this study performed?

This report is the main result of a study which was designed to develop a methodology to measure the potential impact of the Estonian Electronic Health Record (hereafter the EHR). EHR has been defined as an integrative platform between all health system stakeholders (see also chapter II.B on page 10). Thus, the main virtue of EHR is seen as it being an enabler for change in the health care system through standardized and seamless information exchange between all users and providers of medically relevant information, such as electronic medical records, personal health records, diagnostic service providers, school health services and national registries.

The project was initiated by the Estonian eHealth Foundation to support the implementation of EHR through an evaluation framework. The framework should enable an improved decision-making process, and increase information, motivation and trust among all health system stakeholders in using ICT solutions.

A comprehensive and robust methodology for impact measurement of a digital data exchange platform in health care using an adapted version of the PENG methodology is an important supporting tool not only for the further development of EHR, but also for all related ICT developments by the public sector and by other health system stakeholders.

The specific goals of the project were the following:

• to develop the framework and indicators to evaluate the impact of the implementation of the EHR;
• to validate the methodology of evaluating the impact of the implementation of the EHR using a diabetic patient group as a test case; and
• to develop policy recommendations for different stakeholders in the health care sector in order to develop and efficiently use EHR and related eHealth projects in Estonia.

What do we know about the impact of e-health?

Massive implementation of ICT can have disruptive effects on the health care system and service provision, which affects all aspects of and participants in the system. This study aims to develop a better framework to understand these important changes, so that the management of the process of change is more efficient.

Currently, little is known about the comprehensive impact of digitalization and full-scale integration of health care data exchange between system participants at the nationwide level, especially the distribution of costs and benefits between patients, providers and society as a whole. eHealth is expected not only to change the power relationship between patients, doctors and health insurance organizations, but also enable higher quality and more efficient provision of current health care services with the simultaneous introduction of completely new services in health care. Numerous studies have been published that measure the effect of a single eHealth application.
At the same time, the impact that an integrated nationwide health information system (such as EHR) could have remains largely unknown, even though a great number of countries have declared the need for such a system (see also chapter IV on page 28).

Various international strategic documents such as the eHealth Action Plan (European Commission, 2004) and i2010 (European Commission, 2005) and national strategy documents such as “Estonian Information Society Strategy 2013” (http://www.riso.ee/en/information-policy/policy-document/Estonian_Information_Society_Strategy_2013) stress the need to accelerate the uptake of ICT in the health sector, but at the same time it also stress that the governance of public investments and overall policy implementation must be based on evidence and well-monitored evaluation of the process. ICT developments have a potentially very strong and long-lasting impact, which also raises the relative risk level.

Thus it is valuable for Estonia and internationally to improve its ability to predict and analyze the impact and added value of ICT investments in health care, including the empowering effect of solutions at the national level.

**What is the project about?**

The backbone of the approach chosen for the project is its participatory nature. All of the main stakeholders in EHR participated in the development of the framework and indicators and in gathering evidence and validating the results. The core team included representatives from hospitals and specialist primary care physicians in addition to researchers and policy analysts. The Ministry of Social Affairs as the main policy developer and the Estonian Health Insurance Fund as the main funding agency in health care participated in the role of project partners and advisory board members to better align the scope and priorities of the project with national health policy.

The technical value added by the project is the refinement of economic impact assessment methodology of complicated issues such as a health information system at the national level. The methodology is based on an approach called the PENG model. Initial quantitative validation was performed using non-insulin dependent diabetes as a model disease (see the more detailed methodology description in Chapter IV.A on page 30).
II. ESTONIAN ELECTRONIC HEALTH RECORD SYSTEM

A. History of the Estonian Electronic Health Record System

The Estonian nationwide Electronic Health Record System (EHR) was originally launched in December 2008. Built on a comprehensive state-developed IT infrastructure, EHR is a central electronic database that registers residents’ medical history from birth to death. In terms of technology, EHR utilizes the same state infrastructure solutions (ID card, X-Road etc.) that most Estonians already use to a great extent (http://www.ria.ee/27525). EHR has been successfully fused with other public IT services offered to Estonian citizens and is therefore convenient for all types of users. Citizens and health care professionals can use EHR to enter or view a patient’s health-related data, make enquiries, book appointments and so on.

As EHR forms part of the state information system, the content of the centrally stored information was decided upon and fixed in statutory law (for further information, see The Health Services Organisation Act and Associated Acts Amendment Act, §59¹ section 1, available online at [https://www.riigiteataja.ee/ert/act.jsp?id=12909773]).

![Estonian Electronic Health Record System Diagram](image-url)

**Figure 1.** Estonian Electronic Health Record System
In 2002, the Estonian government initiated the development process of a comprehensive nationwide health information system. In designing such a multifaceted system, not only the technological but also the legal, organisational and ethical aspects of the health care service process needed to be taken into account.

In 2005, the Estonian Ministry of Social Affairs, as a recipient of structural aid, launched a new e-health concept by phasing in four e-health projects: the Electronic Health Record (EHR), Digital Image, Digital Registration and Digital Prescription. In order to effectively manage the process of developing these projects, the ministry initiated the establishment of a separate administrative body, the Estonian eHealth Foundation. This was founded in 2005 by the three largest hospitals in Estonia, the Ministry of Social Affairs, the Estonian Society of Family Doctors, the Estonian Hospital Union and the Association of Ambulance Doctors. In short, it unified various stakeholders in Estonian health care to ensure compliance and cooperation in developing the four projects.

Due to the complexity of the nationwide project, the components of the EHR are being launched on a different time scale. However, a critical aspect of establishing such a system has always been a clear definition of rights and obligations. Therefore, an important date on the EHR timeline was 20 December 2007, when the Estonian Parliament (the Riigikogu) ratified the Health Services Organisation Act and Associated Acts Amendment Act, thus creating a solid legal basis for the successful implementation of EHR. As a result, the four e-health projects were implemented, and the launch of the Estonian Health Information System commenced in December 2008. It is currently projected that the development of the system will continue until 2013.

In essence, the EHR is a nationwide framework with a standardised central information exchange function. However, EHR does not replace the in-house information system of health care providers, which supports their health service process. In other words, health care service provider organizations are responsible for creating their own information systems. In order to interface with the central system i.e. to send data to and obtain information from other health care institutions, each local information system must be updated and modified in a way that enables data exchange according to the technical specifications set by the system’s administrator. As an example, this report analyses the data gathered in the central database during the year after the launch of EHR.

EHR presents a unique opportunity to bring about the large-scale changes needed in the health care sector. The development of a nationwide framework that uses different digitalised medical documents has enabled the exchange of health information to be facilitated. Through EHR it is now possible to share information that was previously only available in local databases and information systems unable to communicate with one another. However, only through capturing the full potential of EHR is it possible to decrease the level of bureaucracy, increase the quality and efficiency of health care and create a truly patient-centric health care system.
B. OVERVIEW OF THE ESTONIAN ELECTRONIC HEALTH RECORD

1. Governance

The four e-health projects mentioned above were complex multi-year projects involving a number of stakeholders. The Ministry of Social Affairs initiated the projects, partially financed by the EU Structural Funds, and played the coordinating and directing role in the implementation process. It is important to note that the e-health projects were not merely large-scale IT projects, but a partnership involving several partners with different interests and viewpoints working towards a common goal. As mentioned previously, alongside the implementation of new information technology concepts, the process included many other aspects such as medical standardisation, ethics and legislation. To ensure even more effective management of the projects, the Estonian eHealth Foundation was established in 2005 by the Ministry of Social Affairs and several other health care providers to lead the projects.

Currently, the division of roles is similar to the initial phase in 2005. The Ministry of Social Affairs is responsible for the administration of the four projects as a whole, while the Estonian eHealth Foundation manages the operating system. To elaborate, the Estonian eHealth Foundation is responsible for the standardisation and development of digital medical documents, maintenance of EHR, international and scientific cooperation with universities and development of new services for citizens and doctors.

2. Operating principle

The leading principle in designing the EHR has been to make as much use as possible of existing and functioning infrastructure and IT solutions – e.g. X-Road (http://www.ria.ee/indexphpid27309), the Estonian ID card and the IT systems of health care providers.

3. Infrastructure

From 2008 to 2010 the basic infrastructure was delivered by the Estonian Informatics Centre, which is a government-funded organisation. However, starting from 2011 it is planned to purchase infrastructure services from a private service provider.
4. **Access rights**

Since all of the e-health projects involve a significant amount of sensitive personal data, ensuring the safety of this information is an extremely important issue. Therefore, great effort has been put into designing the most appropriate and comprehensive security solutions to prevent any adverse events. To correctly identify a specific EHR user, it is necessary to apply complex authentication methods. A good example of this is the ID card and its coding system, which enables Estonian citizens to provide electronic signatures and to identify themselves. The most important rules that ensure the proper use of access rights are:

- all health care providers must send mutually agreed data to EHR (as set out in legislation – the Health Services Organisation Act and Associated Acts Amendment Act);
- all access rights and data use is regulated by law (statutes of the Health Information System);
- access is only enabled to licensed medical professionals;
- a patient’s data can only be viewed by their attending physician i.e. the person currently associated with the patient’s treatment, who is a health care employee registered with the Health Care Board under the Ministry of Social Affairs;
- ID cards are used to authenticate and provide digital signatures;
- citizens can access their own data through the Patient’s Portal, where it is also possible to declare their intentions and preferences regarding certain subjects. More specifically, patients have the right to set access restrictions on single documents, cases of illness and all personal information in EHR. In short, access restrictions can be set on one specific document or applied to the complete set of data in EHR; and
- EHR records how and why all information is used (logging data) enabling citizens
to monitor every incidence of access to their personal medical records. By ensuring that people are able to determine the sources of retrieval of their personal information at any time, it is possible to detect any unwanted action. As each log-in is registered, patients can immediately inform the Estonian eHealth Foundation or the Estonian Data Protection Inspectorate when an unjustified log-in is identified.

5. Services

The development of EHR and its multiple service functions facilitates the exchange of health information from multiple sources. To date, this health data has only been available in local in-house databases, and single information systems were unable to communicate with one another. Through its variety of services and diffusion of information, EHR provides an opportunity to increase the efficiency and quality of the health care system.

The development of these services took place in subsequent phases. First, all stakeholders and associated parties were linked through the standardisation of the information exchange function. As a result, each health care provider was able to send and receive data to and from the central database. This, in turn, enables the continuation of the development of intelligent services, which is an ongoing process and ensures the sustainability of EHR. The standards that form the basis of the joint services have been published on the website of the Estonian eHealth Foundation.

As the services have been developed in association with a broad range of stakeholders, EHR was structured in accordance with the best practice of service orientation. Interaction with end users works via alternative channels, as there are various information systems that connect to central EHR messaging services. Health care institutions, specialist health care registries and others have made use of the possibility to connect to EHR for message exchange.

In addition, there are separate online portals served by the Estonian eHealth Foundation itself. For example, the Patient’s Portal enables patients and their representatives (parents of underage patients, legal representatives and trustees) to browse their health records, download documents, submit consent, update demographic data, book appointments for health care services and review the health record usage logs.

The central system of EHR processes messages according to regulated validation and security requirements.
Figure 3. EHR services

An authorised client of EHR that sends and receives information through the system can benefit from the following services:

- the health record service, which enables them to browse and search for specific health related events in a patient’s treatment history, e.g. valid information on current and past diagnoses, visits to health care professionals, medication prescribed, surgical interventions and diagnostic images;

- the health status service, which enables them to retrieve valuable information about the certain health-related parameters of a patient, e.g. blood type, allergies, physical appearance (height and weight), current health status (pregnancy) and lifestyle (exercise and smoking);

- the booking service, which enables health care service providers to publish information about their in-house health care services and available resources, allowing physicians in other institutions as well as patients to book appointments with providers. The booking service keeps track of referrals and related appointments;

- the reporting service, which provides users with standardised reports about a patient’s health status. An important part of this service is the ‘time critical report’ summarising all of the vital information about a patient’s health records and health status, which proves irreplaceable in emergency situations;

- the ambulance service, which provides the same type of message exchange as with health care service providers, but for ambulance units. In addition, ambulance units also submit data to the central system, which also makes the vital information gathered by ambulance officers available to other health care service participants;
• the document archive service, which organises all digital documents submitted to the central system. As a result, documents can be found and retrieved from the archive by using a unique identification code;

• the statistics service, which reorganises data from patients’ health-related documents for further statistical processing. This provides valuable information not only to public health institutions, but also universities and other health-related organisations;

• the decision support service, which integrates facts about a patient’s health with knowledge pools built on specific evidence-based medical processes. Users of this service are then guided to various recommendations, notifications, health-related calculators etc. that are relevant to the specific patient;

• the demographics service, which collects and reports general information about a patient’s identity, current residence and relationships. This information is based on the Estonian Population Registry, registration documents from various health care institutions and information submitted via the Patient Portal; and

• the consent service, which maintains data about a patient’s expressions of will in a digital format. This includes, amongst others, access rights of trustees, various health care service options such as organ donation, and consent related to health record access rights.

C. ENGAGING SOCIETY

For an IT project of this scope and size, which has a direct impact on society as a whole, the communicative aspect cannot be underestimated. It could be said to be as important as the technological component, if not more. A crucial element to the success of EHR has been raising public awareness so as to inform and educate people on the forthcoming changes in the provision of health care services. It has therefore been extremely important to increase peoples’ confidence and trust in the project. As such, the main goal has always been to minimise the risk that the content of and idea behind EHR will remain unclear to key stakeholders such as citizens, medical staff and IT experts.

For these reasons, a public relations (PR) partnership was established in order to ensure public acceptance of the four e-health projects (see Introduction). This included a comprehensive two-year communication plan to map the possible risks, engage spokespeople and create targeted messages for specific stakeholder groups. In order to become more visible to the public, a corporate design for the Estonian eHealth Foundation and the four e-health projects was developed. The communication campaign included the publishing of information and audiovisual materials and the creation of a joint homepage for the projects (in Estonian and English). To further enhance communication about the upcoming launch of the projects, experts and spokespeople related to the projects participated in national and international medical conferences and round tables. Press conferences were regularly held to keep the public informed and promote collaboration with large-scale media organisations. The PR project also included daily media monitoring and rapid reaction to issues, regular surveys of e-health awareness and attitudes among citizens and physicians, weekly meetings on communication topics with involved
parties and end-user training. As previously mentioned, the piloting hospitals were already involved in the strategic planning phase.

The latter can be deemed particularly vital, as part of the effort to engage society was providing medical service providers with knowledge of how to use the new health information system. Therefore, user training on national paperless (electronic) health records took place between November 2007 and December 2008. The purpose of the training was to create an environment enabling the providers to learn (online) how to use, fill out and forward digital documents in EHR.

A total of 24 online courses were conducted: 12 in Estonian and 12 in Russian. The training sessions were designed for beginners and more advanced IT users alike. The courses included instructions and demonstrations for handling 12 different types of medical documents, lectures on the health information system (including general principles and the need to collect personal data) and security issues such as the role and use of the ID card in ensuring the safe transmission of data. 13,474 people took part in the 1278 sessions held around Estonia.

Regular training was also organised by hospitals, software developers and the Estonian eHealth Foundation in basic computer use and use of the EHR system in particular.

D. STANDARDISATION

1. Business process of digitisation of medical documents (BPDMD)

The role of the EHR project has increased considerably at the national level in Estonia, since a large volume of digitised medical documents were added to the central database in the course of the project. However, this has led to very high standardisation requirements for medical documents, the business processes of and adaptation of information systems by interfacing organisations and the development of the EHR central system. Managing large volumes of medical documents demands careful resource planning and efficient cooperation between different parties in order to adhere to the agreed timeframe.

This process is set out in the BPDMD document (see the full text at http://eng.e-tervis.ee/images/business_process_of_digitization_of_medical_documents.pdf) which can be viewed as a recommended project plan including all of the necessary activities, parties and acceptance criteria required for the digitisation of all new medical documents.

The BPDMD document describes (on the basis of the first approved version) the process of creating medical documents, from establishing need up to the launch of the system. The latter is followed by the administrative process with its own associated activities, which are not, however, described in the document. Therefore, it would be practical to view these activities independent of the other processes. Throughout the development of the system, new inputs are created in each phase for the subsequent administrative phase and for necessary future developments and updates.

The roles of the different parties involved in the project in 2007 are also described in the BPDMD document. In hindsight, it can be seen that the Estonian eHealth
Foundation gradually began taking on the responsibility for activities from other IT partners. The process of shifting roles among participants needed prior planning. Considering the complexity of the system as well as the numerous associations between projects and sub-systems, new employees and participants were not assumed to be able to quickly adapt to the project. Rather than not incorporating new people and not assigning responsibilities during critical sections, it was decided to engage new participants from the start to work in teams with consultants already familiar with a specific area. This was necessary in order to ensure a sufficient transfer of knowledge from supplier to client in the administration phase of EHR as well as in future developments.

Most standardisation and development work takes place in close cooperation with a variety of parties. Therefore, a clear division of roles and responsibilities is critical. As a result, one specific person was appointed to be responsible for each task and sub-process with a key role in performing activities and monitoring the subsequent work progress.

**Figure 4.** The business process of digitisation of medical documents
E. MAINTENANCE OF THE ELECTRONIC HEALTH RECORD SYSTEM

The Estonian eHealth Foundation works in a highly complex environment of service consumers, service providers, resources and stakeholders. This complexity has been maintained and controlled by introducing a common vocabulary and structure. There are two main models of best practice that all of the participants in the system are being mapped to: the 7-layer model of separation of concerns and the ITIL best practice process model.

The 7-layer model enables areas of responsibility to be divided up between major shareholders in the provision of e-health services. Layers 1–3 depict the infrastructure of the system, which is the responsibility of the Estonian Informatics Centre. Layers 4 and 5 are related to the provision of application services, in which the Estonian eHealth Foundation plays a major role. Layer 6 represents the development of new application services, which are implemented in cooperation with the Estonian eHealth Foundation and its partner companies. (Some of these services are listed below in the section ‘Developing New Services’.) Layer 7 represents the improvements in actual health care processes, with the Estonian eHealth Foundation working closely with the Estonian health care sector to constantly redefine future health care processes.

Figure 5. 7-layer model of ITIL

ITIL is the *lingua franca* of IT service management. More information is available online at http://www.itil-officialsite.com/AboutITIL/WhatisITIL.asp.
III. Methods of Evaluating IT Investments

The evaluation of information technology (IT) and information systems (IS) can be defined as “the assessment or appraisal of the value, worth or usefulness of an information system” (Smithson and Hirschheim, 1998). As indicated in literature (Irani, 2008, Remenyi and Sherwood-Smith, 1999) the purpose of IT/IS evaluation is either to predict (ex-ante) or assess (ex-post) how well a project meets the expectations of the various stakeholders involved. In ex-ante evaluations, all of the evidence gathered is in essence future estimates and therefore depends to some extent on the judgement of those evaluating it (Remenyi and Sherwood-Smith, 1999).

Although IT/IS evaluation is a widely researched area, there are several sub-settings that have received little attention. One such is the evaluation of IT/IS investments within the health care system. Moreover, large scale e-health projects have only now been implemented on a nationwide basis and have therefore not been evaluated under these conditions. Nevertheless, there seems to be a general understanding in previous research about the necessity of an evaluation process per se. Literature (Smithson and Hirschheim, 1998, Irani, 2008, Williams and Williams, 2007) concludes that IT/IS evaluation is essential for problem diagnosis, cost planning and the reduction of uncertainty when investing resources in a project. Angell and Smithson (1991) argue (as cited by Myrtidis, 2008) that evaluation of IT/IS investments is a crucial feedback function that helps decision-makers plan and control their investments and enables an organisation to learn.

In literature, IT/IS evaluation issues are often interchangeable, as it could be argued that information systems inherently comprise different parts of information technology. Therefore, the characteristics of such evaluations can be considered similar. Symons (1991) concludes (as cited by Myrtidis, 2008) that information systems are inherently complex social constructs. A good example of this is the Estonian e-health project, which is unique in terms of both scope and scale. It comprises several information systems through which many health care processes are likely to be transformed. Smithson and Hirschheim (1998) agree that the introduction of a comprehensive new information system will have multi-dimensional effects, including economic (e.g. costs), organisational (e.g. structural changes), social (e.g. user interactions) and management (e.g. the decision-making process). An evaluation of such a complex system naturally includes subjective judgements, assumptions and information bias (Symons, 1991 as cited by Myrtidis, 2008).

A. Evolution of IT/IS investment methods

IT/IS evaluation has been a subject of research for decades. There are many reasons why IT/IS investment evaluation research has developed as a separate path compared to other evaluation methods. Inherently, IT investments can be considered somewhat different, as claimed by Powell (1992), who highlights that costs and benefits are harder to identify and quantify for IT/IS investments. Moreover, intangible factors play an important role in these types of investments (Powell, 1992). Due to the often disruptive nature of these investments to existing processes, it is difficult to forecast all of the costs involved in each stage. Moreover, benefits are similarly difficult to pinpoint as they are user-dependent. Schwartz and Zozaya-Gorostiza (2003) reference Lucas (1999) in characterising IT/IS investments as having high upside
potential, high uncertainty and indirect returns. Smithson and Hirschheim (1998) agree that introducing a new IT/IS system often leads to unplanned consequences. Buccoliero et al. (2008) construct a series of specific characteristics that each IT/IS investment evaluation should take into account, e.g. a time lag that is necessary for the potential benefits to become observable. Smithson and Hirschheim (1998) agree that benefits are often realised at a later stage in the process as these social systems evolve over time. Furthermore, intangible benefits are present and should also be accounted for. Finally, as different users have different abilities, the benefits should be tailored to specific processes involving certain users (Buccoliero et al., 2008).

The first IT/IS evaluation theories relied on traditional objective and quantitative evaluation methods aimed at categorising the costs associated with a system, e.g. those related to system functions, the participants involved or the life-cycle of the system. A similar approach was also implemented in the attribution of benefits so that, as a result, all impacts would be quantified in a robust manner (Powell, 1992, Svavarsson, 2005, Smithson and Hirschheim, 1998). Bannister (2004) concludes in *Purchasing and Financial Management of Information Technology* (as cited in Bengtsson and Wredenberg, 2008) that such conventional, accounting-based methods of evaluating IT/IS investments easily lead to wrong conclusions. Alshawi et al. (2003) explain this with the inability to account for strategic benefits or ‘indirect’ costs. Citing Overly (1973), Powell (1992) agrees that as these methods were overly technology-oriented, they lacked the ability to account for all benefits and costs and might therefore have only provided a partial view on the matter (Irani, 2008). However, Smithson and Hirschheim (1998) argue that even these formal approaches to IT/IS evaluation included the subjective judgements of the evaluators.

As a result, Buccoliero et al. (2008) showed that the subsequent evaluations made with these methods failed to acknowledge any increase in productivity. Lubbe and Remenyi (1999) supported this view in their research, concluding that if relevant potential benefits were not taken into account in an ex-ante analysis, the wrong project would be approved.

Powell (1992) discusses the evolution of IT/IS investment by stating that with advances in technology and the integration of IT into everyday processes, tasks became more decision-orientated, which necessitated the widening of the scope of costs and benefits. Therefore the impact of less quantifiable activities increased with a simultaneous decrease in the accuracy of the existing quantification of costs and benefits. This in turn paved the way for more subjective or ‘soft’ analysis methods, which still attempted to quantify benefits, but the inherent quantification now related rather to feelings, attitudes and perceptions (Powell, 1992, Myrtidis, 2008). Williams and Williams (2007) conclude on the basis of previous literature that human and organisational issues form an important part of IT/IS evaluation. As concluded by several authors, such attempts remain riddled with uncertainty (Powell, 1992, Smithson and Hirschheim, 1998, Kanungo et al., 1999).

B. Array of taxonomies

There is a variety of ways in which to categorise the vast amounts of theoretical concepts and practical models and techniques in IT/IS investment evaluation literature. For example, Bannister and Remenyi (1999) assume a value-driven approach where methods are divided into fundamental, composite and meta approaches. In the
first case, one attempts to assign a parameter for a certain characteristic of the investment. This sub-type encompasses all traditional accounting-based methods as well as qualitative user satisfaction ratings. The common denominator of the latter is that all evaluations generally result in a single number (e.g. ROI or IRR) by which to assess the investment. Composite approaches combine several fundamental measures in order to gain a more balanced picture (e.g. Balanced Scorecard or Information Economics). Very often these evaluations also result in a single number, and these types of methods are most frequently used by practitioners. Finally, the meta approach seeks to include an optimum set of metrics but does so in an unstructured manner (Bannister and Remenyi, 1999).

Both Patel and Irani (1999) and Cronk and Fitzgerald (1999) present thorough taxonomies on a variety of literature on IT/IS investment evaluation methods in their respective articles (see Figure 6 for a selection of methodologies in respect to the PENG model).

In some works, division is made not only on the basis of what is measured but also how the process should take place. For example, Remenyi and Sherwood-Smith (1999) propose that methods be divided into formative and summative evaluations. The latter are usually conducted at any point after the implementation of a system to support decisions made previously. It is argued that a mere pre- and post-implementation analysis is unsatisfactory for many practitioners as investments need constant monitoring and analysis. In regard to this, Remenyi and Sherwood-Smith (1999) propose a formative continuous evaluation at each stage of the project. This is a continuous informal process that influences decisions made about the IT/IS at various stages of implementation, thereby impacting both the development process and the resulting technology. However, in evaluating a nationwide system, it could be argued that such a constant participatory evaluation process may demand too many resources and that a cross-sectional method should be preferred. In addition, formative evaluation ought to have been implemented before any system was developed so as to ‘form’ a joint understanding of the proposed e-health system.

As is apparent, there is an array of IT/IS evaluation tools. However, several authors (Lubbe and Remenyi, 1999, Smithson and Hirschheim, 1998) conclude that cost/benefit analysis (CBA) and return on investment (ROI) techniques are most often applied to make decisions in regard to IT investments. Drummond et al. (as cited by Buccoliero et al., 2008) also confirm the longitudinal use of the cost/benefit analysis (CBA) in evaluating the impact of large public sector programmes on society’s well-being.

However, some authors argue that currently there is still a dearth of suitable methods to quantify the intangible dimensions of IT/IS evaluation outcomes (Kanungo et al., 1999) and that existing techniques for ex-ante evaluation need further improvement as they lack the necessary level of accuracy (Williams and Williams, 2007). Lubbe and Remenyi (1999) agree that there is little attempt among practitioners to acquire a holistic view of IT/IS evaluation where all costs and benefits are taken into consideration. Instead, emphasis is placed on economic criteria. As IT/IS projects generate intangible benefits for the community, public sector institutions are justifiably interested in mapping the social impact of innovative action (Buccoliero et al., 2008).

Buccoliero et al. (2008) conclude that e-health projects are particularly heterogeneous
by nature, making them increasingly difficult to evaluate. They highlight three important aspects of e-health project evaluation: first, that evaluation must be able to model the complex processes that are involved in the field; secondly, that the evaluators must be able to assume multiple viewpoints in mapping costs and benefits depending on the stakeholders involved; and thirdly, that the evaluators should be flexible and adapt to new situations (e.g. learning from past mistakes). As is evident, with e-health project evaluation there is a need for the evaluators to understand and interpret complex socio-technical situations. As a result, purely finance-based techniques favour a short term view that is inherently incompatible with the long-term nature of such investments, which are expected to form part of a long-lasting infrastructure (Smithson and Hirschheim, 1998). Therefore, it can be argued that an integrated approach to evaluation would address the specificity of the e-health context (see Figure 6).

In short, a plethora of techniques is available, both qualitative and quantitative (as well as mixed methods) (see Figure 6). Which combination of approaches should be used in each case and why remains a subject of debate. Irani (2008) proposes a solution in stating that if you evaluate an IT investment, you mainly provide relevant information to stakeholders, who in turn have to apply that information appropriately. In short, IT evaluation is a means to make necessary decisions and the nature of these decisions is a crucial factor in choosing an effective evaluation strategy. Therefore, in attempting to evaluate a comprehensive e-health project, a method that is able to map complicated processes, includes multiple points of view and which can adapt to changing situations is needed. From an initial review of literature, the PENG model has been identified as a suitable technique for the assessment of IT/IS investments (see Figure 6).
### Cost/benefit analysis (economic approach: ratio-based)

- Economic approaches are structured and risk analysis can be done by manipulating variables.
- Advantage: straightforward accounting measures are compared i.e. an IT cost measure vs an organisational performance measure (e.g. pre-tax profit).
- Disadvantage: only takes easily quantifiable costs and benefits into account; quantification of ‘soft’ benefits is omitted.

### Net present value (NPV) (economic approach: discounting technique)

- Advantage: hurdles may account for the qualitative approach.
- Disadvantage: despite being accounting-based, a degree of subjectivity is involved in predicting cash flows; non-quantifiable costs and benefits are omitted.

### Competitive advantage (strategic approach)

- Less structured than economic approaches, but assumes a broader view of project implications on company performance.
- Advantage: integrates strategic, operational and financial metrics in measuring how the project enhances the company’s position on the market.
- Disadvantage: limited application in the public sector; involves thorough competitive analysis.

### Risk analysis (analytical approach)

- Structured method of analysis.
- Advantage: clearly defines risks associated with the project and tangible and intangible metrics are often both included.
- Disadvantage: evaluation is highly subjective in nature and little concrete information included.

### Balanced Scorecard (integrated approach)

- Integrated approaches combine subjectivity with formal structure. Balance Scorecard is a flexible method and can include various metrics depending on the place of application.
- Advantage: integrates the financial and non-financial costs and benefits of an investment; intangibles are given weighting to account for their importance.
- Disadvantage: the weighting of intangibles involves subjective evaluation, which affects the outcome.

### PENG model

- An integrated approach that includes both numerical and non-numerical data.
- Advantage: highly practical tool with a framework for conducting evaluation; non-quantifiable benefits are clearly stated and evaluated according to their impact on the overall project; a holistic view on the project is assumed and multiple sources are used, including various parts of the organisation.
- Disadvantage: degree of subjectivity involved in evaluation.

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C. THE PENG MODEL

The PENG model is a cost/benefit tool used to measure the net benefit or net present value of an IT/IS investment (Dahlgren et al., 2003). It is a multi-dimensional framework that combines parts of various methods of project evaluation including Balance Scorecard applications, goal guidance models and institutional development methods. This composite approach enables the evaluation not only of immediate financial gains and costs, but also the impact of intangible benefits (Bannister and Remenyi, 1999). As became apparent in an analysis of literature, information systems involve more than just direct monetary savings, and in order to reach an objective evaluation it is crucial to take into account the impact of the investment as a whole. Moreover, the ‘softer’ benefits of an IT/IS investment can often prove to be most valuable to society, but are frequently excluded due to an inability to measure them in traditional monetary terms. As such, the PENG model is particularly appropriate as it attempts to quantify the more intangible values of an investment.

PENG can be implemented at any point in time in the course of an investment depending on the purpose of the evaluation. In ex-ante evaluation, the aim is often to choose from different investment options. In this case, PENG serves to create a clear basis for decision-making by mapping potential future costs and benefits. This provides a holistic view and enables decision-makers to focus on the most important goals that need to be achieved. Furthermore, pre-investment benefit mapping makes significant intangible benefits visible that can also be integrated in the analysis (Hjort, Rehnberg 2003).

Using the PENG method in the course of implementation can create an awareness of the potential benefits that need to be achieved or help to decide whether to continue with a project. This type of evaluation provides information about the process and where the main hindrances lie. It can also facilitate organisational change by enabling evaluators from various backgrounds to form a joint view on the desired outcome.

An ex-post evaluation can serve as a method of analysis of the process of implementation in hindsight and a starting point for an appropriate follow-up strategy. More specifically, it will reveal the hidden costs which emerged that were initially not accounted for. Therefore, rigorous follow-up provides a more realistic view of the IT/IS investment evaluation process (Hjort, Rehnberg 2003).

1. Using the PENG model in the health care sector

PENG can be used in any type of organisation, but it is especially suited to evaluating projects in health care, where benefits that are difficult to measure arguably form an essential part of the investment.

In essence, the PENG model is based on a framework consisting of ten steps which evaluate an investment from different perspectives in terms of benefits and costs (Dahlgren et al., 2003). The process begins with an initial preparation phase, with steps designed to define the scope of the evaluation with the respective goals in mind.

The subsequent realisation phase includes the identification, structuring and measurement of the costs and benefits of an IT/IS investment. In the final ‘quality
assurance’ phase the results are critically revised and validated and the final net benefit of a project is calculated. The net benefit is therefore defined as the difference between the gross benefit and the cost of achieving the benefit (Figure 7).

![Figure 7. Calculating the net benefit of IT investments (based on Dahlgren et al., 2003, as referenced by Hermansson et al., 2003)](image)

The gross benefits are further divided into direct, easily quantifiable benefits; indirect benefits that can be quantified through indirect reference measurements; and intangible benefits that have an important impact on the overall outcome but which are nevertheless not quantifiable.

PENG is designed to take into account the specifics of implementing change in the health care sector. As such, it further divides benefits into three main categories: those for the care provider, those for the patient and those for society (Figure 8). The individual benefits under each category are often interconnected and can be further divided into direct, indirect and intangible benefits.

![Figure 8. Benefit relations (Hermansson et al. 2003: 33) (Dahlgren et al. 2003)](image)
The direct and indirect benefits are quantified into monetary units to make them easy to comprehend and compare. In the course of doing so, the intangible benefits are also carefully mapped for each stakeholder (i.e. patient, provider and society) and included in the final analysis. Although it is not really possible to measure these ‘soft’ benefits in monetary terms, they are one of the most crucial aspects of the service. Although the PENG method measures benefits in quantitative terms, the overall aim is not to calculate rigid financial figures but rather to evaluate the size of the various types of benefits and thereby achieve a robust analysis of IT/IS evaluation.

2. Using PENG to evaluate IT/IS investments in e-health

In reference to the review of literature, the PENG model is highly suitable in evaluating IT/IS investments. It provides many benefits, such as a structured systematic approach to IT/IS evaluation, the inclusion of a broad range of benefits (both quantifiable and non-quantifiable) and a good basis for a follow-up process.

Ward and Murray (1997) (as cited by Alshawi et al., 2003) as well as Devaraj and Kohli (2003) conclude that benefits from an IT/IS investment stem from the use of the system rather than the system itself. In the PENG model, future benefits arise not only when the system has reached a satisfactory level of technological performance, but when it is used frequently and accurately enough to produce the benefit (Devaraj and Kohli, 2003). As Alshawi et al. (2003) propose in their work, an appropriate IT/IS evaluation not only has to identify the range of costs involved in implementing the project, but also identify and structure the benefits. PENG places significant emphasis on benefit recognition, which Alshawi et al. (2003) consider essential in successful IT/IS evaluation, as it enables the identification of the benefits that are delivered and the impact of these benefits on the entity in question. Another important feature of PENG is the prioritisation of benefits, through which the benefits with the most substantial effect are highlighted. Finally, Devaraj and Kohli (2003) highlight the importance of quantifying the overall impact of an IT investment in health care, as this data can be used for the cost/benefit analysis of a future project.

To justify the method in the highly specific setting of a national e-health project, the main emphasis is without doubt on the clear definition of intangible benefits. E-health in various forms is showing promise in terms of boosting the quality, efficiency and effectiveness of health care. However, the high level of investment needed is often daunting to policy makers, especially when the benefits achieved are difficult to measure. Therefore, a method of analysis that identifies the full range of benefits likely to be achieved is a must. The evaluation process of an e-health system needs to assume a holistic view by defining all of the costs and benefits and highlighting the benefits that truly matter in achieving the goals originally set out.

In short, project evaluation through the actual use of IT/IS systems with subsequent exhaustive benefit identification and quantification will bring about a comprehensive reflection of the desired result and the optimum state of affairs in any IT/IS investment in health care. As such, the PENG model is an appropriate framework to use when evaluating a nationwide health information system.
D. RESEARCH DESIGN

1. Research process

It can be argued that every comprehensive change in process needs to be fully understood and managed in order for a shift in common practice to take place. In health care in particular, the care process is closely connected to human interaction. Therefore, careful management of the integration of IT into the health care sector is needed for any e-health project to succeed. As mentioned earlier, the Estonian e-health project is unique in terms of both scope and scale, therefore providing great potential for a new dimension in e-health project analysis.

Research was based on the PENG method and no theoretical framework as such was provided in advance. Instead, the approach taken was inductive, with specialists from various fields of health care analysing the Estonian EHR system and defining the best method for the evaluation of the comprehensive nationwide e-health project. Once the method was chosen, it was validated by evaluating the Estonian e-health project using the example of diabetes management.

The process started with a meeting in September 2008 at which experts from different areas involved in health care came together in order to launch a process of attempting to evaluate a nationwide EHR system. Their initial goal was to generate awareness and streamline the purpose of the project in order to meet the needs of all of the participants.

The project team was made up of members from various organisations, including academic and research establishments such as Tallinn University of Technology, the PRAXIS Centre for Policy Studies and the Estonian eHealth Foundation (the manager of the EHR system in Estonia). In addition, medical service providers were represented at the hospital management level.

To begin with, the problem area was subject to careful group discussion to define where evaluation would be most valuable and where it would prove to be most challenging. The aim of the project was clearly defined and described. The PENG method was chosen through focus group discussions and revision of previous literature about IT/IS investment, after which the panel of experts familiarised themselves with the model and its capabilities.

As the project was designed to identify a method for the evaluation of the benefits of an entire nation where health care service users vary greatly, it was necessary to delineate the scope of analysis. Type II diabetes patients were chosen as the group of service users in order to form a data sample that would be clearly defined, have a fairly standardised treatment process, use health care services on a regular basis and be prevalent enough in society to ensure that the results could be sufficiently generalised. The patients were divided into two sub-groups depending on the severity of their condition to reflect the differences in the treatment process and benefit realisation. (This rationale is described in detail in the next paragraph.)

It became evident that the range of experts needed to be broadened in order to achieve a comprehensive viewpoint on the beneficial effects of EHR. Therefore, medical personnel from both the primary and secondary levels of care were included.
in the process, as well as a representative of patient organisations. Through subsequent workshops, the initial benefits were mapped for each group i.e. patients, care providers and society.

The benefits identified were then carefully discussed at the following group meetings in order to achieve consensus on the list of benefits EHR would generate. Benefit mapping was carried out and a benefit tree created for each stakeholder at the subsequent workshop meetings. As the group dynamics was multi-faceted, discussions were lengthy, but resulted in a comprehensive division and structuring of benefits. After the latter, the team of experts approached the complex problem of benefit evaluation. In order to be able to evaluate the benefits accordingly, the team broke up into three sub-groups based on the three broad groups of stakeholders. The division followed a rationale of the proximity of each expert to a respective stakeholder. Each proxy for a benefit calculation was then carefully discussed and validated in the main group of experts to ensure continuity and consensus within the project team.

After the calculations of benefits, the costs were identified and structured in a similar manner to the preset division of participants. The costs mainly included the direct monetary amounts that were needed to launch and maintain EHR. Indirect costs were also taken into account as risks and threats to the success of the project. A timeline of 10 years (until 2020) was decided upon in order to map the indirect costs that would emerge at later stages. Threats and obstacles were identified for each of the three stakeholders at smaller workshops and subsequent group discussions. Future direct costs were also calculated on the basis of current budget plans and a conservative assumption of increasing maintenance costs.

As a final step, the structure of costs and benefits was presented with a calculation of the net benefit achieved. The threats to the success of the project were added to the conclusive analysis to boost the validity of the results and provide a source for follow-up. The results were discussed within the project team and with external experts. Once again the underlying presumptions were validated to ensure a common understanding of the process within the group. The external experts formulated opinions on the method chosen and the process of method validation so as to reinforce the results.
IV. TYPE II DIABETES AS A MODEL DISEASE USED FOR ANALYSIS

We used Type II diabetes as a test model to assess the net benefits of the Estonian EHR. The decision to use diabetes was based on the following rationale:

- the disease has a high rate of incidence and prevalence among the Estonian population;
- the diagnosis and treatment of the disease and its complications involve a broad spectrum of specialities;
- there must be evidence-based clinical guidelines for the treatment of the chosen pathologic condition;
- there are indicators for quality of care;
- the diabetic care process crosses organisational boundaries; and
- proper disease management:
  - has a strong positive influence on the patient’s quality of life; and
  - decreases the economic burden on society.

There is overwhelming evidence, in Estonia and globally, to support the choice of this condition. Diabetes is one of the most common non-communicable diseases worldwide (Adeyi et al. 2007, Khatib 2006). The global prevalence of diabetes for all age groups was estimated to be 2.8% in 2000, rising to 4.4% by 2030. Furthermore, the total number of people with diabetes is projected to increase from 171 million in 2000 to 366 million by 2030 (Wild et al. 2004). In order to gain a more local perspective, the estimated prevalence of diabetes in Estonia in 2004 was 1.2%, 6.2% and 9.4% in the age groups 20–44, 45–64 and 65+ respectively (Eesti Arst 2008; 87).

Not only the definition of diabetes but also its diagnostic criteria and classifications have been agreed upon at the international level, including, amongst others, the World Health Organisation (WHO). The term ‘diabetes mellitus’ is used to describe a metabolic disorder of multiple aetiology characterised by chronic hyperglycaemia with disturbances of carbohydrate, fat and protein metabolism. This results from defects in insulin secretion or insulin action, or both. The current WHO diagnostic criteria for diabetes are as follows:

- Fasting plasma glucose $\geq$ 7.0 mmol/l (126 mg/dl); or
- 2-h plasma glucose $\geq$ 11.1 mmol/l (200 mg/dl).

However, there are two additional conditions connected to relatively high blood glucose levels:

- Impaired Glucose Tolerance (IGT) is diagnosed when:
  - fasting plasma glucose is lower or equal to 7.0 mmol/l; and/or
  - 2-h plasma glucose is between 7.8 and 11.1 mmol/l.
- The condition when the fasting plasma glucose level is between 6.1 and 6.9 mmol/l is called Impaired Fasting Glucose (IFG).
Diabetes is a chronic disease with a high rate of incidence in today’s world. The diagnosis, treatment and management of diabetes encompass a wide range of clinical specialists and institutions, which was further reason to choose diabetes as the model disease for the project. In short, fulfilling the second criterion presented above makes diabetes an appropriate example for the evaluation of the influence of a national health information system on the provision of health care services.

Diabetes is classified into four groups based on the aetiology of the disease: Type I, Type II, Other Specific Types and Gestational Diabetes Mellitus (American Diabetes Association 2004, WHO 1999). Type I diabetes is primarily caused by pancreatic islet beta-cell destruction or dysfunction, which therefore makes it prone to ketoacidosis. Type II diabetes includes the common major form of diabetes resulting from defects in insulin secretion in the body, almost always with a major contribution from insulin resistance. Type II diabetes accounts for 90–95% of all diabetes mellitus cases in the world. Other specific types of diabetes involve genetic defects, diseases of the exocrine pancreas, endocrinopathies, drug- or chemical-induced diabetes, infections, uncommon forms of immuno-mediated diabetes and other genetic syndromes sometimes associated with the disease. Gestational diabetes mellitus is defined as a certain degree of glucose intolerance identified during pregnancy.

Diabetic patients have an increased risk of microvascular damage (retinopathy, nephropathy and neuropathy) which is associated with reduced life expectancy and significant morbidity. The most common macrovascular complications are ischemic heart disease, stroke and peripheral vascular disease, all leading to a diminished quality of life.

The relationship between increased plasma glucose levels and retinopathy has been proven in many scientific studies, making it essential to consistently and regularly monitor the plasma glucose levels of diabetic patients. Another test that measures the glycated haemoglobin in the blood is known as HbA1c. This is especially important in tracking glycaemic control over an extended period, for example every three months. The relationship between HbA1c and prevalent retinopathy is similar to that of plasma glucose. Elevated levels of HbA1c have been associated with cardiovascular disease, nephropathy and retinopathy in diabetes. However, it is generally considered by specialists that an HbA1c of 7% is sufficient to avoid complications.

To fulfil the third criterion in selecting a model disease to measure the costs and benefits related to e-health, evidence-based guidelines are required for the diagnosis, treatment and management of the condition. Management guidelines are available in Estonia for both Type I and Type II diabetes. They are approved by the Estonian Health Insurance Fund and by societies of clinical specialists. The objectives of the guidelines are to provide GPs and diabetic patients with relevant information about the treatment and monitoring of the condition and to provide patients with support. Diabetics need to cooperate with physicians in adjusting to their new situation and solving related problems. The guidelines also assist in disease management by monitoring symptoms and performing tests to measure possible eye, kidney, foot and/or vascular complications, as well as in the timely diagnosis and treatment of diabetes and its complications. The guidelines also aim to provide diabetic patients and care-givers with recommendations on setting up diabetic care groups and related organisations, and delineating the structure and process of diabetes care.

Furthermore, the quality of care in diabetes mellitus has been established at the
international level. In 2004, the Organisation for Economic Co-operation and Development (OECD) published a paper describing indicators for the quality of diabetes care at the level of health systems. Indicators were selected to cover all of the clinical processes in diabetes care as well as proximal and distal outcomes. Indicators for processes in diabetes care are regular (quarterly and annual) HbA1c and low-density lipoprotein (LDL) cholesterol testing, annual screening for nephropathy and an eye examination. Indicators for proximal and distal outcomes are HbA1c and LDL cholesterol control, lower extremity amputation rates and kidney disease and cardiovascular mortality in patients with diabetes. In short, the quality of care in diabetes is well mapped at the international level, thereby giving a concrete and univocal basis of evaluation and comparison for disease management with or without an e-health system.

A. Grouping of diabetes patients

For this project we divided Type II diabetes patients into two groups based on the complexity and costs of their diabetes management pathways. This allowed us to differentiate the benefits relating to EHR with greater precision. The main difference between the two groups was the amount of resources needed to treat the disease, monitor risk factors and diagnose and treat complications. The same approach was used in a study calculating the cost of diabetes care in Sweden (Henriksson and Jönsson 1998) where the researchers noted that the costs of managing and controlling diabetes constituted less than 25% of the overall cost of diabetes care. Another study about the economic cost of diabetes was performed in the United States in 2007. This revealed that as much as half of all medical costs attributed to diabetes care were used to treat chronic complications of diabetes. In particular, conditions such as cardiovascular disease, neurological symptoms and renal complications demand an increasing amount of resources in diabetes management (American Diabetes Association 2008).

The first group in Type II diabetes included patients with a compensated disease course. This group was characterised by a good glucose balance, controlled medication of diabetes and relatively few visits to their GP or other specialist. They had, on average, two appointments annually, one to visit their GP and the other to do an eye fundus examination. In general, the patients in this group had a relatively good quality of life. More specifically, there were no high costs for society in managing their conditions.

The second group consisted of patients with uncompensated diseases and/or complications of Type II diabetes. This group included further sub-categories consisting of patients whose diabetes was well compensated but still with serious vascular complications. Patients in this group had multiple visits to their GP every year as well as to other specialists. They also faced hospitalisation due to poor glucose balance, complications or other accompanying diseases. The economic burden on society resulting from the maintenance of their disease was high.
1. **Examples of management changes of Group I and Group II patients**

a) **Group 1 – patients with compensated diabetes**

According to diabetes guidelines, a patient with compensated diabetes requires regular self-checks of blood glucose and monitoring of blood pressure and body mass index. All of these measurements are taken in the patient’s home and the results can be forwarded electronically to their GP or directly to the health information system. Some testing still needs to be done on the health care provider’s premises, such as cholesterol and triglyceride values, creatinine values in blood serum or plasma and the urine albumin creatinine ratio. All of these, plus visits to an ophthalmologist for eye fundus imaging and the assessment of foot arterial pulse and skin sensitiveness should be done once a year. Follow-ups on HbA1c should be conducted twice a year. However, as it is not possible to conduct an HbA1c test using portable self-monitoring equipment (WHO 2006), patients with compensated diabetes have to visit a health care institution at least twice a year to give a blood sample.

b) **Group 2 – patients with uncompensated disease and/or complications of diabetes**

The second group consists of three separate types of patients:

- Patients with uncompensated disease
- Patients with complications (who may have a near-normal HbA1c level)
- Patients with uncompensated disease and complications

Although the management of every type differs to an extent, the similarity of these three types is that the health care resources needed for the diagnosis and treatment of them is remarkably higher than that of patients in the first group.

Compared to the first group, the follow-up procedure for patients with uncompensated disease includes additional measurements of HbA1c. In this case, the test should be done four times a year, which means at least four separate visits to a health care institution annually. Depending on the results of the HbA1c tests, each visit at which a patient gives a blood sample should be followed by a visit to their GP or endocrinologist to discuss the changes needed in their medication and to plan for subsequent tests and examinations. In such cases, special attention needs to be paid to hypertension and lipid management. In addition, uncompensated patients frequently need to consult diabetic nurses. Some of these visits can be replaced by remote e-consultation using EHR. Moreover, e-health provides additional information through the platform to improve patients’ awareness of various risk factors and of the complications of diabetes. The platform can encourage patients to strive to achieve glycaemic goals, control hypertension and dyslipidemia, cut back on or quit smoking and/or set about losing weight. The disease management information available in EHR could include personalised recommendations on exercise and drug therapy, with attention also being paid to e.g. cardiovascular risks depending on the specific conditions of the patients.

The follow-up for patients with complications also depends on the nature of the impaired organ system. Usually a patient is first seen by an endocrinologist for complex assessment of the extent of micro- and macrovascular complications. Microvascular complications are retinopathy, nephropathy and neuropathy. Examples of macrovascular complications are myocardial infarction, stroke or amputation. Treatment of complications is a complex task and often demands a joint effort by a
multi-disciplinary team. Cardiologists, nephrologists, ophthalmologists, neurologists, vascular surgeons and/or podiatrists could be involved in the treatment of a single patient based on their specific pathology. Each specialist needs to order additional imaging or laboratory tests to diagnose and treat the specific conditions related to their area of expertise.

B. Changes in diabetes management

EHR allows access to the clinical data of patients. This data is available to both patients and appropriate health care specialists simultaneously, enabling diabetes management pathways to be re-engineered. The general concept of this change in process is shown in Figures 9 and 10.

The most important change in using the shared database is the opportunity for diabetic patients to become more involved in the process of disease management. A patient has access to their own medical data, recorded and collected in different health care institutions during multiple visits to various physical locations. This leads to higher quality in self-monitoring as well as to better planning of visits to specialists. Another aspect is that the processing of complaints is also faster and requires less human resources. EHR provides a comprehensive overview of the entire disease management process involving multiple parties. Health care professionals are able to forward relevant treatment recommendations and test results directly through EHR, eliminating the need to see patients in person. The patient’s awareness of diabetes also increases through better engagement in the risk evaluation of complications. It could be argued that a more transparent information flow leads to better communication between the patient and the physician. This is an important factor in ensuring a patient’s compliance with treatment guidelines and recommendations, and timely adjustment of the treatment. A data-rich EHR with continuous self-monitoring information added by the patient via the Patient Portal allows the physician to spend much less time gathering anamnesis during appointments. Another important feature worth noting is that the sharing of information with the patient increases the quality of medical information being submitted to EHR. As a result, the patient acts as an external auditor of the health care system. The future features of the Patient Portal in the health information system will include self-care and virtual health check algorithms, which will further enhance the quality of diabetics care. All of these benefits will increase diabetic patients’ quality of life by avoiding complications and giving them more time to live normal lives. Recommendations will be targeted at smaller groups of patients, but broader communication networks between patients with similar conditions and support groups will be established. Finally, the time needed to go and see doctors will decrease as the number of required visits decreases due to the availability of shared information.

From the point of view of health care providers, the matrix pathway allows a patient’s diagnostic and treatment processes to be changed. There is no longer a need to physically transport all clinical data with a patient: instead, the data can be used at any time and anywhere depending on when and where the decision process takes place. It is possible to distribute and integrate current data with other relevant data throughout the patient care process. EHR enables the coordinated sharing of resources, problem-solving in diabetes treatment and follow-up in a virtual, dynamic, multi-institutional setting with the involvement of health professionals from different institutions. who obtain information about entries and medical tests done by other
medical specialists or GPs through EHR, therefore eliminating the need to carry out repeated tests. This latter point also applies to imaging, including eye fundus imaging and photos of skin wounds. Moreover, receptionists, in cooperation with doctors, are able to make a more efficient and informed selection of patients needing care by using data from EHR when booking appointments and compiling waiting lists for procedures. This allows for more urgent cases to be seen first. As previously mentioned, data sharing and home monitoring enables patients to be discharged from hospital earlier, which is therefore more cost-efficient. EHR makes it possible for doctors to collect patient data quicker and in a more comprehensive manner. Patients, in turn, do not have to wait at the hospital for the relevant information, but receive it via the national e-health platform. As better informed patients are unlikely to visit their physicians without sufficient reason, unnecessary visits to specialists will also decrease. In terms of quality of care, the use of applied guidelines and control algorithms for the dosage and prescription of medications will reduce hospital-induced adverse effects. Last but not least, it is possible to gain an overview of patient groups through the information system and use the information to estimate the profile and cost of patients for specific health care organisations.

The third beneficiary of the EHR is society as a whole. Society benefits from the e-health system through quicker and more thorough analysis of diabetes epidemiology. In addition, the prognosis of health care costs for diabetes management will have a more solid basis, and the quality of data emerging from EHR will enable further scientific research to be carried out into diabetes mellitus. Increased knowledge of Type II diabetes enables early intervention by health care administrators and especially GPs as first-level health care providers, and aid in the further prevention and spread of the disease in Estonia. An overall improvement in diabetes care will lead to a smaller number of patients with complications, thus decreasing overall health care costs. These funds will then be able to be channelled into other necessary services, improving the quality of health care in general. Better informed and treated patients are able to return to their normal lives much faster, enabling them to work and contribute to society. In short, this not only improves the quality of the patients’ lives, but also has a positive economic effect on the state through tax revenue and decreased rates of sick leave.

**Figure 9.** Linear or sequential workflow. Patient data moves with patient. The information flow is in one direction. No parallel processes.
Figure 10. Matrix or shared workflow. Patient data is accessed at any time and from any place. The change of information is mutual. Parallel processes are available.
V. RESULTS: DESCRIPTION OF BENEFITS AND COSTS, REFINED APPLICATION OF PENG MODEL AND CALCULATIONS

A. Description of benefits and costs

All of the potentials costs and benefits were identified using the methodology described in Chapter III.C. As already explained, the benefits were structured and systematised in such a way as to measure the positive effects for patients, health care providers and society. As a result, it has been possible to avoid duplications and cover all relevant areas where benefits ought to appear after implementing EHR. In terms of related costs, three items of expenditure were considered: in addition to the most obvious and direct resource allocations to the project itself, subsequent investment and maintenance costs were also taken into account. A detailed description of these costs and benefits is presented in the following subsection of this chapter.

1. Benefits

As was identified in the course of this project, certain benefits often arose due to process enhancements and were therefore present in more than one analysis. To tackle this issue, the benefits were structured and systematised in a final concentrated list of benefits to be used in calculations. The process of identifying duplication followed the methodology described in Chapter V.B and the final list of benefits is presented in Table 1. The colours reflect an underlying logic where the direct benefits are marked in green, indirect benefits in yellow and intangible benefits in red. The relations between different categories of benefits and the PENG model are described in Chapter III.C.
Table 1. Potential benefits for patients, health care providers and society

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Patient</th>
<th>Health care provider</th>
<th>Society</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access to care improves</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional revenue from bonus payments (to GPs)</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Availability of all data</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Avoided complications (incl. postponed complications)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Avoided decrease in salary</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Better information helping patient to participate in process</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Better overview of personal medical information</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easier benchmarking of health care providers</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Improved (opportunities for) self-management of disease</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved planning of resources and optimisation of investments (e.g. choose-and-book system)</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Increased capability to participate in pharmaceutical research</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Increased number of skilled public health experts (due to increased demand)</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Increased potential for selling Estonian eState services</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Increased productivity (incl. more efficient time management)</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Interactive prevention of disease for citizens</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Less administrative burden</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Fewer complaints</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Fewer service costs for disabled people</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Fewer disability payments</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Fewer hazardous examinations</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fewer hospital days</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Less institutional care</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Less manual transfer of information/documents</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Fewer prescriptions</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Fewer sick benefit payments</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Fewer visits</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Maintain (smaller) providers in business</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>More accurate budget planning and targeting for health programmes</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>More early discharges</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>More satisfied patients</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>More taxes</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>More time for patients during visits</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>More years of healthy life</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient profiling enables costs for providers to be forecast</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients can add personal self-monitoring data</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Policies in Estonia are considered robust due to improved use of information</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prevent complications</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Promotion of hospital</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quicker return to labour market</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Receive medication on time</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced cost of stay</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Reduced number of unused bookings</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Replacing doctors’ visits with nurses’ visits</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revenue for hospital from new services</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saved time from going to doctor</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saves time from low-quality work (because it is too complicated)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Saving doctors time during visits</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saving transportation costs</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Savings from co-payments</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shorter visit times</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Shorter waiting lists</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Value of life</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It was necessary to assume a focal point as there were numerous benefits to analyse. In aiming to describe the origin of benefits in general it was decided to focus on health care providers, where detailed analysis presented focuses on improved communication between doctors and patients and/or their relatives. The complete tree of benefits is presented in Appendix 1, providing a more in-depth view of the
matter. In general, health care provider benefits are divided into five main categories. In addition to the benefit mentioned above, the other four groups are improved access to relevant medical and health data; improved access to knowledge and/or medical experts; more motivated health care personnel; and enhanced possibilities to create new services and specialisations. The final calculations were arrived at through subsequent analysis of the latter categories, one of which is described below.

In analysing improved communication between doctors and patients and/or their relatives it was necessary to focus separately on medical professionals and patients. By taking advantage of e-health services, patients are much better informed and therefore able to manage their medical condition much better. As a result, their compliance improves, which in turn results in more early discharges, higher patient satisfaction and money saved from compulsory payments to see their GPs. Higher compliance also increases the overall stability of the medical condition, resulting in fewer complications. This reduces the number of visits that patients with complications need to make to their doctors, even more early discharges and avoided or postponed complications, along with fewer complaints and an overall reduction in the cost of being ill. Overall higher satisfaction among patients will not only result in fewer complaints and visits, but also promote the medical institution. There are many other benefit analyses like this one, but since they follow a similar logic and the algorithm of benefits is the same, they are not described in detail here.

2. Costs

There are two main components of costs related to e-health projects, of which the first comprises direct costs associated with projects, all of the necessary investment expenditure and maintenance costs. The second includes any negative impacts which may arise when implementing the EHR. The different sources comprising each item of expenditure in the first group are described in the subsequent part; however, all concrete figures are presented in Appendix 2 for the sake of more concise analysis. As the second group includes intangible negative impacts and can be considered more as threats and risks to a project’s success than specific expense items, they are neither quantified nor included in socio-economic analysis. Nevertheless, they are discussed at the end of this chapter.

Direct project costs include the resources spent by the Estonian e-Health Foundation and the Ministry of Social Affairs on the EHR. The costs for the ministry can be further broken down into development costs and the costs of establishing the E-Health Department within the ministry, which in turn consists of labour and administration costs. Labour costs until 2008 also take into account the fact that the predecessor of the Estonian eHealth Foundation was initially established under the ministry. Each individual cost item up to 2008 was aggregated. The data concerning the costs incurred in 2009 is based on the approved budget. Therefore, all costs for subsequent years are predicted with a 2% annual growth rate on the basis of 2009 with the exception of development costs, which are predicted to increase by 15% every year. The development costs in the first group comprise the European Social Fund resources allocated to the four e-health projects.

The eHealth Foundation’s costs include both direct and indirect costs of development. The direct costs of development consist of two main areas: all of the expenses covered by employment contracts, and resource allocations related to the standardisation
process. Indirect costs of development mainly consist of labour, administration and maintenance expenses.

The main cost item for health care providers is related to investment. The specific expense items that have been identified are costs related to software development and piloting and the installation and maintenance of computer work stations. Investment costs also cover resource allocations to IT personnel, the Doctor’s Portal and all ID card-related costs, including expenses incurred for the use of ID cards and interfacing with the X-Road. All of these cost items have been extended into future periods with the exception of piloting and interfacing expenditure, which were only relevant until 2008. The costs extended into future periods are fixed and no additional investments are foreseen for GPs.

Maintenance costs include the expenses incurred in sustaining the main services of the Estonian eHealth Foundation as well as the development of EHR functionality and its general administration.

A (not exhaustive) list of potential negative aspects, also referred to as threats and risks, is presented in Table 2. These are divided in much the same way as benefit distribution into three categories according to the stakeholder most affected by it.

<table>
<thead>
<tr>
<th>PROVIDER</th>
<th>SOCIETY</th>
<th>PATIENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usage skills of IT tools differs between people</td>
<td>Electronic information bias</td>
<td>Decreased personal contact between doctor and patient</td>
</tr>
<tr>
<td>Information recorded by doctors will be available to others</td>
<td>No capability (skills) to use data</td>
<td>Due to increased amount of information available about a patient, doctors may form preconceived ideas and attitudes towards them</td>
</tr>
<tr>
<td>Delicate personal data used by unauthorised people (data security)</td>
<td>IT will not work</td>
<td>Data leakage, sensitive data and misuse of data</td>
</tr>
<tr>
<td>Data integrity not guaranteed</td>
<td>Low trust</td>
<td>Trouble understanding own medical information (when viewing test results etc.)</td>
</tr>
<tr>
<td>Doctors refuse to use system</td>
<td>No clear vision or vision not followed</td>
<td>Not knowing patients rights or legislation connected to e-health</td>
</tr>
<tr>
<td>Opposition to new technology (IT)</td>
<td>Low quality data (non-standard coding etc.)</td>
<td>IT system crashes and all data is lost</td>
</tr>
<tr>
<td>Doctors notes will be ‘sterile’ i.e. tenuous data</td>
<td>Partially implemented applications (e-register)</td>
<td>Not patient-friendly</td>
</tr>
<tr>
<td>‘Customer is always right’ – doctors must develop customer service skills</td>
<td>Outdated application used by health care service provider cannot provide data</td>
<td>Complicated e-forms that patient must complete without physician’s help</td>
</tr>
<tr>
<td>More time spent on computer than on patient</td>
<td>Privacy and security concerns</td>
<td>Problems using computer (disability, lack of skills etc.)</td>
</tr>
<tr>
<td>No motivation to use data available in system</td>
<td>Future under-funding of maintenance and development</td>
<td>IT availability issues – no Internet connection, no computer or Internet at home etc.</td>
</tr>
<tr>
<td>Cyber attack – system blocked</td>
<td>Unequal treatment of normal and ‘e-patients’</td>
<td></td>
</tr>
</tbody>
</table>
B. Refined application of the PENG model

For the most part, this project has followed the PENG model as described in Chapter III.C on page 23. However, additional efforts have been made to systematise the benefits using influence diagrams (Howard and Matheson 2005). It can be argued that this approach allows further analysis to quantify the actual effects of EHR or enable comparison and meta-analysis with similar systems elsewhere.

An excerpt from the full decision tree is presented in Figure 11. The main difference between the structured tree approach described by the PENG method and the technique used in this project is the underlying principles of how the tree is built. The PENG model chooses to group initially identified benefits according to ‘what goes together’ and separate benefits into lower level categories using the verb ‘need/demand’. For example, ‘increased benefits for patients’ demand ‘shorter waiting lists’, ‘better information’ and so on.

On this project, the benefit tree was constructed by comparing the desired future situation, where the provision of diabetes care is achieved with the aid of a fully-functional EHR, with the current situation. The path of change was built in a logical manner as initial changes gave rise to additional and more specific benefits. The manifestation of benefits followed the expected causal relationship, which was agreed by the broad range of experts that took part in mapping out the benefits. This exercise was repeated until measurable/quantifiable benefits could be described for each end-branch of the tree. During a subsequent phase, similar branches that sprouted along the same path were regrouped, while maintaining all similar/repeated benefits if their origins were described along different paths.
Figure 11. Excerpt from EHR benefit tree
To exemplify this process, EHR will deliver benefits to the ‘provider’ through improved patient-doctor communication which will, in turn, increase both patients’ and physicians’ knowledge of specific medical problems. Here the two paths diverge to follow separate chains of events, even though some of the measurable benefits may be identical for both branches. In the case of ‘improved patient compliance’, a possible justification stems from the patient’s increased awareness of their medical condition. Alternatively, more knowledgeable physicians can provide higher quality care, including more appropriate treatment plans, or are able to better explain issues to individual patients.

As illustrated above, the benefit tree can be used to reflect a traditional hierarchical relationship and to enable an analysis of more complex models using many-to-many relationships at different levels of the causal chain of the benefits, which have been maintained in this application. Eight different distinct measurable benefits (numbers 1–8 in Table 3; see below) were identified for patients, while at the same time it was also possible to describe 42 different causal routes that are able to deliver the benefit labelled ‘avoided decrease in salary’.

In final calculations, each benefit is only counted once. However, the predictive assessment of benefits related to EHR is not dependent on how the benefits are created as long as there is no duplication in the calculations; the separation of benefit-creation pathways becomes important once follow-up valuation is conducted. The benefit development process enables comparable repetition if the benefits are actually achieved and especially if it is possible to use real data to calculate the end result. This approach also enables duplications to be avoided in counting benefits which may implicitly be comprised of similar outcomes.

It can be argued that when assessing the benefits of ICT investments for a complex solution such as a nationwide health information system, the possibility to follow the logic of benefit creation using such an epidemiological approach is very important. Such investments are most probably made as a series of separate decisions, which calls for a continuous mutual understanding of what was initially anticipated, what has actually been realised and what could potentially be achieved in future. As previously mentioned, the approach described in this project enables, by repeating the evaluation over time and thus improving the model, decisions to be made in complex situations. It also makes it possible to conduct separate focused studies/analyses of specific sub-branches to further challenge the reliability and validity of the model in terms of both benefit realisation and subsequent calculations.

There is an infinite number of ways in which benefits may proceed, but at the same time there is almost a finite list of results that can be obtained from EHR (see Chapter V.A.1). In order to better identify relationships between benefits and potential results, it is useful to visualise the net of benefits on a map which, in this project, took the form of a decision tree.
C. Calculations and results

1. Evaluation of benefits

In the case of every benefit, an indicator was also identified to measure that specific benefit. This means that each manifestation of a benefit was directly related to a certain change in the underlying indicator or indicators. Although the indicators were identified on the basis of expert opinions, some were relatively universal and thus applicable to several benefits. The monetary values of specific benefits used in the calculation are presented in Appendix 2.

Table 3. Benefit and benefit indicators

<table>
<thead>
<tr>
<th>BENEFIT</th>
<th>MEASUREMENT INDICATOR(S) OF BENEFIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Lower legal costs</td>
<td>Volume of complaints/complications; cost of legal cases</td>
</tr>
<tr>
<td>(2) Less time spent on complaints</td>
<td>Volume of complaints/complications; value of time</td>
</tr>
<tr>
<td>(3) Saved time on going to doctor</td>
<td>Volume of specialists’ &amp; GP’s visits; value of time</td>
</tr>
<tr>
<td>(4) Saving transportation costs</td>
<td>Volume of specialists’ &amp; GP’s visits; costs of transportation</td>
</tr>
<tr>
<td>(5) Avoided decrease in salary</td>
<td>Diabetes patient’s average wages</td>
</tr>
<tr>
<td>(6) Avoided co-payments of treatment</td>
<td>Volume of specialists’ visits; volume of prescriptions; self-financed visits; non-reimbursed visits and medicines</td>
</tr>
<tr>
<td>(7) Avoided time spent with poor health (value of life increased)</td>
<td>Volume of complaints/complications; value of healthy life (or WTP not to be with poor health)</td>
</tr>
<tr>
<td>(8) Shorter waiting time</td>
<td>Length of queue; value of time</td>
</tr>
<tr>
<td>(9) Shorter ALOS</td>
<td>ALOS; per diem</td>
</tr>
<tr>
<td>(10) Saved doctor’s time</td>
<td>Doctor’s &amp; nurse’s wages; doctor’s &amp; nurse’s working hours</td>
</tr>
<tr>
<td>(11) Saved cost of treatment</td>
<td>Volume of specialists’ &amp; GP’s visits; limit prices</td>
</tr>
<tr>
<td>(12) More services</td>
<td>Volume of specialists’ &amp; GP’s visits; limit prices</td>
</tr>
<tr>
<td>(13) Saved laboratory test &amp; other materials</td>
<td>Volume of analysis &amp; tests; cost of analysis &amp; tests</td>
</tr>
<tr>
<td>(14) Saved cost of visit</td>
<td>Volume of specialists’ &amp; GP’s visits</td>
</tr>
<tr>
<td>(15) More tax revenue</td>
<td>Volume of tax revenue</td>
</tr>
<tr>
<td>(16) Lower cost of benefit payments</td>
<td>Volume of sick benefit payments</td>
</tr>
<tr>
<td>(17) Increase in GDP</td>
<td>Volume of tax revenue</td>
</tr>
<tr>
<td>(18) More foreign money for research</td>
<td>Volume of foreign funding</td>
</tr>
</tbody>
</table>
2. Results

This chapter illustrates the results using annual net benefit and cumulative net benefit. The latter figures were chosen on the basis of prevalence. As these figures are mostly used in this kind of study, it is possible to compare results with previous studies done worldwide. In addition, the potential distribution of costs and benefits is also provided below.

Before presenting these figures, it is necessary to make an important disclaimer. The primary purpose of this project was to develop a framework methodology to estimate and measure the future costs and benefits of the Estonian Electronic Health Record System. The following calculations only represent the first validation exercise of this methodology and as such are based on expert opinions rather than direct empirical measurement of the EHR’s implementation. This is a goal for the next project in line, which will then enable the methodology to be validated and evidence for policy guidance in regard to EHR implementation to be generated. However, it can be argued that the general direction of the outcome of this cost/benefit analysis is plausible, since the assumptions were made on a conservative basis with the natural threat of a bias towards the positive.

Another important issue to bear in mind is the fact that only diabetes and Type II diabetic patients were used for benefit calculations (see Chapter IV). While they arguably represent the potential benefits of a nationwide EHR, the validity of this assumption should be verified in future analysis.

Net benefit is the most important measure of any socio-economic analysis, as it enables you to determine when the expected benefits will exceed the costs involved. The details of the net benefit and its calculation are presented in Appendix 2. The values of annual benefits and costs for each year are presented in Graph 1. It can be seen from this graph that the estimated annual net benefit will be realised in 2010. From then on, the annual benefit will be even more substantial and increase every year, showing a strong and sustainable positive effect. The growth of annual benefits from 2010 to 2014 will be induced by the increasing number of e-health application users as their potential benefits gradually appear. The growth rate of the annual benefit will decline after 2014, since all of the potential benefits will already have emerged to some extent as a result of the multiple e-health services available to stakeholders. The period of increasing costs and non-existing benefits up to 2010 can be explained through the need for a large initial investment and the necessary implementation activities of the applications. This period also included intense planning and development, which manifested itself in the high annual costs in the period up to 2008. From 2010 onwards the annual costs will attain stability.
The aggregation of annual costs and benefits to cumulative values indicates the overall socio-economic impact over time. Estimated cumulative costs and benefit are presented in Graph 2. EHR will reach a positive cumulative net socio-economic benefit as early as 2010. The logic behind the rapid increase in cumulative benefit is the fast positive growth of annual benefits with a respective decrease in annual costs. The main benefits of growth include increased tax revenue, an avoided decrease in diabetes patients’ wages and avoided sickness benefit payments. The cumulative cost curves increase slowly throughout the life cycle. The main costs are related to investments and maintenances activities.

Graph 2. Estimated cumulative costs and benefits
Graph 3 indicates the distribution of e-health costs and benefits between patients, health care providers and society. It can be seen that as much as 65% of costs are borne by health care providers, with the remaining costs covered by society. The high costs of health care providers are mainly due to the investments required in e-health applications and the subsequent need to maintain the system. Despite all stakeholders having net benefits, the respective benefit distribution does not match the allocation of costs between stakeholders. With the highest percentage of all of the costs made to build and maintain the e-health system, health care providers shall be entitled to only 6% of the total net benefit, which is equal to the benefits attributed to patients. The main beneficiary, receiving 88% of all potential benefits, is society. This is mainly due to increased tax revenue emanating from the fact that people are healthier and able to be active participants in the workforce.

Graph 3. Distribution of costs and benefits
VI. DISCUSSION

The following are general remarks regarding the technical implementation of the project.

Overall project implementation

The focus of the project was the Estonian Electronic Health Record System (EHR) as a system enabling the exchange of electronic health data. As such, EHR is an integrated system that enables the exchange of health-related data between provider information systems and health care sector registries. The assumption is that such a platform will help to improve the quality of patient care and planning, as well as better monitoring of national health policies. One of the main benefits of implementing such a health information system is that it will enable people to become better involved in the decision-making processes related to their health issues, thus improving their quality of life. Implementing e-health services is also expected to decrease health care costs. The single provider-based approach which has been prevalent to date, where patient health data is kept isolated in different health care organisations, will be replaced by a patient-centric health care model. This means that patients will be better informed about their health data, and by using technology it will be possible to involve experts in diagnostic and treatment processes regardless of time or place.

The project was designed to develop a methodology to assess the potential impact of EHR as described above. Although a nationwide mapping of costs and benefits demands sacrifices in terms of the detailed accuracy of quantifications, it provides a valuable general overview of the pre- and post-implementation ‘state of affairs’ in the scope of a nation’s health care system. In addition, it is possible to provide valuable information not only to the developers and funders of the project, but also primary users e.g. medical personnel and patients. As a comprehensive analysis of EHR had not previously been carried out, this project presented a unique perspective on the implementation of electronic health services.

The project succeeded in building the framework and indicators for impact evaluation of the implementation of EHR as well as in performing initial validation of the methodology using a diabetic patient group as a test case. Policy recommendations arising from a policy workshop are presented in the last chapter.

Through the inductive process of evaluating EHR using a modified PENG model, a theoretical construct on the realisation of the benefits could potentially be formed at a later stage. However, this can only become a testable theory once longitudinal post-implementation analysis has been conducted.

The present and future of EHR

The Estonian eHealth Foundation is the developer of EHR, which has been up and running since January 2009. However, at the time of writing this report, only core services – electronic health records, e-bookings, digital imaging and digital prescriptions (see chapter II B.5 for more details) – had been implemented. The full potential of EHR will be achieved once follow-up services are rolled out. The main
functionalities that have been planned are: (1) decision support tools, to increase the quality of patient care; (2) e-paramedics, to integrate digital data exchange between ambulance crew and EHR; (3) e-school-health, to integrate the monitoring of children’s health and immunisation data from activities at school with the dataset of family physicians; and (4) personal health records with improved functionalities for better personal health management. It has been assumed that these services will be implemented during the period that the benefits for the cost/benefit analysis were estimated.

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How EHR creates value for diabetes care

• Using EHR to coordinate laboratory visits with GPs and eye fundus examinations, there is no need for additional visits to GPs or specialists. Additionally, EHR allows former tests and eye fundus images to be compared wherever acquired.

• EHR enables clinical data already acquired to be used simultaneously by different specialists, avoiding duplication in GP or specialist visits, imaging exams and laboratory tests. The availability of previous and current medication from the one source avoids adverse effects, decreases medical errors and increases patient safety.

• EHR is also used to share reports issued by clinical consultants and specialists and to request other colleagues for consultations, which can be performed in different locations depending on where the knowledge that is needed is available.

• Patients with uncompensated disease and especially patients with complications are prone to hospitalisation. For elective hospital admissions, shared information endorses the development of a glycaemic management plan with the patient before admission and the sharing of the plan between the colleagues who will be involved in the patient’s care.

• In the case of emergency hospitalisation, the information about diabetes obtained from EHR is of the utmost importance. It will lead to quicker diagnosis and adequate treatment of the condition, also taking the medication of the underlying disease into account.

• Discharge from hospital can take place sooner because case summaries, recommendations for further medication administration and plans for follow-up visits to be conducted after discharge will be available online for both patients and health care teams managing individual patient care.

Reliability and validity of the chosen approach

The reliability of a study determines whether the same outcome could be achieved if another set of researchers were to conduct the same analysis. It can be argued that since the qualitative aspects are subjective in nature, they are prone to manipulation. Threats to reliability lie in the human factor involved. As the benefit tree is implemented and respective quantifications made by the same group of people, a skewed view of the overall situation could emerge. In short, by manipulating the set-up of the research team, the results obtained for the e-health project could vary. However, as
external experts are used to validate both the findings and the benefit tree, reliability is increased.

Moreover, as all of the qualitative measures were discussed between researchers, only the most relevant ones were agreed upon for inclusion in the analysis. As the team of experts that interpret and analyse the results came from different types of organisations affected by the e-health system, they each provided a unique viewpoint that enriched the overall view of the subject.

In short, reliability is a possible shortcoming in this study, but attempts have been made to address this by including external experts. This paper provides significant author triangulation in addressing this issue.

During the project we also considered the validity of an adapted PENG methodology for the evaluation of a matter as complex as EHR.

External validity is the degree to which the conclusions derived in a study are representative beyond the existing setting of the particular case. Obviously the situation described and evaluated in Estonia cannot be identical to others elsewhere in the EU. However, this study provides not only a good perspective on the costs and benefits e-health can include for various stakeholders, but also a model with which to evaluate a comprehensive e-health project. Choosing to conduct non-probability sampling and evaluate the costs and benefits using the example of diabetes can be criticised for lack of ability to be generalised on a broader scale. However, the possibility of drawing an exhaustive sample in this case is highly debatable and the ultimate goal of exemplifying the use of an evaluation method is achieved. In short, external validity is restricted due to the nature of the study, but useful lessons can nevertheless be derived in the process of evaluating an e-health project.

Construct validity measures the appropriateness of the results to the underlying concept of measurement. In this case, the method chosen could be the source of criticism. Hermansson et al. (2003) also concluded that the model is primarily developed for practical use and has limited scientific value. However, as the aim of this project was to provide a practical tool for the evaluation of supporting policy makers and to aid in evaluating real investments, its theoretical validity is somewhat weaker – the reason being that it takes a back seat to the focus on case-specific conditions in each separate project evaluation. Furthermore, it may be argued that the exemplification or quantification made for each qualitative benefit could have been done differently, leading to another result for the evaluation. However, as each of the benefits has been described extensively by explaining the rationale behind the expression of a benefit, adequate pre-operational explanation of constructs is achieved. Moreover, the use of the benefit tree method aided in making sure that each benefit was identified and mapped appropriately. Finally, using a group of people from various groups of stakeholders and differing levels of expertise and experience will have minimised the risk of excluding a relevant cost or benefit from the analysis.

As Mathison (1988) states in discussing data triangulation, using various sources of information benefits the validity of the overall work. The data used therein included, in addition to the panel of experts, documented data about costs, former literature on the subject and the opinions of an unbiased board of advisors.
VII. CONCLUSIONS AND POLICY RECOMMENDATIONS

The conclusions drawn and policy recommendations made as a result of the project are based on the discussions that took place as part of the second workshop of e-health partners (26.11.2008 and 12.04.2010) at which the project research team (the Estonian eHealth Foundation, the PRAXIS Centre for Policy Studies and the Tehnomeedikum of Tallinn Technical University), the Ministry of Social Affairs, the Estonian Health Insurance Fund, hospital managers, doctors and IT development specialists were represented.

Conclusions related to methodology

ICT options in the field of health care have been studied and implemented in Estonia since 1973, when a special centre was established as part of what was then the Ministry of Health Care. By the 1990s many hospitals were working with information systems supporting their financial accounting. ICT solutions have now been implemented in a targeted manner in the provision of health care services for more than 10 years, and 80% of employees working in the field of medical services today use computers.

The pertinence of this area at present can be seen in the fact within three months of the official launch of the digital prescription service, 75% of all prescriptions were being issued digitally. Although final implementation of the project had to be postponed for technical and organisational reasons, such active use is indicative of the fact that people are prepared to use ICT solutions as part of the system.

It is important to look at the provision of health care services and system improvement through ICT from three perspectives: those of the service provider, the patient and society. It is also important to accept that different parties see the same thing from different angles.

It is assumed that information technology will not only lay the foundations for completely new products and services in health care, but also that it will create new ways of providing and managing services. This will result in changes to the way that work and business is organised, and the rules that govern how organisations operate are already changing – as has already been the case in banking, the media and trade. At the same time, we have to gradually change the way we look at things; the new generation is certain to embrace the new approach.

Despite the amount of work involved in determining the benefits of EHR, it must be conceded that we were unable to produce monetary value for all of the benefits, even though by their nature they may be important objectives for which to aim. Nevertheless, the systematic description of potential benefits created in the course of the project, i.e. the benefit tree should give us some idea of the ways in which these benefits should emerge and the connections between them so that even if a single case (such as ordering a test or issuing a prescription) takes longer than expected, we can still analyse the benefit that will bring elsewhere – for example, improved quality or more responsive treatment. We are looking at the effect of the exchange of information.
While the aim of the project was to develop indicators and methods, to implement them throughout the country will require a follow-up project to be launched and for us to think about where and how we can begin gathering data. The objective of this project ends with theory. A framework has been created in which we can place the initial figures. If we find that it is worth pressing on with, the initiative for the broadening of the pilot programme should come from the likes of hospitals, private associations and the state.

Based on initial assessment, the framework that has been developed can be used anywhere in the world for all diagnosed diseases.

**Conclusions and recommendations related to the successful implementation of EHR**

A key expectation in terms of the population is that they will become much more active and careful in regard to their health. At the same time, in order to increase patient-centredness the Patient's Portal must be developed further and not merely become hospital-centred, but health- and wellbeing-centred.

It is also important that doctors talk to their patients in a language they can understand. The health care information system can be of help here, e.g. in providing them with important information either before or after visiting their physician. People must become beneficiaries, and what those benefits are – the services and what the e-system can truly do for them – must be explained to them.

Ideally, EHR and the additional services established on the basis of it should enable the measurement of the overall ‘health result’ produced in the course of treatment, not simply assess individual parts of the treatment process. The current system does not enable this, and as a result mostly only individual cases are paid rather than the overall treatment result. Successful implementation of EHR would create a greater opportunity to motivate service providers based on results. The introduction of motivation mechanisms (such as performance bonuses) could take place on a stage-by-stage basis, but first and foremost the conditions need to be created for the implementation of the system. For example: the ‘result’ of the successful treatment of the health problem of a specific person as the sum of the actions of various service providers forms the basis for the payment of performance bonuses. The question of how to distribute the bonus between the providers who contributed to it is the future of the funding of health care services.

An important objective in the proper implementation of EHR is reducing the volume of unnecessary contact. Maintaining the level of quality of treatment is the key measure here. To this end, we must be able to transfer some services in patient contact to the digital level. Both mechanisms need to be used to motivate this process: the results-based one and the provision of services motivated through direct support without meeting with patients. Another option for this is the standardisation of processes and activities, which involves some transfer of responsibility from specialist doctors to GPs, and from there to nurses and finally to the patients themselves.

The long-term aim of the organisation of health care is to make treatment more home-based, i.e. to gradually reposition services from hospital inpatient departments
to outpatient treatment, and from there to the primary level and eventually home nursing and the patient’s home with the support of ICT.

In order for innovation to be more actively adopted in health care, including the use of ICT, there must be demand for services which can be more effectively implemented through ICT solutions. Financing must support a new approach. The experience of other countries shows that before a system begins operating and benefitting the parties involved, money must be invested in it, with additional money possibly needing to be invested to motivate people.

Communication between the parties involved must also change. Access to information has improved and new services have been launched which in the past were simply not able to be provided. The problem is the paradox that the way in which many of the parties communicate needs to change at the same time.
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