EHR IMPACT
European Commission, DG INFSO & Media
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Report on

The socio-economic impact of the Hospital Information System in National Heart Hospital-Sofia, Bulgaria

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About EHR IMPACT

The EHR IMPACT study was commissioned by DG INFSO and Media, unit ICT for Health, and will result in ten independent evaluations of good practice cases of interoperable electronic health record (EHR) and ePrescribing systems in Europe and beyond. The goal of the study is to support ongoing initiatives and implementation work by the European Commission, Member States governments, private investors, and other actors. The study aims to improve awareness of the benefits and provide new empirical evidence on the socio-economic impact and lessons learnt from successfully implemented systems.

Full project title

Study on the economic impact of interoperable electronic health records and ePrescription in Europe

Number and title of deliverable

This report is deliverable D2.3c of the EHR IMPACT study. It addresses the socio-economic impact evaluation of the hospital information system at the National Heart Hospital Sofia, Bulgaria.

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Hospital Information System at National Heart Hospital Sofia

Socio-economic impact and lessons learnt for future investments in interoperable electronic health record and ePrescribing systems

Bulgaria

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Bonn, November 2008

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Disclaimer

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Abbreviations

A&E	Accident and Emergency
ADT	Admission-discharge-transfer
CBA	Cost Benefit Analysis
CIS	Clinical Information System
CPOE	Computerised Physician Order Entry
CSIEMD	Common Standard for Information Exchange of Medical Data
DRG	Diagnosis-Related Group
DSS	Decision Support System
EHI	eHealth Impact study
EHR	Electronic Health Record
EHRI	EHR IMPACT study
ECG	Electrocardiogram
EPR	Electronic Patient Records
GP	General Practitioner
HIS	Hospital Information System
HPO	Healthcare Provider Organisation
HR	Human Resources
ICT	Information & Communication Technology
IS	Information system
NGO	Non-Governmental Organisation
NHH	National Heart Hospital Sofia
NHIF	National Health Insurance Fund
PACS	Picture Archiving & Communication System
RFP	Request for Proposal
SOA	Service-Oriented Architecture
WTP	Willingness to pay

EXECUTIVE SUMMARY

The Hospital Information System at the National Heart Hospital Sofia (NHH), Bulgaria, is analysed as one of ten implemented and ongoing European good practice cases in the context of the EHR IMPACT (EHRI) study. EHRI investigates the socio-economic impact of eHealth utilisation, with specific focus on interoperable Electronic Health Record (EHR) and ePrescribing systems in Europe.

The NHH is the biggest hospital specialising in cardiology and paediatric cardiac surgery in Bulgaria. It is a tertiary care facility providing all necessary services in the field of cardio vascular diseases and neurology for children and adults, including inpatient and outpatient care. NHH's rehabilitation unit is at a separate site in Bankia, some 25 km from Sofia. This entirely state-owned hospital has some 320 beds and is run by a team of about 900 employees who served approximately 48,000 inpatients and 15,000 outpatients in 2007.

The hospital-wide information system was initiated in 2001. Implementation of the outpatient modules was in 2003, followed by inpatients in 2004. The HIS assists the healthcare teams in their work along the whole patient journey. The backbone of the system is the electronic patient record (EPR), facilitating real patient-centred care. The EPR consists of information on health status, chronology of diagnosis, therapy at the hospital, examinations and analytic tests and results, as well as alert information, such as allergies. The HIS also supports diagnosis and procedure codification, billing and invoicing, calculation of patient's healthcare costs and stock management. Each of these is connected to the EPR. Increasing steadily, the number of times HIS records are accessed has reached over 30,000 per year.

Efficiency and improved quality of care are the most prominent benefits of the HIS. Efficiency gains include improved productivity for coping with increased demand, avoided labour costs, and reductions in operating costs. Patients benefit mainly from the improved timeliness and quality of care, including reduced risk of errors. Healthcare professionals mostly profit from being better informed, investing their time in activities more closely related to their job, and better work satisfaction. The identified costs of HIS include the financial investment for ICT, but also any negative impacts of implementing the system. The latter include non-financial effects, such as irritation to staff during the phase of change, as well as forgone income from avoided admissions, and increased time requirements for certain procedures due to a regulation-led duplication of recording practices.

The socio-economic evaluation, based on cost benefit analysis, shows that a significant net benefit margin is achieved from year five onwards, the third year after implementation of the first functionalities. This development is some two to three years shorter than average for EHR systems. It has to be stressed that the net benefit is not a measure of financial returns, but of the value of all positive and negative effects. The steady decrease in costs is shortly interrupted by two humps in 2003 and 2008. While the first reflects the bulk of development and costs including hardware and network infrastructure, the second one is smaller and reflects the replacement of the server infrastructure to accommodate increased technology demands. A positive cumulative net socio-economic benefit is already achieved in 2006, year six of the lifecycle and in the fourth year of implementation. This short gap between the first year of realised annual net benefits and cumulative net benefits is consistent with observations at other sites and can be attributed to the relatively fast increase in the annual net benefit margin. The cumulative cost curve increases gradually over the whole lifecycle, slightly accelerating in 2005 and 2008. The rate of increase of cumulative benefits stabilises after 2005, at a rate significantly higher than the stable rate of increase in costs. This is a critical relationship confirming the long term economic sustainability of the HIS at NHH.

The annual net benefit to cost ratio, the relationship between the net socio-economic impact of the evaluated system to the costs, turns strongly positive with +0.45 at year five, rising to

an impressive +5.50 in 2010, year ten. The cumulative ratio increases steadily over the lifecycle and turns positive in 2006, year six. By 2010, the cumulative net benefit to cost ratio reaches +1.92, meaning that for every BGL 100 worth of negative impact, there are BGL 292 worth of positive impact. This indicates an overall socio-economic return, albeit not purely financial, from the HIS and NHH of about 190% over a lifecycle of 10 years.

The lion's share both in costs and benefits accrues to NHH, with about 81% and 94%, respectively. Healthcare providers as individuals bear approximately 9% of the entire costs. Their benefits account for only around 4% of the total benefits, but due to the difference in size between total costs and benefits, this still leaves them with a positive net impact. Third parties, in contrast, are the only group that has constantly negative net benefits. This is explained by the knowledge creation and transfer costs from a prototype system in the years before implementation. These costs were borne by a charity donation.

Unlike most comparable sites, the financial classification of benefits shows that 58% of the benefit, over BGL 9.7 million, is extra released finance. This is compared to 45%, or just over BGL 2.5 million, of extra financial costs related to the investment. This means a net financial return from a social planner's point of view of BGL 7.2 million over a period of 10 years. This remarkable development results from a rare bundling of investments, showing that the combination of systems for clinical and supportive processes can lead not only to a positive socio-economic impact, but also to a net financial return. Most of this net financial return is for NHH, with NHIF enjoying a small share of about 0.5% of extra financial benefits from avoided admissions. Further, a net value of resources of over BGL 4 million can be potentially redeployed.

The annual net socio-economic benefit from the system at this point in time has reached a stable size and will continue to improve the cumulative position. The real future potential, however, lies in the immediate and planned future developments of the system, already being undertaken.

Regarding the EU policy theme of transferability, there is an advantage in working with a vendor, rather than developing in-house at NHH. Transferability has been a constant issue throughout development. The vendor, Gama/Sofia Ltd, has managed to separate the general components from the specific needs of NHH, thus making the system a replicable product.

The experience of NHH provides a number of lessons to be learnt for future investments. These include the importance of integrating different systems into a comprehensive, EPR-centred HIS; providing inter-system interoperability; an implementation approach of gradual extension of the system in scope and scale and continuous, interactive training; and creating an information culture in which users ask for more.

Even though the results achieved at NHH are above average, the HIS at NHH illustrates in a profound way what interoperable electronic health record systems can do for healthcare provision in a hospital environment. The three main factors driving the socio-economic success and the financial returns are that (1) the investment was imbedded in the overall development strategy of the hospital, not an add-on project for pioneers, (2) the effective engagement of healthcare professionals in the development process, ensuring usability and usefulness of the system, and (3) the bundling of investment in clinical and non-clinical applications, which leads to clinical systems being financially covered by finance released from within the organisation.

1 Background

1.1 Health system setting

The national health policies and programmes developed and implemented by the Bulgarian healthcare system are defined by the ministry of health and its 28 decentralised regional healthcare centres. These authorities are also responsible for defining the specific objectives and priorities of the health system, and are in charge of emergency care and public health activities. The public health system was restructured in 1999 and took on additional functions related to public health protection and promotion.

Healthcare institutions in Bulgaria are differentiated between primary and outpatient health institutions, hospital care, and emergency care services. The primary and outpatient health organisations include single and group practices for primary healthcare, i.e. general practitioners (GPs), and single and group practices for specialised medical care comprising health facilities that provide specialised ambulatory care within separate medical subfields.[1] Hospital care is provided by public and private health facilities, divided into multidisciplinary and specialised ones. National hospitals, both general and specialised, are state-run. Interregional and regional hospitals are joint-stock companies with one part of the capital owned by the state and the other owned by the local municipality. Local hospitals are trading companies owned by the municipalities in which they are located[2]. The municipalities are also responsible for specialised paediatric and gynaecological hospitals, as well as for specialised regional mental health institutions[3]. Emergency care services cover the whole of the country and each of the 28 administrative districts has a Regional Centre for Emergency Care.

The Bulgarian healthcare system is funded through several sources: In 2003, out-of-pocket payments accounted for the largest share in the structure of total health expenditure (44.8%), followed by compulsory health insurance expenditure (28.1%), government budget expenditure (taxation) (26.4%), external sources of finance (donors, NGOs) (1.0%) and Voluntary Health Insurance expenditure (0.7%).[4]

In 1999 the National Health Insurance Fund (NHIF) was established as a semi-independent institution for compulsory health insurance. It is responsible for managing the financial resources in accordance to the 1998 Health Insurance Act and the National Framework Contract. NHIF is also in charge of guaranteeing access to healthcare services for the insured population.[5] The operational activities are executed by 28 Regional Health Insurance Funds. The NHIF is primarily funded by payroll-based contributions. A system of contracts regulates the reimbursement of healthcare providers by NHIF. Each Regional Health Insurance Fund enters into a contract with the health institutions (public or private) in the region, provided that they satisfy the requirements of the National Framework Contract. The NHIF then funds the entire healthcare network for outpatients and those hospitals with which it has stipulated a contract through its regional subsidiaries. Municipalities partially finance their own healthcare facilities. They also receive additional resources from the central government, which they use for funding the non-contracted hospitals within their territory. Private co-

[1] European Observatory on Health Systems and Policies (2007): Health Systems in Transition. Bulgaria. Health System Review. Vol. 9, No. 1. Copenhagen: World Health Organisation, Regional Office for Europe., p. xvii, Available at: http://www.euro.who.int/Document/E90059.pdf
[2] ibid. summary: p.6-7
[3] ibid. p.20
[4] ibid. p.35
[5] ibid. p.20

payments for services going beyond those covered by the contracts with NHIF and its regional offices are allowed and take place on a regular basis.

Since 2000, reimbursement follows clinical pathways defined by NHIF for that purpose. This system is seen as a first step towards the eventual introduction of diagnosis-related groups (DRGs). The clinical pathways reimbursement levels only cover current expenditure. The pathways prices have no allowance for capital expenditure, such as depreciation and amortisation costs. Given the low margins, internal financing is only an option for investment items of a value of BGL 2,000-3,000 or less. Decisions on larger investments depend on finance coming from the government.

1.2 The place of EHR, ePrescribing and interoperability in the relevant eHealth strategy setting

EHR, ePrescribing and interoperability do not play a significant role in the Bulgarian healthcare system. Concerning the use of information technologies in health and healthcare, Bulgaria is at the bottom end of growth among the new EU countries. It neither has a centralised data store of electronic medical information about patients, nor a system for delivering the information needed for analysis, planning, and executive reports to the ministry of health electronically.

However, the importance of further eHealth development has been recognised. Objectives in this area have already been defined and include improved quality of healthcare, qualifications of the health professionals, and application of innovative medical technologies. As a result, the government has scheduled up to 3.5% of the 2007 healthcare budget for the introduction of electronic technologies.[6]

In order to reach the objectives, projects involving implementation of eHealth cards, hospital information systems, personal health records, and web-based applications for use by patients have priority and are part of the action plan. The action plan for the implementation of eHealth is particularly focusing on the introduction of electronic and patient health records and serves the practical realisation of the National eHealth strategy. Apart from a number of pilots, including one on ePrescribing, eHealth activities on the national level currently focus on the reimbursement system, not on point-of-care support.

[6] European Commission (2007): eHealth Priorities and Strategies in European Countries. eHealth ERA Report. Towards the Establishment of a European eHealth Research Area. Fact Sheet Bulgaria. Available at: http://www.ehealth-era.org/database/documents/factsheets/Bulgaria.pdf

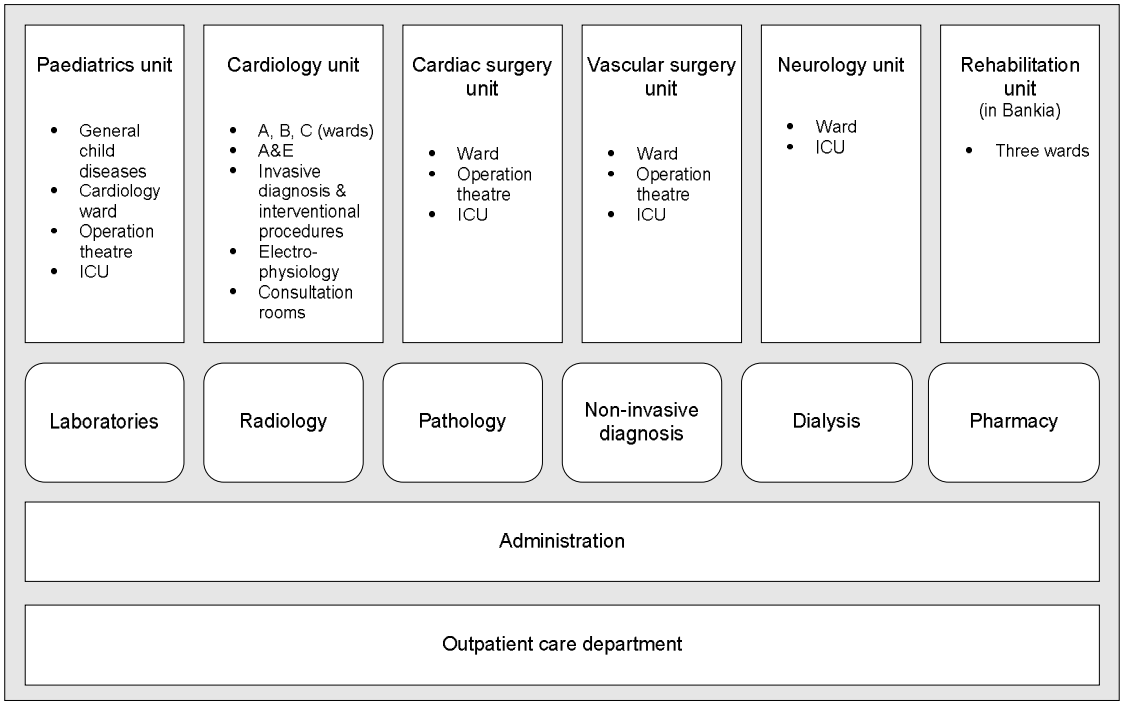
2 The EPR and hospital information system at the National Heart Hospital Sofia, Bulgaria

2.1 Organisations involved

The organisation on which this evaluation focuses is the National Heart Hospital Sofia (NHH). The hospital was established as a community hospital in 1961. In 2001, it became the national tertiary heart centre and, like all other hospitals in Bulgaria, was registered as a commercial organisation. As a hospital of national importance, it is 100% state owned. The hospital has some 320 beds and is run by a team of about 900 employees. Both the number of inpatients and outpatients has been constantly increasing since 1998, reaching some 48,000 and 15,000 patients in 2007, respectively.

The NHH is a tertiary care facility providing all necessary services in the field of cardio vascular diseases and neurology for children and adults, including inpatient and outpatient care. The hospital's mission is oriented towards the development of health promotion, and prevention, diagnosis, interventional treatment and rehabilitation of cardio vascular diseases at a national level. The NHH is the biggest hospital in Bulgaria specialising in cardiology and paediatric cardiac surgery. It is the only one that has a cardiac paediatric unit and an electro-physiology unit. The organisational structure is depicted in Figure 1 below.

Figure 1: Organisation structure of NHH Sofia



The rehabilitation centre in Bankia, a small town located approximately 25km away from Sofia, is a physically separated unit of the NHH. All post-operation patients are transferred to that unit before discharge.

There are only two other hospitals specialising in cardiology in Bulgaria, one in Plovdiv and one in Varna.

2.2 Context of the initiative and eHealth dynamic

In 1992-93, Dr. Todorov, then head of the paediatric surgery unit, and Dr. Pilossoff, then head of the paediatric department, came up with the idea to install the first three PCs in the paediatric unit of the hospital. The software system implemented was a copy of the system used at that time at the Plovdiv cardiology hospital. It allowed only basic information about clinical processes to be stored and viewed, via fairly complicated and user unfriendly interfaces. The idea to re-design the system with a view to eventually expand it to the whole hospital was born in 1998. As a beginning, a prototype system was developed for the paediatric department only. The technical specifications, however, included the requirement that the system is designed in a way that accommodates future functional and other scope extensions. This meant that the old, DOS-based, system had to be abolished.

The first release of the module-based electronic patient record (EPR) system was in place by 2000. This clinical information system (CIS) was implemented in the paediatric department, piloting the way for the rest of the NHH. The new system connected some 30 workstations and focused on storing and maintaining patients' medical data.

On 13.09.2002 Prof. Pilossoff was appointed head of the NHH, which paved the way for a hospital roll-out of the information system (IS). In November 2003 followed phase I of the implementation of the new hospital-wide information system covering registration and outpatient care. The modules for inpatient care followed in spring 2004. The department-level IS became a full hospital information system (HIS).

In parallel, commercial systems for accounting, stock control, and HR management were bought externally, made interoperable, and connected to the main HIS. The system for stock management and accounting was implemented in 2004. Medication and consumables stock management at ward level was implemented 2007. An online link for the transfer of drug orders between wards and the pharmacy is planned for the near future.

The following IT systems are already in operation at NHH:

- HIS, built around a CPR for clinical information
- "AjurL5" for accounting and hospital stock control
- "SMOBZ" for stock control in wards and departments
- "GEOCON" for Human Resource (HR) management
- "OMEKS 2000" for wage payments
- "iLab" for laboratory data
- "ACSTRE" for general administration
- "APIS" for legal and regulatory information

The following ones are planned to be implemented at NHH in the near to mid-term future:

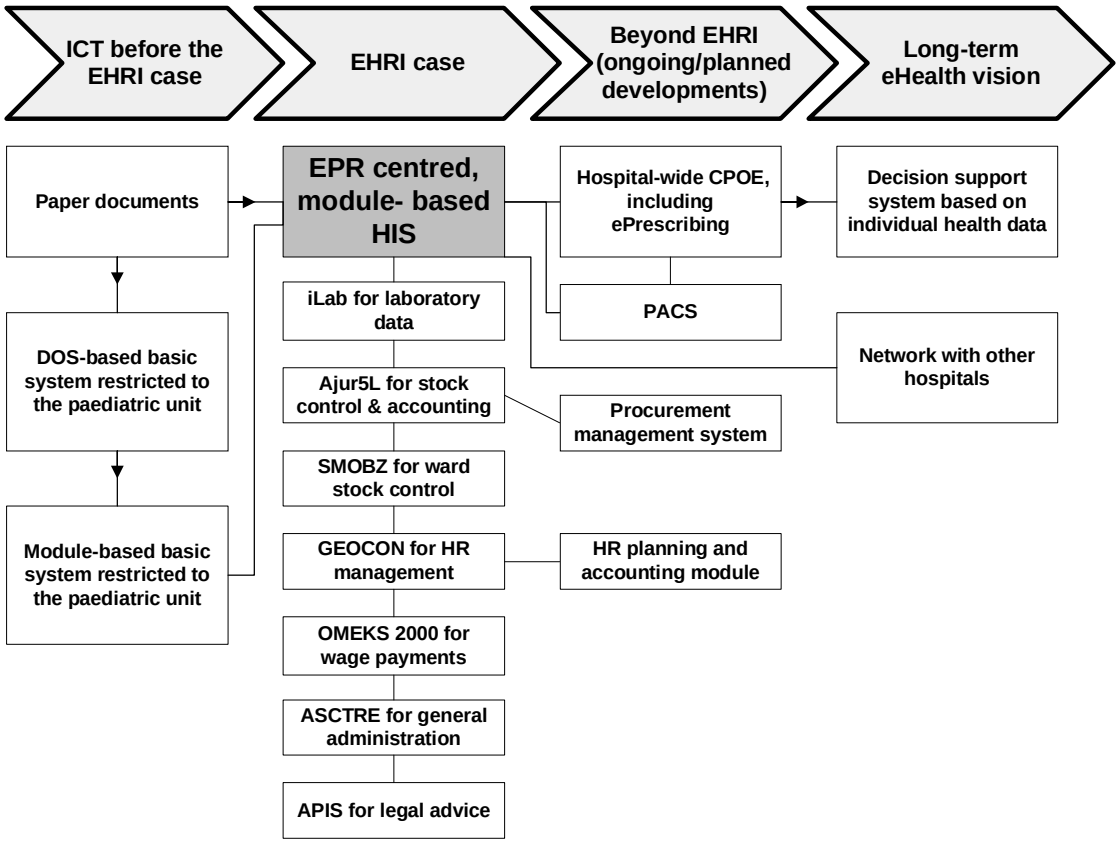
- PACS
- An ePrescribing module of HIS linking wards with the hospital pharmacy
- System for monitoring public tender requests for proposals (RFPs) and contracts, including a module for electronic procurement
- Management support in control over planned versus actual HR expenditure

Further to this, long term plans include the development of:

- A full CPOE system including ePrescribing
- Decision support systems, starting with drug prescription alerts based on the medical record of the patient
- A network between NHH and other hospitals using information systems, as well as GP and specialists practices, and external labs.

The ICT developments at the NHH follow a typical[7] path of starting small and gaining inertia until the initiative transforms itself into an eHealth dynamic of organic change and continuous development, as shown in Figure 2.

Figure 2: eHealth dynamic at the National Heart Hospital Sofia



The focus of this evaluation is laid upon HIS, since it is the system storing and administrating the medical information of patients, i.e. the EHR system. At the same time, HIS is connected and sets the backbone for all information flows within the hospital by being connected to the non-medical systems. The impact may thus not be strictly separated from HIS. In order to draw the scope of the evaluation, the impact of HIS on the work of the satellite systems is taken into consideration.

2.3 The health services affected

The HIS is essential for organising all working processes within NHH. The NHH management considered the implementation of an information system to be the only solution for meeting

[7] Found in most evaluations based on the eHealth IMPACT methodology. See www.ehealth-impact.eu

increasing demand and the associated diagnostic, treatment, administration, and statistical reporting procedures.

The services affected include all hospital activities and in particular registration, admissions and re-admissions, transfers, discharge, consultations, laboratory and other examinations, inpatient and outpatient treatment, surgery, rehabilitation, and reporting to authorities for public health purposes.

By its design, HIS does not affect health services in primary care or any other non-hospital services.

2.4 Components and functionalities

The eHealth system at the NHH Sofia consists of two parts:

- Medical IT applications (Patient Records Data Base, Departmental level IS, Laboratory IS); and
- Administrative IT applications (Stock Control and Accounting IS, Consumables IS, HR and Office IS, Procurement IS).

The backbone of both parts is the electronic patient record, which includes demographic and other administrative data and feeds the administrative IT applications. The HIS is built in a modular structure, which makes it open to various expansions in scope. In order to store the EPR and enable the organisation of the numerous hospital activities, HIS consists of the following modules:

- Registration & orientation to a consulting room
- Planning for medical check-up / internal scheduling
- Planning for admission / internal scheduling
- Patient status, chronology of diagnosis & full chronology of therapy at the hospital
- Medical check-up
- Internal & external consultation reports
- Examination & procedures; with the following examinations supported:
  - Lab tests
  - Uninvasive examinations (ECG, ultrasound, etc.)
  - Roentgenology & image diagnostics
  - Intracardial investigations (catheterisations)
  - Interventional procedures
  - Electrophysiological examinations
- Inpatient therapy, during which the following data can be entered:
  - Admission
  - Stay at a ward (anamnesis, daily patient observation & therapy, medicaments, operations, consultations, transfers, companions)
  - Discharge
- Discussion and planning for operation, operating scheduling
- Alert information, including:
  - Allergies
  - Contraindications

  - Chronic diseases
  - Further alert information, e.g. operations, immunisations, etc.
- Hospital information centre, providing information material for the entire hospital staff
- Diagnosis & procedure codification
- Patient death & autopsy
- Billing & invoicing
- Calculation patient's healthcare costs
- Reports, eReports
- Tools for integration with other systems in the hospital
- Security and system log.

ePrescribing, the first step towards a comprehensive CPOE system, is at the planning and development stage. Currently, drug orders are entered into the HIS and are simultaneously reported to the EPR and the administration systems. The information transfer between ward-level prescribing and the pharmacy, however, is based on USB sticks with the medication lists being physically carried by the nurse. The information is transferred to the pharmacy ICT system and feedback is given via the same medium. Paper orders still have to be kept for legal purposes.

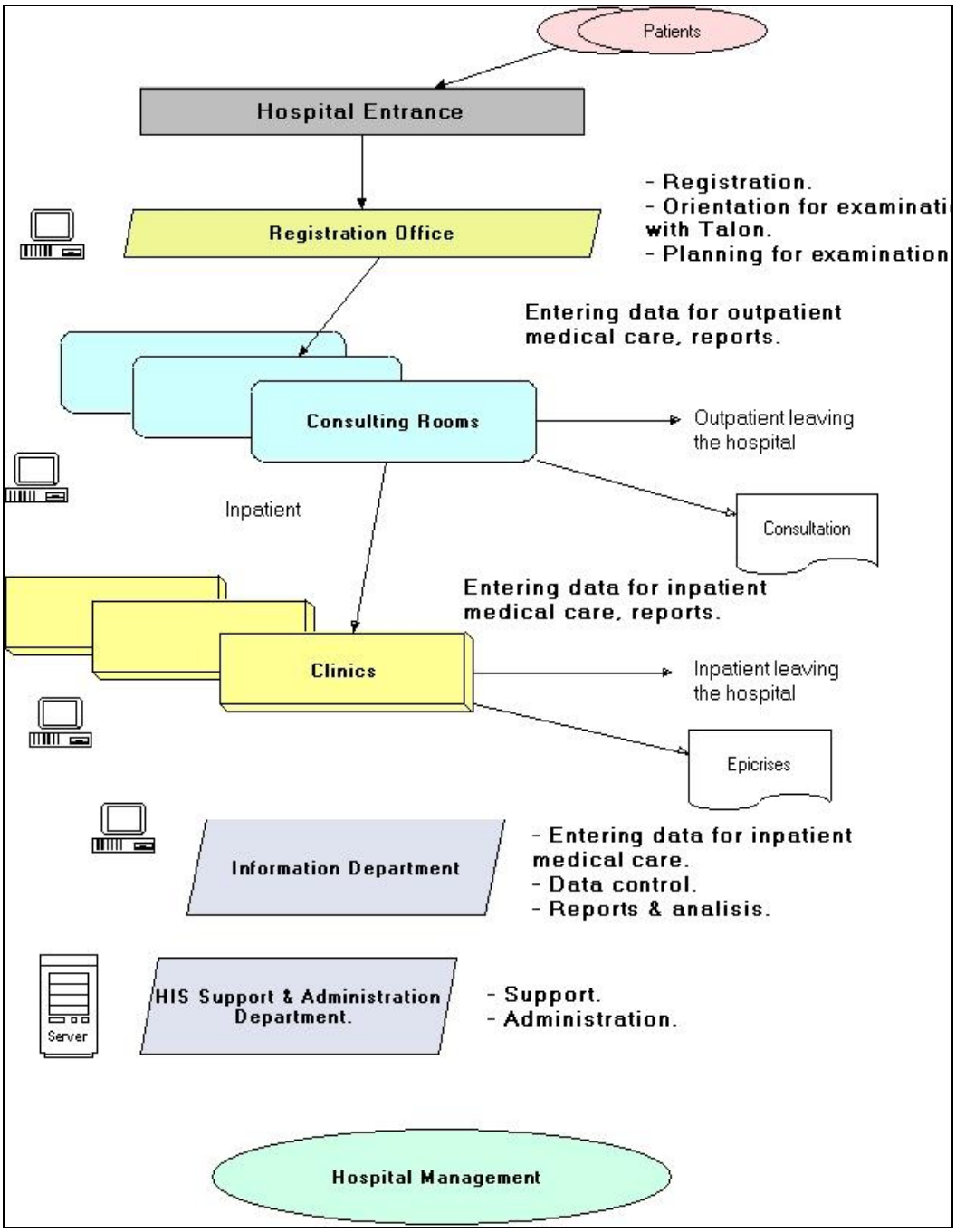
2.5 The system in practice

The system is currently used by about 460 care professionals (physicians and nurses in the hospital), 4 medical secretaries, 6 persons from management and some 200 staff members from general administration. The HIS currently stores data on about 118,000 patients, viewed and updated each time a patient is registered for ambulatory or inpatient care.

The nurses in the consulting room and the inpatient departments have an overview over the planned patients for the current day as scheduled by the registration office, which has also entered the patient-related demographic data into the HIS. The nurses add the information related to the medical check-up and, if necessary, schedule an additional laboratory or physical examination. The wards and departments are also connected to the HIS. Doctors and nurses are responsible for entering data connected with anamnesis, therapy, and further medical details. The medical secretaries present the first level of data quality control, ensuring all necessary information from diagnosis, examinations, and treatment results is entered with due care. They are responsible for supporting the medical staff in their work with the HIS.

The seamless patient journey through the hospital is made possible through linking different hospital elements, including the wards and departments, the registration office, the consultation rooms, the medical centres, management and administration, and the rehabilitation facility, as shown in Figure3.

Figure 3: HIS elements facilitating a seamless patient journey



Source: Gama Sofia Ltd.

For patients, the first point of contact in the hospital is the registration office. Emergencies are also registered. If a record for a patient whose arrival is expected exists (e.g. those patients brought in by an ambulance), the registration procedure would be prepared prior to arrival of the patient. Registration involves creating an active ambulatory visit or hospitalisation record with demographic data and initial schedule for the visit. In case of a repeat visit, the demographic details are only validated and when necessary updated.

When a patient is seen in a consultation room for an ambulatory check-up, the doctor or nurse first consults the HIS record of the patient. Both administrative information, such as where the patient is referred from and dates of past hospitalisations, and medical details, like examination and lab test results, are used to facilitate the diagnosis and treatment

decision making processes. After the consultation, the doctor or nurse enters the following information into the system and thus into the patient's electronic health record:

- Common data (date and time, place, doctor, nurse, consultants etc.)
- Accompanying documents, carried by the patient (type, date, doctor etc.)
- Anamnesis
- Physical examination (temperature, blood pressure etc.)
- Planning for new check-up or admission
- Final data (diagnosis, conclusion, recommendations, therapy etc.)

In case the patient arrives for hospitalisation, a pre-admission medical check-up is performed, and additional relevant data, from referral letters through diagnosis, test and therapy results, to the discharge letter, are entered into the system. The data is then checked for completeness by the medical secretaries and made available for statistical and reporting purposes. Of course, it also stays available around-the-clock for medical purposes in case the patient needs to be re-admitted. Archives are kept and used electronically, yet paper print-outs have to be stored in addition in order to comply with legislation.

All documents connected to the patient's therapy at the hospital, like consultation reports, protocols, epicrisis etc., are prepared by the HIS on the basis of the entries by doctors and nurses. Where possible, the data are stored in a structured form. In some cases, however, data needs to be stored as a free text. Every document can be edited before printing and it is always saved in its edited form. Every copy can be issued and/or sent via email.

Based on the patient records and the data about the outcomes of each hospital unit, the cost of each hospital service and each patient's hospital stay can be calculated. These results are reported to management for further analyses. A long-run opportunity from this is to calculate DRG rates for a potential future reimbursement system.

The HIS is developed in accordance with the requirements of the Bulgarian legislation in the field of healthcare and provides full reporting capabilities for all external entities. It allows reporting according to clinical pathways for reimbursement purposes to the NHIF. All hospital activities are reported monthly to the ministry of health[8], the national centre of health information[9] and NHIF[10] via an XML file generated by HIS.

The ward stock management system is directly linked to the EPR. When consumables are used for the patient, the information is entered into the HIS and simultaneously sent to the stock management system. So, information on the ward inventory is always available and up-to-date. Since the stock management system has a reporting mechanism that operates as soon as the orders posed are exceeding the allowed stock quantity, mismanagement of the ward storage can be avoided.

2.6 Technology

The HIS was developed and implemented by a small Bulgarian private software company called Gama/Sofia Ltd[11]. A number of other vendors, including BonevSoft (Ajur-I5) and SkyWere (iLab), have been chosen for supplying most peripheral modules like HR management, accounting, etc., which are integrated with the HIS. The following description comprises the medical part of HIS: the backbone of the IT infrastructure at NHH.

8 http://www.mh.government.bg/
9 http://www.nchi.government.bg/
10 http://www.nhif.bg/bg/default.phtml?w=1024&h=738
11 http://www.gama-sofia.bg/en/index.htm

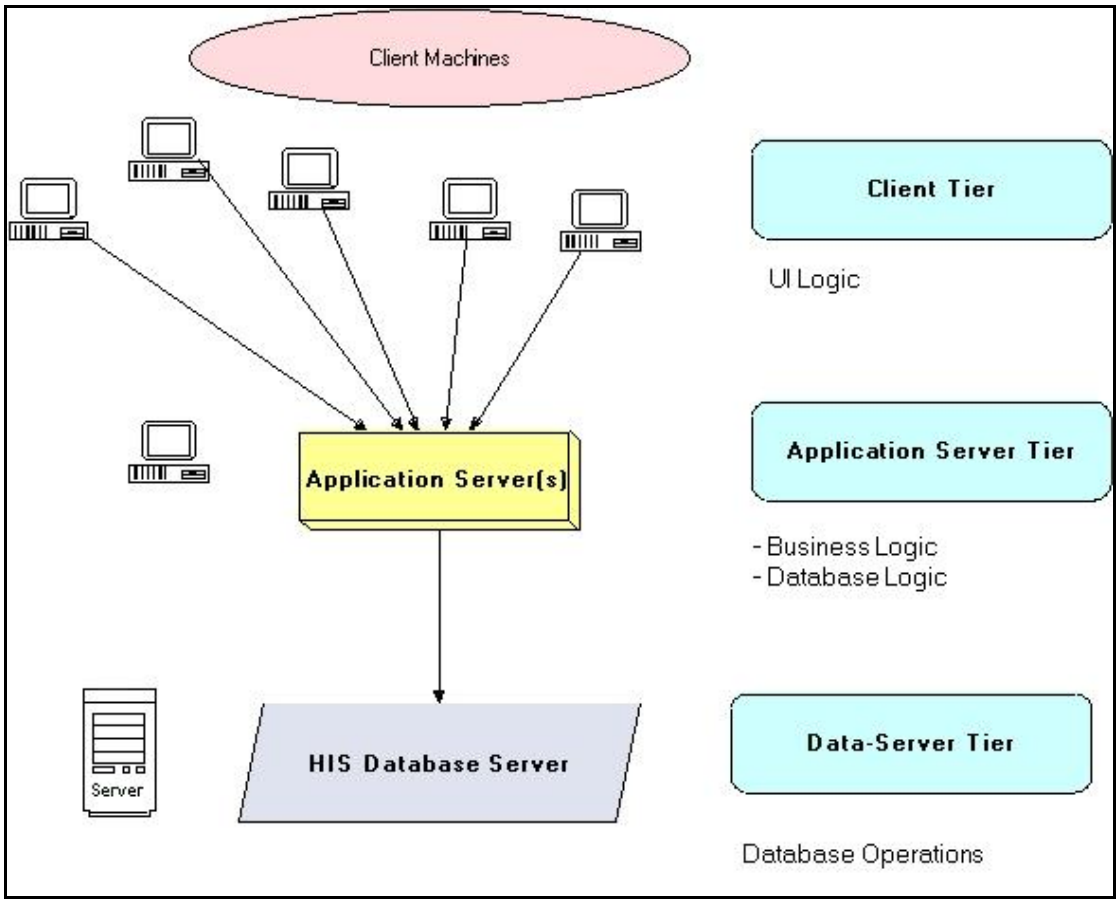
2.6.1 Overview

The Hospital IT infrastructure consists of 350 PCs and ten servers linked in an Intranet network. Main software platforms are Windows 2000, Windows 2003, Windows XP, Oracle, Microsoft SQL, and Visual Basic, with Visual Studio 2005 used as development environment.

Architecture

HIS is developed with a 3-tier client-server application. This Service-Oriented Architecture (SOA) provides best performance in complex networks with more than 250 clients. Figure 4 shows the structure of the system.

Figure 4: Tier structure of the HIS at NHH Sofia



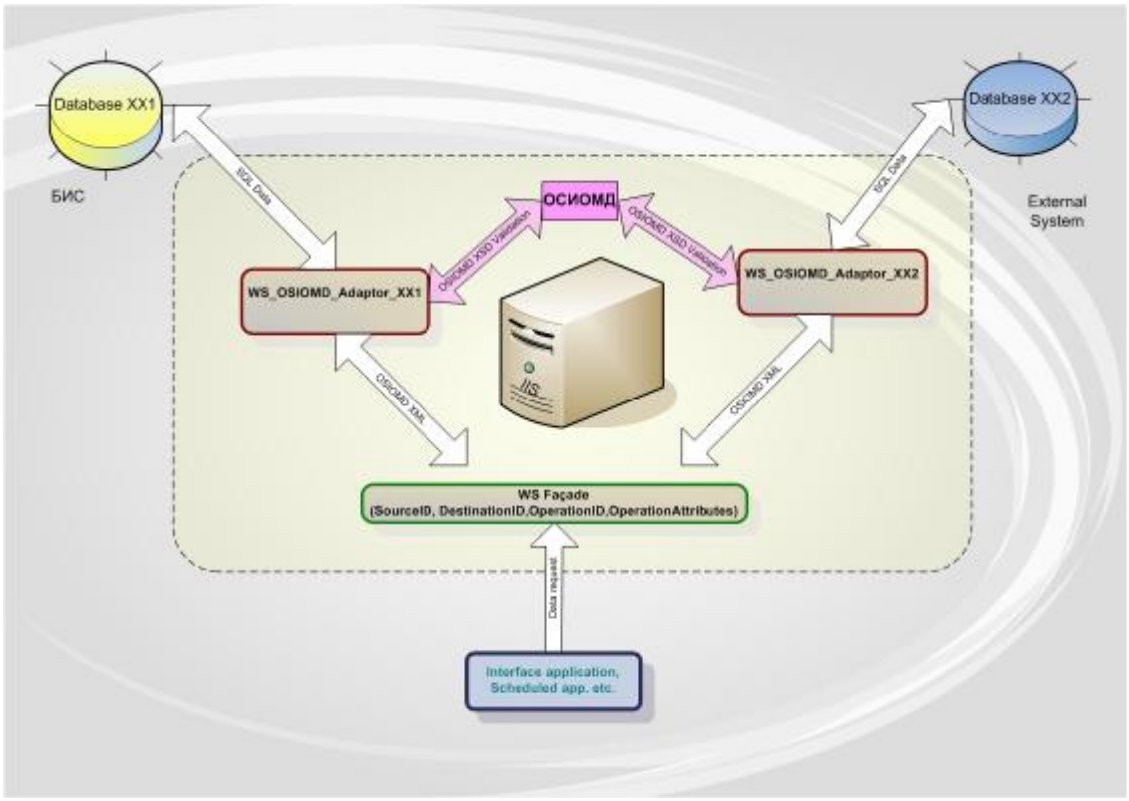
Source: Gama Sofia Ltd.

HIS includes a tool for integration and data transfer, based on the *Common Standard for Information Exchange of Medical Data (CSIEMD)*. This open, platform-independent standard is based on XML conventions and enables interoperability by describing the objects and the specific software components and translating the specifications of each information system data in accordance with the CSIEMD structures. The CSIEMD is used for integration between medical and non-medical modules of the overall IT infrastructure, thus linking all hospital IT and activity to the patients and the relevant parts of their records.

System integration and interoperability

The system integration is a way to utilise several information systems simultaneously, using data transfer between them. The CSIEMD is the heart of the interoperability platform of the HIS at NHH. The application uses four main modules, as illustrated in Figure 5 below.

Figure 5: System integration platform



Source: Gama Sofia Ltd

Adapter to the particular information system

The adapter is realised as a web-service and works as an interface between the backbone HIS and the particular external information system. Each adapter transforms the SQL structures in the system in a standardised flow of data, based on the CSIEMD standard.

Dispatcher of services

The dispatcher synchronises and controls the work of all adapters. It is also a web-service.

Administrative module

The administrative module performs system functions connected to the administration and configuration of information exchange. It is built as a Dot.Net desktop application, using a MSDE database for storing configuration data, logs etc.

Client module(s)

Client modules are developed for each external information system participating in data exchange. The client module principally initiates the data transfer.

Several systems are integrated with HIS in the National Heart Hospital, utilising this interoperability platform:

- "Ajur" for stock control and accounting

- "SMOBZ" for stock control at wards and departments
- "iLab" for laboratory data.

2.6.2 Security and confidentiality

Net security is achieved through the usage of passwords, which are changed weekly, and implementation of national data security and protection regulations.

Internet access in the hospital is secured through using an encrypted channel and a firewall. The access of each user is controlled and particularly assigned to his/her tasks in working with the HIS. For example, the rights assigned to a nurse a different from the user rights of a member of the administration.

Identical copies of the digital archives are kept in a hospital safe and a bank safe. The archiving in the bank safe is done once a week.

2.6.3 Software development, installation and challenges

The software development and installation has luckily taken place without major problems. Nevertheless, an incidence of a malicious hacker attack in 2005 revealed the extent to which the NHH daily operations were already relying on the HIS. The attack consisted of deleting the active directory of users, leading to complete downturn of the system. As a result, the NHH staff had to return to paper-based operations for one day, causing widespread dissatisfaction and anxiety. Due to the regular and common back-up procedures, a re-installation of the server with the back-up data solved the problem by the next morning.

2.7 Level of interoperability

Of the three EHR IMPACT (EHRI) interoperability classifications of potential interoperability, limited connectivity and extended actual connectivity, the HIS at NHH falls in the second category of limited connectivity. Connectivity is given by providing access for all NHH elements, i.e. the HIS can be connected to the numerous other IT systems within the NHH. The connectivity is even extended to the rehabilitation centre in Bankia. However, the availability of the EPR is limited to the system of these two facilities. Even though patient data are exchanged or shared with public health organisations, such as the NHIF and the ministry of health, there is no common interface to their information systems. In order to transfer the records to these organisations, the information has to be transmitted as a file but it cannot be accessed automatically by the relevant entities in real-time.

The HIS at NHH has an EPR system available, but it has not yet implemented ePrescribing. In terms of the level of interoperability, HIS is classified as having local and multi-site connectivity. NHH elements are comprehensively connected. Additionally, connectivity with the 25-km-distanced rehabilitation centre via a standing virtual private network (VPN) within the municipality network is provided and enables a smooth data transfer between the two sites. Regional or national connectivity is not reached yet. Other health service provider organisations (HPOs) are not connected to NHH's HIS, partly because of regulatory restrictions. Reports to the health authorities and NHIF are produced as MS Excel and XML files, yet they are not automatically transferred XML files. Solving the problems of adapting the data to the respective system is still underway.

The interoperability, interoperation, and thus facilitated collaboration cover local teams of doctors, nurses, other health professionals, and management and administrative actors.

Informal carers and patients have no direct access, which is in line with the design and philosophy of the system – to support health professionals and managers at NHH in their daily work. The classification according to type of connectivity is summarised in Table 1 below.

Table 1: Scope of interoperability at NHH Sofia

Type of connectivity	Characteristics	NHH Sofia
Single site	People within teams and between teams in one organisation	Yes
Multi-site	People within teams and between teams in one organisation	Yes
Regional	People, teams and organisations in one region	No
National	People, teams, organisations and regions in one country	No
International	People, teams, organisations, regions and countries	No

3 Case analysis

3.1 Stakeholders

Stakeholders fall under the four groups defined by the EHR IMPACT methodology[12]. In the case of NHH Sofia, each group consists of the following specific actors:

Patients, informal carers and other people

Out of the first category mainly patients are affected by HIS at NHH. The category 'patients' comprises adult and child in- and outpatients, suffering mainly from cardio-vascular diseases. Patients are not active users of the system, yet they are directly affected as the HIS changes the quality of care and provides new options for care.

Informal carers are affected to the extent that changes in quality of care and in administrative and clinical workflows impact on parents of paediatric patients.

Health service teams

This group of stakeholders includes mainly healthcare professionals, but also non-medical support and administration staff. The health professionals' teams at NHH include some 195 doctors and over 480 nurses. Together with administration and other non-medical staff, comprising some 200 people, they present the primary users. As a result, they are directly affected by the HIS, although the single team members are involved at different points in the system. The HIS is designed to support and improve the work of health service teams. Thus, many of the impact indicators are linked to them. In this stakeholder group we regard the team members as individuals, and not as employees of the hospital. Only the impact on their private lives is included in this theme.

It is nevertheless important to analyse the net impact on healthcare staff, as they influence the outcome of the system. If their private net impact is negative, they have a strong incentive to resist change by refusing to work with the system, thus reversing any positive impact of the HIS.

Health provider organisations

NHH Sofia, including its rehabilitation department centre in Bankia, is the stakeholder in this group. Impacts to NHH include the investment in HIS, as well as effects on clinical workflows and working practices. Efficiency is an important aspect of the implemented system, comprising, among other things, the re-deployment of liberated personnel and material resources. Besides managerial tasks, such as analyses of hospital activities, the reporting module supports the workflow with third parties, including NHIF, the ministry of health, and the national centre of health information.

Third parties

Third parties in this case include the NHIF, the ministry of health, the national centre of health information, the police and judicial authorities. Impacts include the possibility to obtain statistical reports in real time. Furthermore, changes in the quality and outcomes of care have a direct impact on reimbursement bills to NHIF.

[12] EHR IMPACT, D1.3: Methodology for evaluating the socio-economic impact of interoperable EHR and ePrescribing systems

The main vendor, Gama/Sofia Ltd., and a charity foundation that funded the prototype, department level EPR system are also third parties.

3.2 Process change

The HIS is designed to control and optimise the patient flow. Thus, it is developed as an information system which supports the activities of all hospital units, allowing direct utilisation by the entire hospital staff (doctors, nurses, management body, medical secretaries, etc.). Easy access to the EHR and to all data related to medical treatment provided by the HIS is considered an instrument for increasing the quality of the medical services. The main changes in comparison with the pre-ICT situation include fairly common themes such as more structured clinical and working practices, and different processes resulting from availability of information independent of point of time and space.

3.2.1 Workflow

The HIS is meant to support the workflow at the NHH. The core change in the workflow of doctors and nurses concerns shortening the flow by one step: the physical search for patients' past records. Workflow in the information department was fundamentally transformed. Archivists and statisticians have a new role. Previously, they would spend most of their working day by manually counting and writing up paper reports. Today, they need a high level of computer literacy and spend more time with controlling the quality of information, thus performing not only tasks related to statistical reporting, but also supporting the clinical performance of the NHH by ensuring that medical records are correct.

The patient flow has changed insofar as it is organised in a more efficient way. However, the single steps and stages, from registration, through admission, transfer, and discharge, remain similar to the previous ones.

3.2.2 Clinical practices

At the beginning, the medical procedures have hardly experienced any change. It is less the procedure that has changed than the way in which it is realised, and thus its quality. The foundation on which decisions are made is faster and more informed. Instead of waiting for the relevant records to be found in the hospital's archive or deciphering the previous doctor's handwriting, the information is available immediately and it is reliable. In individual cases, this can lead to a different medical decision by a doctor or nurse, since it is based on better quality information. As a result, time loss can be avoided and the quality of the results improved.

The HIS does not, and will not, replace doctors, nurses, and other healthcare team members in their work. Yet clinical practices can be structured better and new clinical evidence can be introduced into clinical practice faster. This is consistent with NHH's strategic move towards evidence-based medicine. As a first step, the introduction of clinical pathways as a means of structuring the reimbursement procedures by NHIF was facilitated by the existence of HIS. These clinical pathways define certain clinical procedures that need to be performed in order for reimbursement to be secured. Whether these pathways are best of breed from a clinical perspective is an issue beyond the scope of this evaluation. The important point is that HIS can be used as an instrument for guiding clinical practice according to the principles of evidence-based medicine.

3.2.3 Working practices

The HIS has led to improvements with regard to work organisation, discipline, logistics and overall hospital management. The most important two changes were a) the way to put data in the patient record, mostly when this was done by direct care providers such as physicians and nurses; and b) the way to access information, such as past diagnostic results, radiology reports, discharge letters and other clinical information on patients.

With respect to entry, medical information is now typed, instead of hand-written. Paper records stored for legal purposes are only print-outs. Initially, the system focused on free text entry, in order to reduce the disruption caused by change. Currently, some structuring of data has been introduced. This leads to physicians and nurses improving the quality of data already at the entry stage.

The work of medical secretaries, as a first level of data quality control, is completely re-organised by the introduction of HIS. With paper records, they would spend their time searching for doctors and nurses in order to complete or clarify information, often only because of illegible handwriting. With HIS, their task has shifted more towards support and coaching health professionals in using the system, with the data control task being used more as way of identifying the need for focused coaching.

On the information access side, the main change concerns the way of accessing past patient records. Because of the HIS, healthcare staff do not depend on the archive's office hours or the archivists workload. Paper records are only available during office hours, and not on weekends. Further, the time needed for a paper record to be made available depends on the workload of the archivists. A daily task of nurses and junior doctors used to be the trip to the archives. With the system, past records are accessed immediately at the point of care by the professional who needs them. This change in working practice was one of the main reasons for investing in the system. The old practice of physical search for paper records still exists, since records from before 2003 are not digitalised. However, the normal procedure is the new practice, which has also decreased the workload of archivists so that access to the remaining paper records is quicker.

A further change enabled by the information system is observed in scheduling of the current day's appointments in the consultation rooms for ambulatory and inpatient care. Unnecessarily long waiting times are prevented by real-time scheduling according to level of urgency, and the patients records can be accessed directly from the scheduling interface in the consultation room. Before the introduction of the HIS, unplanned patients, usually ambulatory, would wait in an unstructured queue, and once they enter the consultation room, a member of staff would need to go to the archives to request the patient's records. The result was a less efficient patient flow, often combined with frustration by patients and carers alike.

One more significant working process that has changed is the transfer of patients between the main site in Sofia and the rehabilitation site of the NHH in Bankia. The former procedure of sending handwritten (and sometimes illegible) faxes is replaced by just entering the referral letter into the HIS. Instead of registering the patient once at the NHH and again at the rehabilitation centre, preparing two handwritten copies of the patient's documents, the necessary administrative and medical information is entered once into the system and accessed at any of the sites.

A feature that is becoming increasingly important is the link between the medical HIS and other systems, such as logistics, stock management, and billing. This integration allows improving efficiency and time savings. Instead of manually processing thousands of paper records in order to construct specific reports for these purposes, the reports are made available through a few mouse clicks. This includes reports for management, like cost

calculations, and activity reports for further analyses, statistical reports for the ministry of health and the national centre of health information, reimbursement bills to NHIF, and stock management reports. HIS provides reliable information on the stock quantity at each ward, based on an analysis of the patients' records. This information helps reduce ordering and thus keeping too much stock, and also prevents waste and misuse. The HIS thus becomes the backbone of all IT at the hospital.

3.2.4 Reaction and acceptance of users

In general, the acceptance of HIS by the NHH users is prevalent throughout all hospital activities. However, this was not the case initially. Due to high IT illiteracy among the hospital staff members, insecurity was widely spread and many had concerns whether the newly introduced HIS would indeed enhance the working practices. However, after the users had grown familiar with the system, they accepted it and integrated it into their daily routine. The best indication of the current high acceptance levels are the kinds of complaints received by the IT department and hospital management. All feedback consists of requests and suggestions for improvements and fine-tuning of the system. This was confirmed by interviews with users, all of which insisted on the fact that work without the HIS is unthinkable. Some interviewees claimed that they would leave the hospital if the HIS is de-installed.

3.3 Timeline and milestones

As with other complex systems, the HIS at NHH was gradually developed and extended, with regard to both location restrictions and content. It did not have the scope of functions and connectivity available today at once. The milestones in the process leading to the current position are a follows:

1993: Introduction of a basic, DOS-based system in the paediatric department of the NHH.

1998: Idea and strategic decision for development of new, module-based and expandable system, built around and electronic patient record.

2000: Implementation of the first release of the system at the paediatric department.

2002: Strategic decision to expand the system from the paediatric department to the whole hospital.

2003: Implementation of the patient record system and of the administrative IT applications into routine operation for ambulatory consultations and outpatients.

2004: Integration of the medical and administrative IT applications into a single HIS built around and electronic patient record. Expansion of HIS to cover inpatients.

2005-2007: Gradual connection of all hospital departments and their sub-units on the main site

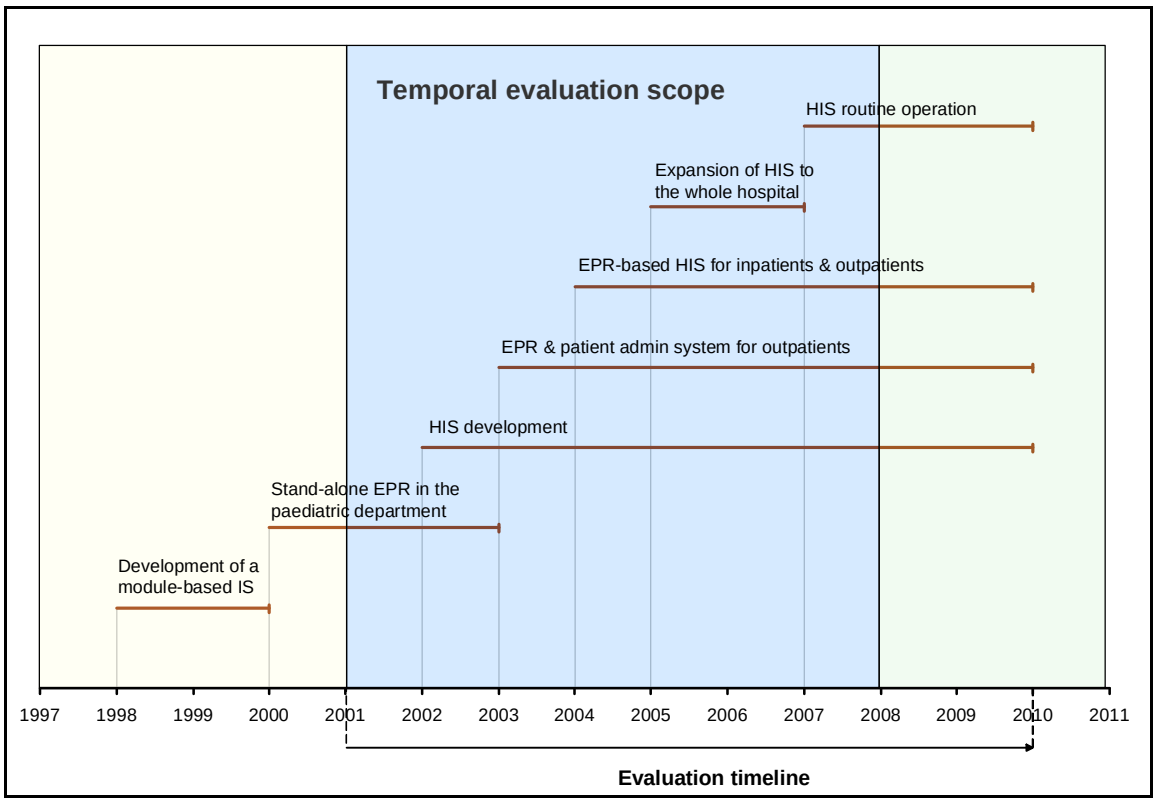
2007: Online connection between main site and rehabilitation centre in Bankia, allowing real time data input and access to records from either site.

2008/2009: Implementation of PACS, with immediate integration with the HIS.

The time scope of the evaluation reflects the scope defined in Chapter 2. Thus, the evaluation starts in 2001, when the idea of the hospital wide information system was first envisaged, and includes all milestones up to and including developments in 2007. The EHR IMPACT timeline extends to 2010 in order to allow for the impact of latest developments and

implementations to be reflected. However, costs and benefits of actives currently on the agenda, such as introduction and integration of a PACS in 2008/2009, are not part of the quantitative evaluation. Figure 6 shows the development timeline, highlighting the EHRI evaluation temporal scope and timeline.

Figure 6: Temporal evaluation scope and timeline – National Heart Hospital, Sofia



3.4 Supporting take-up

The first hospital-wide module implementation followed a comparatively radical approach of replacing the paper-based system with the HIS with an extremely short overlap period of less than a week. This tactic was backed by management in order to avoid a prolonged period of confusion and duplicative work with two systems. It was feared that running two systems in parallel would lead to professionals disregarding the electronic records' system out of habit and convenience. Without entering the data into the HIS, they would not have found it beneficial and would have resisted its roll-out based on biased experience. This feature is different from many other case studies, especially such in the more advanced countries. The need for such an approach is explained by the starting position of replacing paper records and introducing computers for the very first time, in an environment marked by relatively low digital literacy levels.

The effect of this take-up approach was a period of fairly strong complaints and insecurity, requiring the full attention and presence of all IT professionals on site. However, it lasted only about a fortnight before healthcare staff started to appreciate the advantages of the HIS.

The success of the system is partly based upon the following high motivation of the hospital management and staff members and their engagement in the development and implementation of the IT applications. The good coordination between the developers and

the users, including continuous dialogue in structured meetings as well as in ad-hoc discussions, witnessed by the evaluation team during the site visit, indicates a broadly successful take-up support strategy.

Nevertheless, some lessons had to be learnt in the process. The installation of the hospital IT infrastructure and network did not proceed as was originally planned. At the beginning, IT developers had difficulties understanding the medical procedures and terms in order to develop the system in accordance with the medical and clinical processes. The medical staff, on the other hand, had to learn how to enter the data and use the system immediately, upon first implementation, in order to avoid errors. It took some time to overcome this mutual non-understanding. A user manual tailored to the needs of each unit is distributed during each new implementation phase. Yet over-reliance on this passive method of communication and lack of sufficient interactive training were identified as having caused more disruptions than necessary. As a result, the former procedure of presenting use cases in one-off sessions is being replaced by interactive training sessions provided prior to the implementation of new or up-dated modules. Solely for this purpose, a training room has been equipped with terminals for hands-on exercise.

3.5 Benefits

Analysing the benefits resulting from the HIS at NHH against the background of the three main types of eHealth benefits, quality, access and efficiency, the most prominent ones are efficiency and improved quality of care. While time savings and cost avoidance can be primarily assigned as HPO benefits, patients mainly benefit from the improved timeliness and quality of care. Healthcare professionals mostly profit from being better informed, investing their time in activities more closely related to their job, and better work satisfaction. Interviews with several involved actors confirmed the numerous positive impacts of the HIS. The main benefit categories of the HIS at the NHH are summarised in the following:

- Efficiency:
  - Coping with increased demand
  - Avoided labour costs
  - Reductions in operating costs
- Quality of care:
  - Patient safety – reduced risk of technical errors
  - More informed carers – more and better quality of information at the point and time of care
  - Better effectiveness of care – faster discharge or avoided admission because of better informed decisions
  - Timeliness of care – better preparation in transfers between wards and sites
- Faster access – reduced waiting for patients during hospital visits.

The following analysis of the benefits for each stakeholder group provides a more thorough picture of the positive impact of the HIS at NHH.

3.5.1 Patients, informal carers and other people

Patients and informal carers, mostly parents of ill children, benefit mainly from faster access to care and improved quality of health services. They profit significantly from enhanced organisation features provided by the HIS, including scheduling, registration, orientation, admission, re-admission, discharge and transfer. Faster admission-discharge-transfer (ADT)

and other administrative procedures reduce the time patients spend waiting before and between consultations. The priority-oriented scheduling module for the consultation rooms further improves the timeliness of care, facilitating that patients get the attention of carers at the time they really needed it.

On the quality side, patients benefit directly from better-informed consultations, examinations, and care decisions. The provision of personal health data through the HIS reduces the risk of technical errors potentially resulting in adverse events. The up-to-date and around-the-clock availability of past hospitalisation and patient specific information, such allergies, reduces the risk of adverse events. In a paper based environment, the lack of real-time information can lead to adverse events, often resulting in an avoidable extra day of hospitalisation. Interview partners reported that one out of twenty patients is exposed to a lower risk of an adverse event due to the availability of information. This is consistent with findings on the probability of adverse events in general[13].

3.5.2 Health services teams

The most commonly stressed benefit to all individuals in this stakeholder group is a general alleviation in their work environment. This involves two aspects: availability and quality of patient-specific information. Both attributed to the EHRI benefit category of 'better informed carers'. The relevant records are available 24 hours a day, every day. This is considered an enormous improvement compared to the paper-based system, in which access to records for incoming patients was limited to the archive's office hours: from 8am to 4pm, weekdays only. The benefit is particularly pronounced with regard to chronically ill, and thus repeat patients, which present a significant share of all patients by virtue of the hospital's specialisation.

The second aspect, quality of data, refers to the fact that the data stored in the HIS is far more detailed than the information usually available on paper, often limited to a discharge letter. This allows the physician to take better-informed decisions and thus be assured in taking the responsibility for them.

Nurses pointed out that their work has become easier through the availability of information, allowing them to focus more on their main activity and spend less time on administrative issues, which are regarded as an irritating part of the job. Medical secretaries also reported improved satisfaction with work, stemming mainly from less stress associated with searching for doctors in order to clarify illegible handwriting or unclear abbreviations on hand-written notes.

Doctors and nurses also stressed the fact that they appreciate a better quality of life, since coping with the increased demand without the system would have led to overtime levels beyond sustainable levels.

Staff in the information department, responsible for statistics reporting to the ministry of health, the national centre of health information, NHIF, and NHH management, is particularly affected by the information system. Unsatisfying work such as manual counting of entries in paper records belongs to the past. The team highlighted that their work has become intellectually more challenging, as the required skills have changed, but also much more satisfactory, as outcomes are produced much faster.

The positive impact of HIS on hospital staff is measured in WTP estimates, which can only provide a conservative proxy. Most estimates are based on the current level of income, which limits the monetary value of WTP estimates. A consistent statement of interviewed system

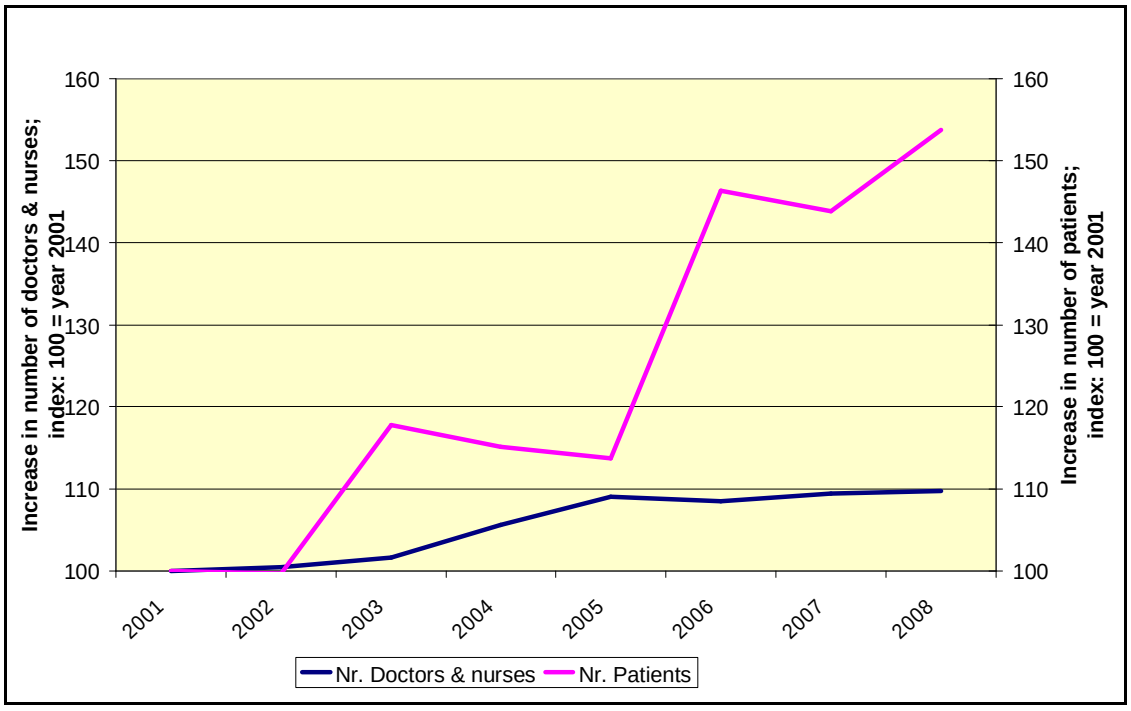
[13] Stroetmann, V.N., Thierry, J-P., Stroetmann, K.A., Dobrev, A., eHealth for Safety: Impact of ICT on Patient Safety and Risk Management European, Luxembourg: Office for Official Publications of the European Communities, 2007, ISBN-13 978-92-79-06841-6; available at: http://ec.europa.eu/information_society/activities/health/docs/studies/eHealth-safety-report-final.pdf

users was that they cannot imagine working without a HIS any more. Some even emphasised that they would rather leave the job than work without the system.

3.5.3 Healthcare Provider Organisations (HPOs)

The NHH gains from improved efficiency, as well as from consequences of improvements in quality sub-categories such as effectiveness, timeliness of care, and patient safety. Efficiency gains make up the larges part of the estimated benefits to the NHH. The most pronounced efficiency indicator is **improved productivity to cope with increasing demand**. Given a general scarcity of qualified professionals willing to work in the public sector in Bulgaria, meeting the increased demand could not have been achieved by employing more physicians and nurses. The burden on the current teams has substantially increased. Without the HIS, the increased burden would have inevitably led to a decrease on the quality of healthcare provision, due to stress, tiredness, and decreasing morale of staff. Chart 1 below shows the increase of demand in relation to the change in the number of physicians and nurses.

Chart 1: Relative increase in demand and resources 2001-2008



The second most notable efficiency benefit is a sizable **reduction in the cost of hospitalisation** from 2006 onwards. The costs of a hospital day dropped by 11% between 2005 and 2006, cutting a sustained trend of cost increases before and after. This is consistent with claims by hospital management that better control over utilisation of medicines and consumables, better financial reporting, and better clinical reporting, facilitated and ensured by HIS, have led to a reduction in costs of between 10 and 15%.

The third block of benefit indicators consists of **time savings**. These include mainly savings related to the search of past records, which involved **nurses, doctors, and archivists**. Time saving based on the EHR accounts for 10-15 minutes per record. In some cases, e.g. if there is high demand on the archivists, the time may increase to 30 minutes per record for the nurse. In contrast to common believes, time savings were also identified in the process of data entry, since pre-typed texts can are re-used, instead of having to re-write everything by hand. A number of structured, drop-down menu entries further speed up the process. The

time saved for the healthcare teams through the HIS can be reallocated to more important (healthcare) demands.

The time that can be saved for medical secretaries through the HIS amounts to approximately 1 hour per day per secretary, otherwise dedicated to deciphering illegible handwriting and searching doctors for clarifications. The prevention of repeated registration after transfer to the rehabilitation centre also saves nurses' time, as well as reducing the risk of errors.

Patient safety and effectiveness of care are further benefits to the hospital, measured by proxies such as the estimated reduction in risk of errors and avoided admissions. Adverse events are often the result of lacking information rather than human mistakes. The HIS substantially reduces the risk of this type of adverse events, which usually lead to one or more additional days of hospitalisation for the patient. Better effectiveness of care is also facilitated by the availability of information, since a number of emergencies can be immediately dealt with, instead of admitting the patient until either the archives open or the results of new, unnecessary tests become available.

Additional benefits for the HPO are generated by the reporting modules of the HIS, allowing the performance of medical and financial analyses based on the integrated medical and administrative data. Reporting to the NHIF for reimbursement purposes is also facilitated through the system. For coding procedures required by the NHIF information system, 15 additional staff members would be necessary, according to calculations by NHIF. Through the HIS, no additional personnel is required for this procedure. The same holds for the reports requested by other organisations, such as the ministry of health and the national centre of health information. Before the implementation of the HIS, the relevant reports were prepared manually. Additional two full time equivalents would be needed to provide the number of reports produced to date. In addition, enhanced traceability through the EHR makes dealing with incidents and complaints easier.

The implemented stock management module directly connected to the patient records has led to a reduction of stock level of consumables worth some BLG 1.7 million in 2006. Further benefits from this module include an avoided effort of up to 3 hours per day for each head nurse. New regulations introducing quotas on consumables and clinical pathways for reimbursement purposes have led to more reporting requirements, met much more easily with the help of HIS.

The synthesised information provided by the HIS is also of value for police and judicial purposes. On the average, between 2 and 3 times per year information is required by the judicial authorities. Every time this reporting is inquired, one full day for one hospital employee is necessary to provide the necessary information. Through the HIS the required information can be effortlessly and immediately synthesised for the relevant purpose.

A benefit reported at similar eHealth evaluation sites, but not found at the HNN is a reduction in the number of imaging and lab tests. The clinical pathways defined by NHIF for reimbursement purposes require certain tests and procedures to be performed. If the requirements are not met, the hospital does not receive any reimbursement. This explains the somewhat surprising lack of an impact on the number of tests.

3.5.4 Third parties

The avoided admissions related to more effective emergency care creates a tangible benefit for the NHIF. Even though a rare occurrence, the prevention of one day of hospitalisation per affected patient reduces the reimbursement bill of NHH.

The police and judicial reporting also save time for the police and relevant judicial institutions. Similar to the time contribution of the NHH gathering the required information, these organisations would otherwise have to contribute one full day of one of their staff member.

Even though the NHIF, the ministry of health and the national centre of health information receive reports prepared by the HIS, there is no additional benefit for these organisations. Since the data are required either for reimbursement purposes, or by law, they would necessarily receive them anyway. The benefit of easier reporting is only evident for the NHH.

3.6 Costs

The identified costs of HIS include the financial investment for ICT, but also any negative impacts of implementing the system. The latter include non-financial effects such as irritation to staff during the phase of change, as well as forgone income from avoided admissions and increased time requirements for certain procedures due to a regulation led duplication of recording practices. The costs to the different stakeholder groups are described below.

3.6.1 Patients, informal carers and other people

Estimated costs for patients and informal carers are nil.

3.6.2 Health services teams

Users as individuals, not as NHH employees, were faced with a relatively unknown tool, which was radically different to the paper-based system they were used to. Apart from the team in the paediatric cardiology department, all other staff members were confronted with a computerised system for the first time. Many of them were even introduced to using computers for the first time. Consequently, the initial inconvenience and irritation caused by the system is a significant negative impact, or cost, to the overall endeavour.

The other noteworthy cost to users was a small share of training time, which had to be invested from non-working time. This was in part due to the nature of the work – shifts made formal training for all during shift times impossible. In addition, care could not be suspended for training reasons either, so some of the training had to be either on a peer-to-peer basis or before and after shifts.

3.6.3 Healthcare Provider Organisations (HPOs)

Whereas citizens, patients and carers did not have to contribute any costs, and healthcare professionals “only” non-financial costs, the National Heart Hospital Sofia has the biggest share in costs involved, both extra financial and redeployed financial resources, required for the development and implementation of HIS.

Software development and maintenance, hardware, and other ICT expenses such as network infrastructure licences account for 37% of the costs to the NHH, or 40% of total costs. Given that the system was build to replace a paper-based environment in most of the hospital, hardware included everything from PCs through cables and servers. Obsolescence costs are also included. The vendor contract comprises everything from developing and maintenance of

the system to small ad-hoc improvements and integration of other systems to the HIS, which serves as the IT backbone of the NHH.

The other 63% of the costs to NHH are found in organisational issues. The most significant is negative impact of extra time for double entry of ADT data. Due to regulations, the paper ADT forms have to be filled in by hand although the information is made available electronically. This leads to some additional 20 minutes per patient for a doctor on ADT procedures, compared to the no-HIS situation. These negative impacts are recurring costs to NHH and thus amount to a substantial proportion of the overall cost of the HIS over the lifecycle.

The outright non-ICT investment costs include the resistance to change and adaptation period, in which productivity was reduced for between 1 and 3 months, depending on the specific person. Other non-recurring costs are the time spared for training and pre-development planning and procurement by the NHH. The time IT department staff spent on the HIS is a direct, recurring cost to the system. Such is also the time spent by the HIS clinical coordinator, as well as the time spent by the consultation group of doctors. The latter consist of about 40 physicians, spending between 30min and one hour per week on specification and feedback.

There is also a negative impact from avoided admissions. Even though the avoided admission due to improved care can be considered a benefit for the HPO, it has nevertheless also to be regarded as omitted income.

3.6.4 Third parties

The third party investment was the pre-contractual involvement of Gama/Sofia, the main vendor for the HIS.

Since the HIS was based on the knowledge and experience gathered in developing the prototype EPR system for the paediatric department, an estimated price mark-up that would have been required without his prior experience has been included. This mark-up reflects the value of transferred knowledge.

3.7 Socio-economic analysis

3.7.1 Summary of methodology

Cost benefit analysis (CBA) is the theoretical foundation for an EHR IMPACT (EHRI) evaluation. The UK Treasury's Green Book[14] and Germany's WiBe[15] specify the CBA methodology as an appropriate tool for analysing the impact of investments and activities in domains of public interest, including healthcare. CBA enables the impact on all stakeholders to be included in a socio-economic evaluation and the financial implications estimated over the selected timescales, extending from 1998 to 2010 for the EHRI evaluation. Three datasets are: statistics, costs and benefits.

Statistics include data about the population affected by the EHR or ePrescribing solution, the number of users, eHealth transactions, and changes in healthcare activity. Indicators can be

[14] HM Treasury, "The Green Book, Appraisal and Evaluation in Central Government. Treasury Guidance", London: TSO, 2003; available at: http://www.hm-treasury.gov.uk/media/05553/Green_Book_03.pdf

[15] WiBe 4.1. Recommendations on Economic Efficiency Assessments in the German Federal Administration, in Particular with Regard to the Use of Information Technology, 2007, based on the version 4.0, 2004, http://www.wibe.de/html/konzept-uberblick.htm (4.8.2008)

available from healthcare provider organisations (HPO), but not always for the whole evaluation life-cycle, so some estimation is needed. These assumptions are held separately from data of actual activity, increasing transparency and helping identify critical assumptions. A feature of the EHRI methodology is that information gathering has to rely on existing data and expert estimates. It is beyond the temporal and budgetary constraints of the study to perform detailed observational studies in order to investigate precise changes in time allocations or in quality of care. Where data is not readily available, estimated are made on the basis of information from focused interviews with representatives of the different stakeholder groups, as well as secondary literature. The interviews follow a guiding structure in order to focus on the case study topic, yet simultaneously remain open-ended to gather useful and innovative insights beyond expected impact features. Thus, the results are to be interpreted within their order of magnitude instead of absolute values. Despite this limitation, the evaluations provide a sufficient level of rigour to support the qualitative analyses and the conclusions on the overall impact and performance of the evaluated sites.

Information on monetary values of all relevant costs and benefits is seldom readily available from HPOs because their statistical and financial records do not record most of these routinely. Unit costs of resources need to be estimated at constant prices over the whole investment life-cycle of design and development, engagement, testing, implementation, operation and change. Estimates of all stakeholders' involved rely on assumptions about the time allocated to these activities. Doctors' time redeployed from other activities and additional costs, such as new project teams are examples. Actual payments to ICT suppliers are usually bases for their estimated costs over whole life-cycles.

Estimating the monetary value of impact uses several techniques. Time savings of staff and numbers of tests can be estimated from unit cost calculations. Quality gains have five categories of better-informed patients, timeliness of care, effectiveness of care, patient safety and streamlined care. Some of these can be estimated using unit cost calculations, such as avoided hospital admissions. Intangible benefits, such as the value to patients and organisations, rely on willingness to pay estimates inferred from stakeholder behaviour, usually with very small values for some patients who enjoy a new benefit. The same technique is used for benefits to healthcare professionals who can be adamant that eHealth could not be removed because it benefits their working days. Intangible benefits for HPOs, such as reductions in risk exposure, are valued using insurance-based models. Benefits from efficiency gains are valued using estimates of the changes in unit costs from productivity improvements. Some benefits realise cash benefits, such as identifying increased activity that can be billed. Estimates of extra activity multiplied by prices provide the monetary value.

These techniques provide baseline estimated costs and estimated benefits, where costs include all negative impacts and benefits all positive impacts. Contingency adjustments are used to reflect the reliance on estimation. They increase costs and reduce benefits. Contingencies can be as high as 50% for some baseline monetary values. Adjusted estimated costs and benefits are discounted to net present values then tested for sensitivity to identify the impact of the reliance on estimates on the findings.

The overall impact is measured by the estimated monetary values of annual and cumulative benefits, and so net benefits over time. These show the time taken to realise net benefits and their scale. They also reveal the distribution of the costs and benefits between stakeholders and the distributions of extra finance, redeployed finance and non-financial costs and benefits. Judging eHealth impact requires the focus on relative, not absolute monetary values, especially cost benefit ratios and correlations of costs, benefits and eHealth utilisation.

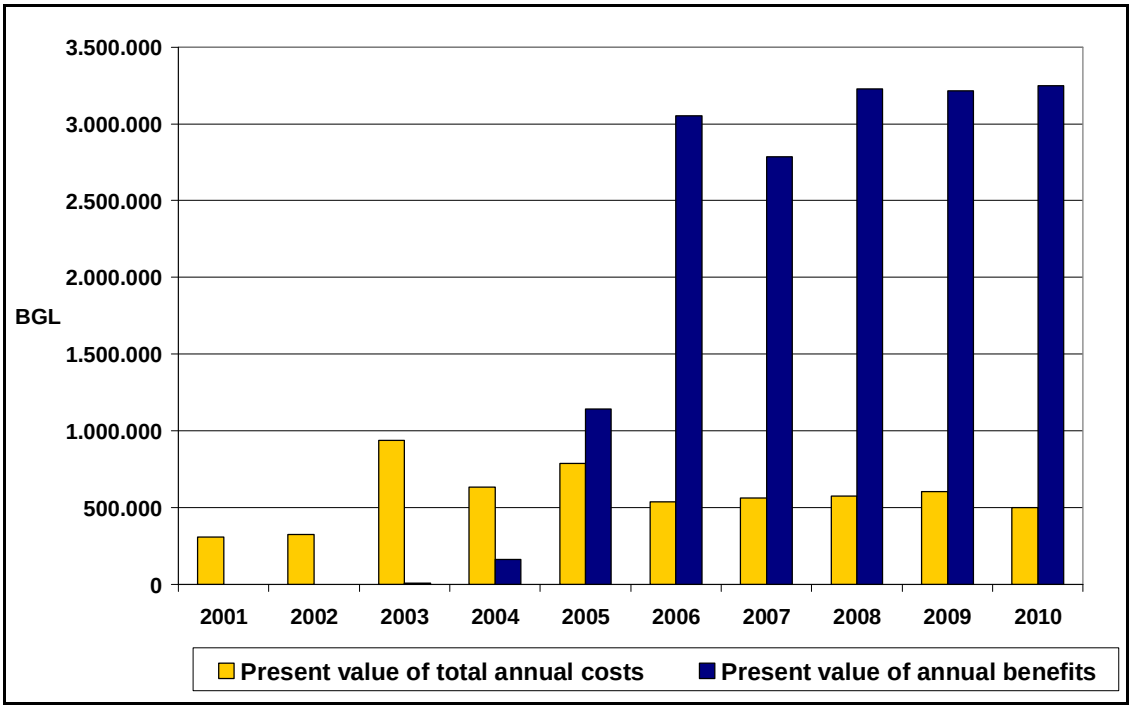
3.7.2 Net benefits

Net benefit over time is the critical measure of the overall socio-economic impact of eHealth systems. It identifies when and by how much, benefits exceed costs over time. Two important features of the net benefit estimates need to be stressed. First, the net economic benefit is a monetary measure of the net value of all positive and negative impacts, not a measure of financial returns. A brief analysis of the financial impact follows in the distribution of costs and benefits into different categories, including financial, in section 3.8 below. Second, as noted above, the value of the conclusions lies in the overall position and performance, not in the absolute values presented[16].

3.7.2.1 First year of annual net benefits

Chart 2 below shows the present values of estimated costs and benefits for each individual year over the relevant lifecycle.

Chart 2: Estimated annual costs and benefits



Estimated annual net benefits took five years to be realised, some three years after initial implementation of the first functionalities. From the very first year of annual net benefits, 2005, the margin is substantial and increasing, indicating a strong, sustainable positive impact. This timescale is comparable to, yet slightly above average timescales found in other eHealth IMAPCT based evaluations[17]. The timescale is, however, some two to three years shorter than average for EHR systems.

The noticeable levels of costs and zero benefits in 2001 and 2002 reflect the time it took for political support to be gained. During this period, the current HIS was only in planning. A small, technically different system was in place at the time, serving only the paediatric cardiology department. As noted in section 2.2 above, this system played an important role in the learning curve for the current system, both for the hospital staff and for the vendor.

[16] Cf. Section 3.7.4 on sensitivity of results
[17] The eHealth IMPACT average time to annual net benefits was 4 years, cf., reports at www.ehealth-impact.eu

Given that the HIS was being planned over that period, based on the simultaneously gathered experience from the restricted system, the costs of knowledge transfer are included in the EHRI evaluation.

The year 2003 is marked by a hump in costs and a comparatively insignificant amount of benefits. This is unsurprising, given that after the long planning period, the actual development of the first release of the system took place during that year. Most hardware and network infrastructure was also acquired during 2003. The implementation followed only late in the year, limiting the scope for benefit realisation.

The dip in annual benefits in 2007 is only relative, and is in line with the overall trend. The deviant part of the curve is in fact the year 2006, which was marked by three overlapping features:

1. One-off benefits such as the reduction in stock levels
2. A statistically significant reduction in the cost of a hospitalisation day
3. Reaching a scope and scale of implementation allowing realisation of most benefit themes, at least to a certain extent.

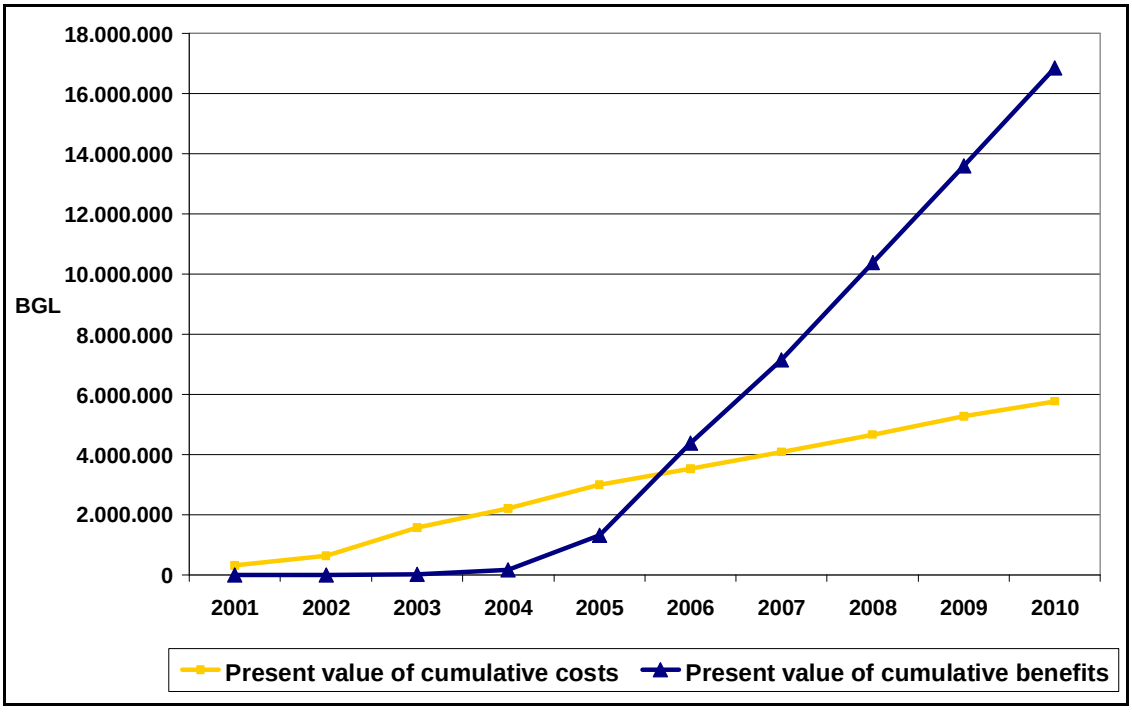
The second cost hump, in 2008, is explained by a replacement of the server infrastructure in order to accommodate increasing demands from a technical perspective in terms of number of applications and utilisation.

The significant net benefit margin achieved from year five onwards is critical for long-term economic viability. Having realised the benefits, they are likely to be sustained above this rate beyond 2010, the end year of the EHRI evaluation timescale, and thus drive the cumulative economic performance of the system.

3.7.2.2 First year of cumulative net benefits

Aggregating the annual costs and benefits to cumulative values shows the overall socio-economic impact over time. The respective costs and benefits curves are depicted in Chart 3.

Chart 3: Estimated cumulative costs and benefits



The EPR-centred HIS at NHH yields a positive cumulative net socio-economic benefit in 2006, year six of the lifecycle and in the fourth year of implementation. The gap of only one year between realisation of annual and cumulative net benefits is consistent with observations at other sites and can be attributed to the relatively fast increase in the net benefit margin once annual benefits start exceeding annual costs.

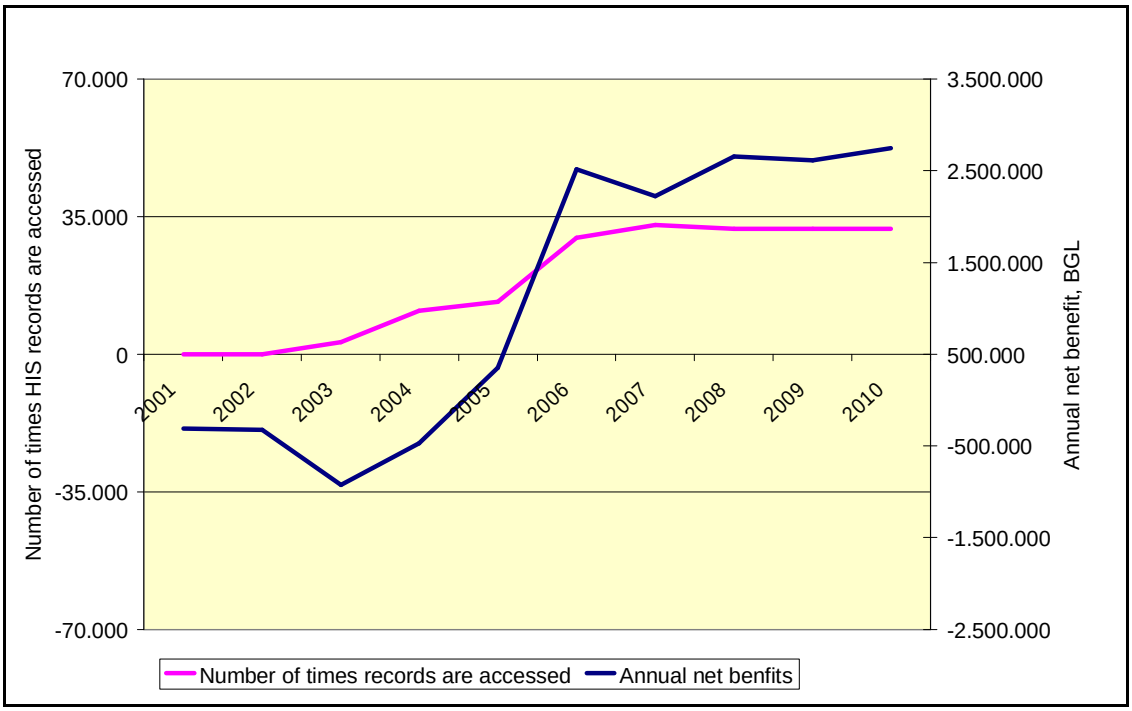
The cumulative cost curve increases gradually over the whole life cycle, slightly accelerating in 2005 and 2008, reflecting the events already addressed above. The stable rate of increase of cumulative costs reflects the stabilised level on annual basis, shown in Chart 2.

Only the use of the system leads to positive impacts, which explains the zero benefits in the first two years of the evaluated period and the low level of benefits during the first two years of implementation. The surge in the rate of increase comes with a reasonable lag to the equivalent phenomenon in the cost curve, starting in 2005. The rate of increase of cumulative benefits stabilises thereafter, at a rate significantly higher than the stable rate of increase in costs. This is a critical relationship, indicating the potential for long-term economic sustainability of the HIS at NHH.

3.7.2.3 Net benefits and utilisation

Generally, annual benefits and utilisation can be seen as broadly correlated. If the HIS is not used, then benefits will not be realised. However, the obverse is not always true. The fact that a system is used does not automatically mean that benefits accrue, unless it provides usable and useful information. In this setting, matching the utilisation and net benefits curves after implementation can reveal some of these relationships. Before implementation, annual net benefits are invariably negative, with utilisation at zero, as seen in Chart 4.

Chart 4: Link between net benefits and utilisation



The annual net benefit curve switches into positive at year five and rises each subsequent year to 2010, save 2007. The reasons for this were already laid out above. The utilisation

curve rises continuously from the point of first implementation, though at different rates, following among other things the increase in the number of patients visiting the hospital. The correlation of utilisation to benefits is about +0.98 and to net benefits is about +0.96, both high correlations. They indicate that the economic impact of the HIS has been substantially achieved by its increasing utilisation.

3.7.2.4 Net benefit to cost ratio

The net benefit to cost ratio provides a comparison of the net socio-economic impact of the evaluated system to the costs, including any negative impact. A positive ratio indicates a worthwhile endeavour from a socio-economic perspective. A ratio of zero equals an implicit break even point at which the overall socio-economic impact is zero.

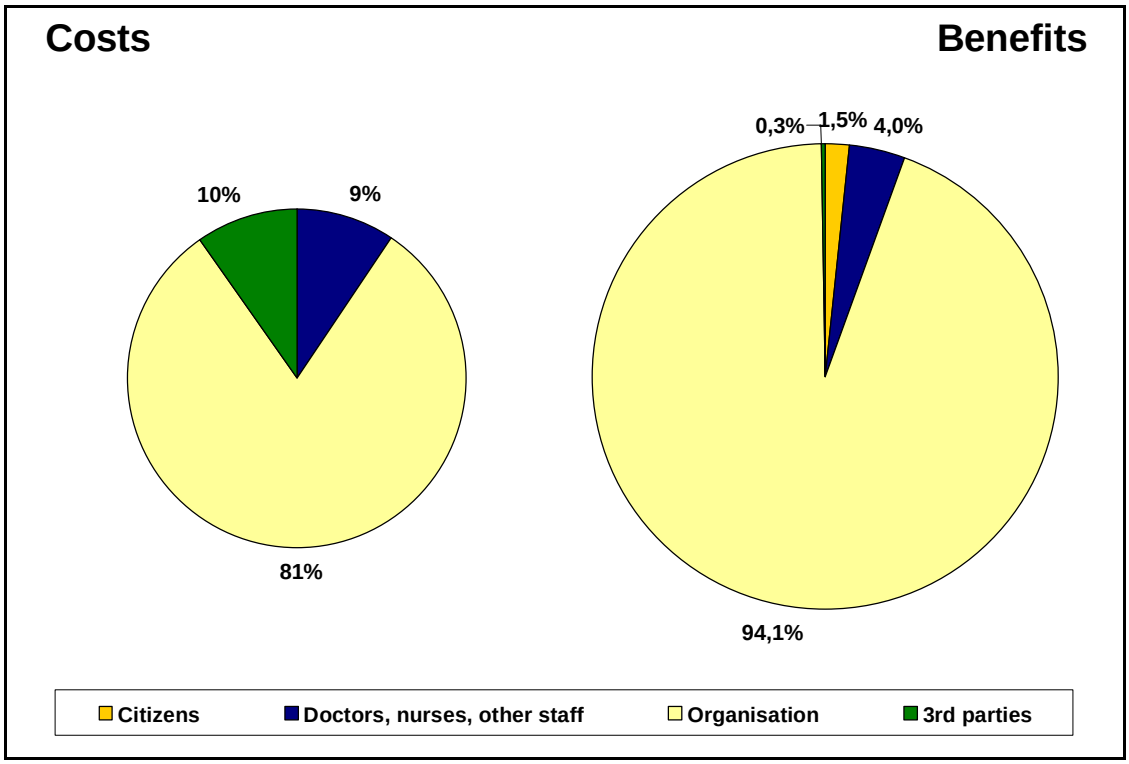
The annual net benefit ratio to costs turns strongly positive with +0.45 at year five, rising to an impressive +5.50 in 2010, year ten. The cumulative ratio increases steadily over the lifecycle and turns positive in 2006, year six. By 2010, the cumulative net benefit to cost ration reaches +1.92, meaning that for every BGL 100 worth of negative impact, there are BGL 292 worth of positive impact.

The ratio can also be understood as a rate of socio-economic, yet not purely financial, return over a given period. This indicates an overall socio-economic return from the HIS and NHH of about 190% over a lifecycle of 10 years.

3.7.3 Distribution of costs and benefits to stakeholders

Chart 5 below shows the distributions of costs and benefits between the main stakeholder groups. The organisation in this case is NHH. The category “doctors, nurses, and other staff” refers to the hospital’s employees as individuals, not as employees. Thus, only impacts such as private time invested or saved, and inconvenience or feeling of comfort, are attributed to this group. As already addressed, “citizens” in this case refers to patients at NHH and some informal carers, mainly parents. Third parties include the vendor, Gama Sofia, NHIF, and the judicial authorities.

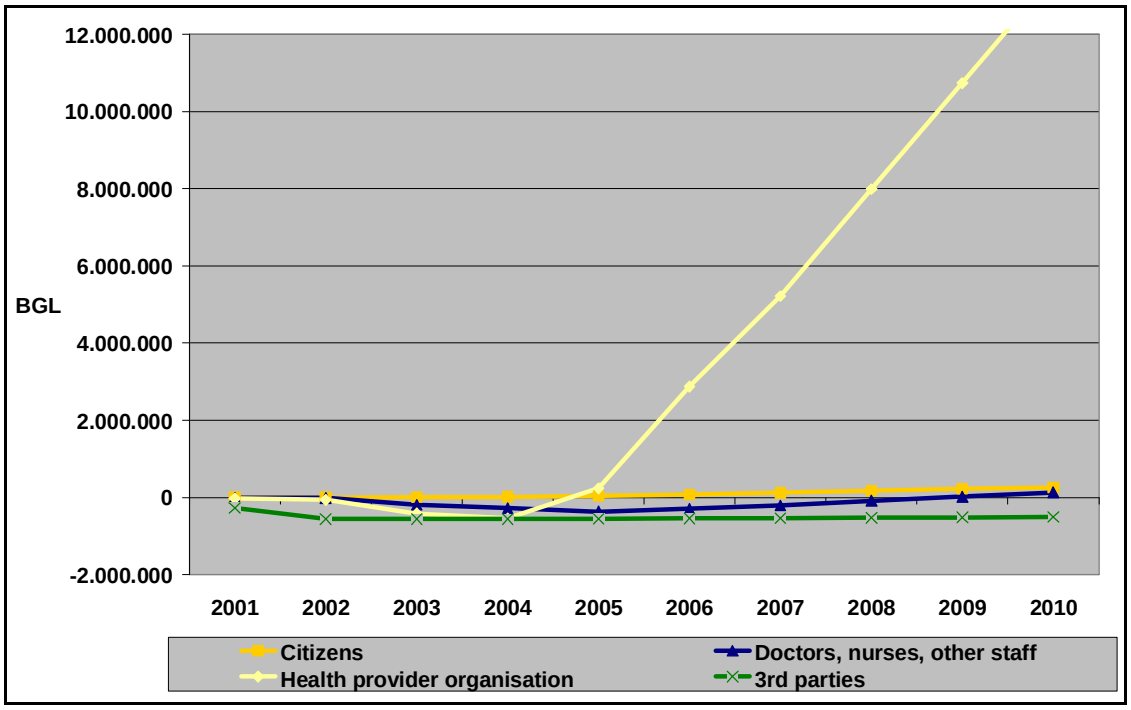
Chart 5: Costs and benefits per stakeholder group



Estimated negative impacts, including investment costs, are borne almost entirely by NHH, as an HPO. Disruptions and inconveniences to care providers account for about 9% of the total costs. The transfer of knowledge is about 10% of the total cost, covered by a charity foundation that financed the prototype system. Patients are not negatively affected by the system.

The distribution of benefits largely reflects the costs distribution, which is a distinct feature of successful eHealth implementations. Chart 6 below summarises the net impact on each stakeholder group. The only group with consistently negative net benefits are third parties, which is explained by the share of the charity donation assigned to knowledge creation and transfer in the years before implementation.

Chart 6: Cumulative net benefits per stakeholder group



All other stakeholder groups enjoy a positive net benefit over the life cycle, as expected by theory.

3.7.4 Sensitivity analysis

The sensitivity analysis consisted of 24 separate tests, focusing on all possible estimated variables that the outcomes of the socio-economic analysis could be sensitive to. Such variables include a number of probabilities based on secondary literature, as well as estimates of willingness to pay values inferred from behaviour, and estimated time changes for which no scientific proof was available. Further, the possibility that the HIS accounts for a smaller proportion of cost savings than assumed by the model was tested.

The tests involved changing the values of blocks of variables included in the calculation of the monetary values of costs and benefits towards a pessimistic scenario. Values were lowered or increased by between 50% and 500%, depending on the variable in question, and in a direction potentially reducing the net benefit over time. The discount rate has been tested for sensitivity at plus 100% and minus 50% of the EHRI rate of 3.5%.

The overall results of the socio-economic analysis are not sensitive to any individual block of estimations. The impact of manipulating assumptions is minimal, with highest impact involving a deferral of annual or cumulative net benefits by one year. The overall socio-economic impact for the EHRI evaluation timeline, measured by the cumulative net benefit to cost ratio in 2010, worsens within a range of up to 1.22, still leaving a comfortable positive result of 0.7.

The results of the sensitivity analysis thus show that the conclusions drawn from the socio-economic analysis are robust, and do not depend on individual estimations or assumptions.

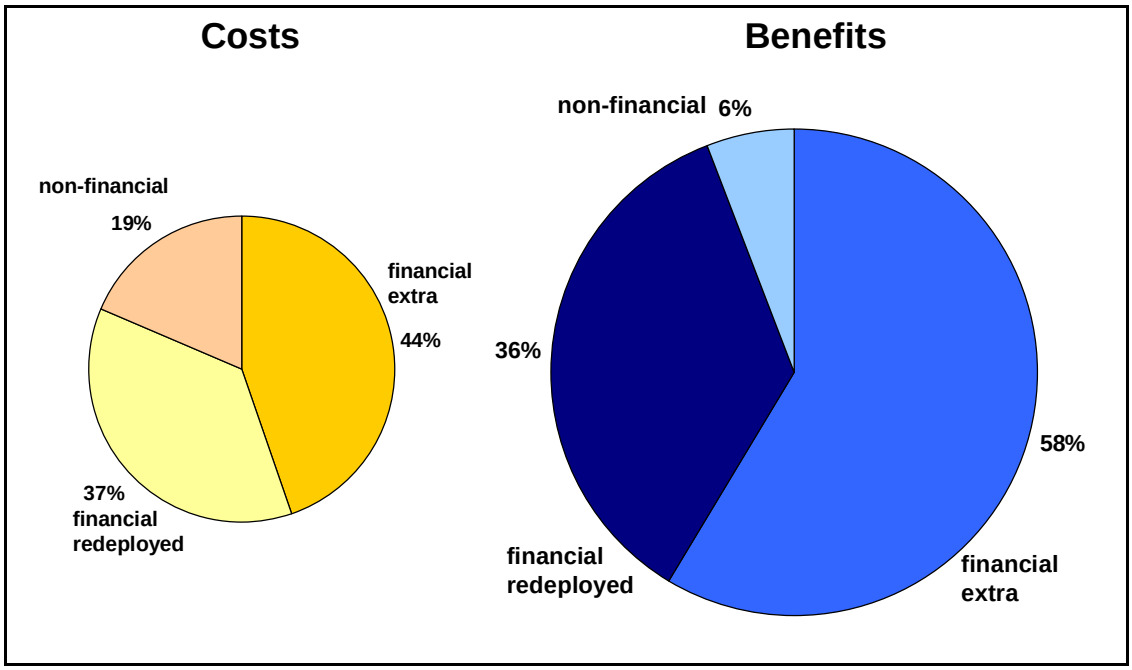
3.8 Financing and financial impact

3.8.1 Financial impact

The financial impact of the HIS shows a very different picture to the cost benefit performance. Each cost and benefit has been assigned to a category of extra finance, non-financial, or redeployed finance to show the financial implications of the investment. Results are depicted in Chart 7 below. Unlike most comparable sites, the financial classification of benefits shows that 58% of the benefit, over BGL 9.7million, is extra released finance. This is compared to less than 45%, or just over BGL 2.5million, of extra financial costs related to the investment. Thus, the overall absolute net financial impact is positive. This is an unusual feature of eHealth investments. It is explained by the relative starting position for the investment. In most investments evaluated till now, legacy systems prevailed. These systems were mainly addressing administrative and support services, such as logistics. Thus, financial savings related to these systems were long utilised, leaving only liberated resources for redeployment and non-financial benefits to investments in clinical applications. At NHH, a rare bundling of investments is observed, showing that the combination of systems for clinical and supportive processes can lead not only to a positive socio-economic impact, but also to a net financial return.

Another 37% of the costs are redeployed resources from other activities. The respective benefits, which can potentially be redeployed into productive resources, present 36%. With a few exceptions, such as where a specific person changes their focus of work, the benefits in the redeployed category are found in many small pockets and cannot easily be redeployed as a set of corporate decisions. Releasing the potential financial benefit from redeploying resources is a difficult managerial challenge. The HNN case is again different to most other EHI and EHRI cases, since the improved productivity measured by a proxy of avoided overtime for care providers, presents a large proportion of redeployed financial benefits.

Chart 7: Financial and non-financial impact



Taken together, the analysis shows a financial position where extra cash of some BGL 2.5million is invested over ten years to realise BGL 9.5million of financial benefits. This means a net financial return from a social planner's point of view of BGL 7.2million over a period of 10 years. Most of this net return is for NHH, with NHIF enjoying a small share of about 0.5% of extra financial benefits from avoided admissions.

Financial benefits to NHH include avoided extra staff for coding, statistical reporting, and archiving, as well as the sizable reductions in hospitalisation day costs and released cash from reduced ward stocks. Further, a net value of over BGL 4million can be potentially redeployed. The realisation of some of this potential would further strengthen the position of NHH.

3.8.2 Financing arrangements

The pilot system implemented in the paediatric unit before 2003 was financed by foundation "Child Heart - Martin Elliott". Founded in 1996 with a charity donation by Dr Martin Elliott, Great Ormond Street Hospital, London, the foundation supports activities in paediatric cardiology in Bulgaria. One of the set objectives of the foundation is the development of HIS for paediatric cardiology units. Even though this system is now replaced by HIS and is outside the scope of the evaluation, its importance has already been addressed.

The HIS was financed by the NHH, out of the capital expenditure budget provided by the ministry of health. Smaller add-on investments were drawn from the operational budget. The financial burden to NHH varies from year to year, but never exceeds about 1.2% of total annual budget, which is some BGL 35million per year. Even including redeployed and non-financial costs to NHH, the investment stays at levels below 2.7% of annual turnover. This finding is comparable to, yet lower than observations at other successful eHealth investments.

3.9 Legal aspects

3.9.1 Data protection

The NHH has a register with two types of personal data – patient related and staff related. As with paper records, the data protection regulations are honoured and internal regulations apply. External people needing temporary access to the databases, for instance software developers in some phases of development and integration of modules, have to sign the data protection regulations of the hospital.

Given that the HIS is currently only used at a multi-site, single organisation, no additional data protection issues arise, compared to the paper-based model. An expansion of the network to other hospitals is technically feasible, yet politically difficult. However, should the political difficulties be resolved in the near future, allowing access to records from a different HPO, data protection should play a more significant role in technical and organisational decisions.

3.9.2 Information governance

To some extent, HIS has even improved the information governance structure of NHH. With paper, access to records was only limited through the physical barrier of time consuming processes. The HIS eliminated this barrier, so a different access control system had to be set up. With HIS, access is managed through user groups, each of which is assigned the rights to

view and enter data only according to the professional needs. Each head of department has the responsibility to assign access rights to each individual in their team. Rights for each user group can include any or a combination of three main activity options: read, write, and delete.

Currently, the following user groups are set up in the system:

- Admin BIS – HIS administrators
- Cabinet – ambulatory and treatment cabinet nurses and doctors
- Clinica – ward nurse, ward doctor
- Informacia – statistical unit (only read rights)
- MedCentar – centre for outpatient care
- Patoanatomia – laboratory staff
- Registracia – ADT admin, registration
- Slujitel – HIS administration staff and medical secretaries.

Further to the access rights to users, individual records can be protected from access even further. For example, records of VIP patients are “hidden” and made available only to the treating physicians at the time of treatment.

A common information governance concern is the potential practice of shared log-in between doctors, and even between doctors, nurses and other team members. At NHH this has successfully been dealt with, following an incidence that led to a complaint and the need to trace back the events in the build-up to the incident. In the context of the incident, healthcare team members became aware of the fact that the log-in information defines liability. This automatically led to an immediate discontinuation of sharing log-in sessions.

4 Conclusions

The HIS at NHH illustrates in a profound way what interoperable electronic health record systems can do for healthcare provision in a hospital environment. This case study shows good practice that can be taken as a benchmark for similar investments with comparable starting positions. At the same time, readers should be aware that the results achieved at NHH are above average; an artefact of the EHRI study design. The general conclusion from the case study is that investing in EHR-centred information systems for hospitals is a worthwhile endeavour, provided the investment is well grounded and an integral part of the organisation's strategy. The investment and all negative impacts are more than covered by the benefits of using the system. Due to the less advanced staring position and a bundling of clinical and process support modules, the investment at NHH has even created realised returns – an unusual feature among eHealth IMPACT and EHRI case studies.

4.1 Future potential

A common feature of this, and other success stories, is that the drive for improvement is continuous. The annual net socio-economic benefit from the system at this point in time has reached a stable size and will continue to improve the cumulative position. The real future potential, however, lies in the immediate and planned future developments of the system. The next steps in the development of HIS are already being taken with the work on new modules and integrations, as described in Section 2.2. The major upcoming developments include PACS, CPOE including ePrescribing, and a number of DSS features.

As with the existing modules, stand alone applications are expected to bring only limited benefits. Therefore, the strategy to keep expanding the ICT support by integrating, rather than adding new applications is considered the only prudent way towards realising the full potential of these new investments. The philosophy of using the EPR as the backbone of the information has already proved to be a successful approach.

It is important that forecast net benefits for HIS at this point in time are not extrapolated to indicate a potential performance from new developments. They will have their own cost and benefit curves that need to be estimated and assessed as part of future investment decisions. The socio-economic performance of the current functionalities and scope of the HIS offers a sound foundation and a high level of reality about the long time scales needed to secure net benefits from these next stages.

The long term vision includes even a network between NHH and other hospitals using information systems, as well as GP and specialists practices, and external labs. An expansion of the network to other hospitals is technically feasible, yet politically difficult. One note of caution, should the political difficulties be resolved in the near future, is that allowing access to records from a different HPO would require a different approach to data protection and information governance. In particular, the issue of liability will have to be solved. This concerns mainly the liability in case of errors that could be resulting from wrong information or wrong interpretation of right information.

4.2 Transferability

Transferability can and should be examined at several levels. A conclusion of the eHealth IMPACT study[18] was that the purely technical components of eHealth are more easily transferred to other contexts than the organisational features. And even this does not secure transferability of success.

Usually, technological transferability refers to the possibility to install the ICT in another setting. This possibility is already proven to be real by the fact that the system is already installed in another hospital in Sofia – the specialised obstetric & gynaecology hospital St. Sofia[19]. Negotiations with further hospitals are underway. Some adaptation is always required, as has been seen in the switch from a department level EPR system to a whole hospital information system. The advantage of working with a vendor, rather than developing in-house at NHH is that transferability has been a constant issue throughout development. The vendor, Gama/Sofia Ltd, has managed to separate the general components from the specific needs of NHH, thus making the system a replicable product.

The organisational transferability depends as much on the system to be transferred, as on the setting in which it is to be transferred. The healthcare sector is well known for its peculiarities and for local specificities in working and clinical practices determined by care professionals. It would be wrong to try and transfer the HIS in all its details at once. However, the approach of engagement prior to implementation, securing acceptance before changing working practices, is transferable.

4.3 The role of interoperability in realising the benefits

Most of the benefits at NHH are the result of a combination and interplay between systems. A simple EPR system alone would most probably not have led to a socio-economic net benefit, and definitely not realised a financial return. The integration of different systems into a comprehensive HIS was the driver of benefits. This integration requires securing high levels of interoperability, focusing not only on specific problems, but also on future, unknown systems that could need integration.

In this sense, providing inter-system technical interoperability was critical for success. Semantic interoperability is less of an issue in a closed hospital setting. It will, however, become an important theme if NHH succeeds in building cross-HPO networks.

4.4 What it means for decision makers

A number of aspects from NHH's experience can be useful for decision makers in planning and managing investments in interoperable EHR and ePrescribing systems.

HIS versus EPR system

A point already made explicit above is that an EPR system in a hospital setting should not be implemented on its own, but integrated with other applications supporting clinical and non-

[18] eHealth IMPACT: Study on economic and productivity impact of eHealth - developing a context-adaptive method of evaluation for eHealth, including validation at 10 sites - covering the whole spectrum of eHealth applications and services; www.ehealth-impact.eu

[19] www.1agb.com

clinical practices. This conclusion is consistent with the experience at other, comparable sites.

Engagement and resistance

A critical success factor is the usefulness of an introduced system. Lack of usefulness can lead to strong resistance to change and potentially failure, when users refuse to change. The approach at NHH has been successful and can be useful in other contexts. The HIS was not developed by IT specialists and then presented to healthcare professionals. Instead, a group of professionals were engaged in and guided the design of the system from the start. Health professionals were **engaged, and not consulted**. Dealing with positions, propositions, concerns and requirements distinguishes engagement from consultation. Executives, managers, and IT specialists can ignore advice and views provided through consultation. In engagement, dealing with advice and views is essential in order to gain subsequent commitment to changes in clinical and working practices that realise the benefits from eHealth.

At the implementation stage, gradual developed and extension, with regard to both location restrictions and content, decreases the risk of introducing too many changes at once. For example, the system initially focused on free text entry, in order to **reduce the disruption** caused by change. Currently, some structuring of data has been introduced. At the same time, rapid implementation is called for where usability, usefulness, and benefits depend on scale, such as access to data across related wards and departments.

If these two principles, engagement ensuring usefulness and a pace minimising disruptions, are in place, the implementation can be more relaxed about resistance to change. The first hospital-wide module implementation at NHH followed a comparatively radical approach of replacing the paper-based system with the HIS with an extremely short overlap period of less than a week. This tactic was backed by management in order to avoid a prolonged period of confusion and duplicative work with two systems. Irritation and discomfort prevailed for a short period, yet users recognised the benefits to them within this short period of less than a month and adopted the new practices.

A common feature of success stories is an **information culture in which users ask for more** information through more eHealth. This level was reached really quickly at NHH, since reactions leap-frogged the high risk stage of complaints of the system into the stage of complaining about the system. The difference is that the former implies that users do not want the system; the latter says that users want it to be better.

Different skills profiles needed

A lesson learned by NHH, which should be transferred, rather experienced anew in other contexts, is the importance of appropriate training. Over-reliance on passive methods of communication and lack of sufficient interactive training were identified as having caused more disruptions than necessary.

The introduction of complex eHealth systems leads to a change in the skills needed to perform. For example, workflow in the information department of NHH was fundamentally transformed. Archivists and statisticians have a new role. Previously, they would spend most of their working day by manually counting and writing up paper reports. Today, they need a high level of computer literacy. The team highlighted that their work has become intellectually more challenging, as the required skills have changed, but also much more satisfactory, as outcomes are produced much faster.

In order to realise the potential of the ICT system, HPOs should invest resources and attention to training. Including education and training as one of many supportive items to contracts and

implementation strategies will not be enough. Sometimes, basic IT illiteracy can be the principle hurdle to success.

Supporting change

On the positive side, ICT can also become a facilitator of change. At the beginning, the medical procedures have hardly experienced any change, in order to minimise disruption. However, once in place, the HIS can be used to improve compliance with existing, and the introduction of new clinical guidelines.

The HIS does not, and will not, replace doctors, nurses, and other healthcare team members in their work. Yet clinical practices can be structured better and new clinical evidence can be introduced into clinical practice faster. This is consistent with NHH's strategic move towards evidence-based medicine.

Clarity on achievable outcomes

Knowing what benefits to expect is often sighted as a success factor. In the case of NHH, it becomes clear that it is also important to recognise what benefits one cannot expect. The reason for this is not necessarily the ICT or the implementing organisation. A benefit reported at similar eHealth evaluation sites, but not found at the NHH is a reduction in the number of imaging and lab tests. The clinical pathways defined by NHIF for reimbursement purposes require certain tests and procedures to be performed. If the requirements are not met, the hospital does not receive any reimbursement. This explains the somewhat surprising lack of an impact on the number of tests, and points towards the importance of assessing future investments in the context its specific environment.

Another important observation is related to the way the benefits curve behaves. During the first years of implementation, benefits may fall on an annual basis. This should not be automatically interpreted as a worsening position. Instead, an assessment of the benefits for one-off improvements should be performed. Dips in the annual benefit curve at later stages give a more serious reason for concern.

Economic sustainability and financial returns

Economic sustainability is a primary indicator of success. The HIS at NHH has already achieved this position as is clear from the stable upward trend in cumulative net benefits. The factors securing this position are not unique to NHH, but are reinforced by its experience:

- Optimal costs / benefits relationship over time
- Addressing real needs, such as the increase in demand requiring increases in productivity, as doctors and nurses were difficult to employ
- Sustainable financing over an appropriate lifecycle
- Business cases for all stakeholders – each stakeholder group must benefit at least as much as the extra effort invested
- Effective risk management and mitigation can make the difference between success and failure. Many risks can be identified in advance, such as the level of technological robustness, usability, and usefulness of systems. The challenge is not to ignore them, driven by over-optimism and enthusiasm
- Investment imbedded in the overall development strategy of the hospital, not an add-on project for pioneers

An unusual feature of NHH is the realised positive overall net financial impact. It is explained by the relative starting position for the investment. At NHH, a rare bundling of investments is observed, showing that the combination of systems for clinical and supportive processes can lead not only to a positive socio-economic impact, but also to a net financial return.

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Appendix 1: Summary of evaluation data

EHRI generic data summary	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
HIS at NHH Sofia	BGL	BGL	BGL	BGL	BGL	BGL	BGL	BGL	BGL	BGL
Estimated COSTS										
Citizens	0	0	0	0	0	0	0	0	0	0
HPOs										
Doctors, nurses, other staff	4.841	4.637	181.288	111.711	108.788	62.679	38.709	8.897	10.973	13.326
Organisation	31.737	29.964	756.563	520.751	680.395	475.291	523.492	565.792	594.505	486.175
Third parties	271.777	288.099	0	0	0	0	0	0	0	0
Present value of total annual costs	**308.354**	**322.699**	**937.851**	**632.462**	**789.182**	**537.971**	**562.200**	**574.689**	**605.477**	**499.501**
Present value of cumulative costs	**308.354**	**631.053**	**1.568.904**	**2.201.366**	**2.990.548**	**3.528.519**	**4.090.719**	**4.665.408**	**5.270.885**	**5.770.387**
Estimated BENEFITS										
Citizens	0	0	3.002	9.911	23.210	39.123	44.801	48.019	48.569	44.215
HPOs										
Doctors, nurses, other staff	0	0	40	22.877	26.073	126.390	130.795	126.556	123.501	121.516
Organisation	0	0	6.685	130.316	1.086.335	2.881.611	2.601.772	3.045.700	3.034.347	3.070.813
Third parties	0	0	0	82	6.976	7.600	9.471	9.331	10.075	10.792
Present value of annual benefits	**0**	**0**	**9.727**	**163.186**	**1.142.594**	**3.054.724**	**2.786.839**	**3.229.606**	**3.216.492**	**3.247.335**
Present value of cumulative benefits	**0**	**0**	**9.727**	**172.913**	**1.315.507**	**4.370.231**	**7.157.070**	**10.386.676**	**13.603.168**	**16.850.503**
Net benefits										
Present value of annual net benefits	**-308.354**	**-322.699**	**-928.124**	**-469.276**	**353.412**	**2.516.753**	**2.224.639**	**2.654.916**	**2.611.015**	**2.747.834**
Present value of cumulative net benefits	**-308.354**	**-631.053**	**-1.559.177**	**-2.028.452**	**-1.675.041**	**841.713**	**3.066.351**	**5.721.268**	**8.332.283**	**11.080.117**
Net benefits over cost ratio - annnual	-1,00	-1,00	-0,99	-0,74	0,45	4,68	3,96	4,62	4,31	5,50
Net benefits over cost ration - cumulative	-1,00	-1,00	-0,99	-0,92	-0,56	0,24	0,75	1,23	1,58	1,92
Number of records	0	0	3.829	24.165	49.543	69.066	90.200	110.090	130.090	150.090
Number of times records are accessed	0	0	3.123	10.989	13.262	29.537	32.796	31.827	31.827	31.827

Distributions	**Costs**	**Benefits**		**Type of costs**		**Type of benefits**	
Citizens	0,00%	1,55%		**financial extra**	44,64%		58,10%
HPOs				**financial redeployed**	36,73%		36,33%
Doctors, nurses, other staff	9,46%	4,02%		**non-financial**	18,63%		5,57%
Health provider organisation	80,84%	94,11%					
Third parties	9,70%	0,32%					
Base year: 2008; Discount rate:							
3,5%							

Appendix 2: Cost and benefit indicators

Table 2: Cost indicators and variables

Stakeholder group		Cost indicator	Clarification	Variables
HPO – healthcare staff	***Nurses***	Training costs	Nurses' spare time they have to spend on IT training	Number of nurses; training involving spare time; value of time for nurses
		Initial inconveniences	Initial inconveniences nurses had to bear initially due changes in the working processes	Number of nurses; estimated value of inconvenience related to adaptation to the system
	Doctors	Training costs	Doctors' spare time they have to spend on IT training	Number of doctors; training involving spare time; value of time for doctors
		Initial inconveniences	Initial inconveniences doctors had to bear initially due changes in the work procedures	Number of doctors; estimated value of inconvenience related to adaptation to the system
HPO – ICT costs		Operational costs	Service contract with vendor for information system operation & support	Annual contract value
		Developmental costs	Contract with vendor for system development	Contract value
		Server & network infrastructure	hardware and software	Historical costs
		Work stations	Hardware and software, in each department & for training purposes	Number of work stations; historical costs
		Obsolescence	Replacement of outdated technology	IT costs; obsolescence rate

Stakeholder group	Cost indicator	Clarification	Variables
HPO – organisational issues	Doctors' time	Doctors engaged in HIS development	Number of doctors engaged in HIS development; time for engagement; share of FTE doctors
	Clinical leadership	C-level engagement in HIS development	Time for engagement in HIS development; share of FTE
	Clinical leadership	Operational engagement in HIS by medical coordinator	Time of medical coordinator engagement; share of FTE
	Extra time	Initial extra time involved until nurses have adapted their working procedures to the system	Extra time involved per patient; relevant number of patients; duration of adaptation process; share of FTE nurse
	Extra time	Initial extra time involved until doctors have adapted their working procedures to the system	Extra time involved per patient; relevant number of patients; duration of adaptation process; share of FTE doctor
	Extra time	Increase in time doctors have to spend on ADT procedures as they additionally have to fill in the paper documents for legal reasons	Extra time involved per patient; relevant number of patients; share of FTE doctor
	Temporary decrease in productivity	Due to nurses' initial resistance to working with IT, the system's potential was not fully realised	Number of nurses; loss of productivity; share of FTE nurse
	Temporary decreased in productivity	Due to doctors' initial resistance to working with IT, the system's potential was not fully realised	Number of doctors; loss of productivity; share of FTE doctor
	Temporary decreased in productivity	Due to other staff's initial resistance to working with IT, the system's potential was not fully realised	Number of non-healthcare staff; loss of productivity; share of FTE relevant staff member
	Foregone income	Due to avoided admissions, no income for these admissions is paid by NHIF	Relevant number of patients; reimbursement rate of hospitalisation after A&E visit
	Training time costs	Training time for nurses during working time	Number of nurses; training time; share of FTE nurse
	Training time costs	Training time for doctors during working time	Number of doctors; training time; share of FTE doctor

Stakeholder group	Cost indicator	Clarification	Variables
	Training time costs	Training time for admin & consultation office staff during working time	Number relevant staff; training time; share of relevant FTE
	IT department	Share of IT department manpower devoted to HIS	IT department resources; estimated share of time devoted to HIS; relevant FTE
	Pre-budget planning costs	Time for designing systems, fund raising, etc. before official project begin	Engagement by HPO; staff costs
	Training room	Redeployed resource by converting a room into a special training room	Equivalent of rent for training room
Third parties	Pre-contractual investment by vendor	Pre-project involvement in planning and design	Estimated share of FTE
	Knowledge transfer	Knowledge and experience transferred from the prototype module based information system of the paediatric department	Estimated mark-up on development costs

Table 3: Benefit indicators and variables

Stakeholder group	Benefit indicator	Clarification	Variables
Patients, carers & other individual people	Time saving	Reduced risk of an adverse event for inpatients with past information leads to avoided extra time spent in hospital.	Relevant number of patients; probability of an adverse events; value of time for patients
	Time saving	Admission can be avoided for some A&E patients as past patient data allow for immediate treatment	Relevant number of patients; length of stay that can be avoided; probability of an avoided admission
	Time saving	For all ADT procedures the system allows for time savings for patients with past information	Relevant number of patients; time saved for ADT procedures per patient; value of time for patients
	Patient safety	Patient safety is increased through the reduced risk of an adverse event if comprehensive patient data is available	Relevant number of patients; estimated WTP for the reduced risk of adverse events

Stakeholder group		Benefit indicator	Clarification	Variables
		Quality of life	Reduced risk of admission as past patient data allow for immediate treatment	Relevant number of patients; estimated WTP for reduced risk of admission
HPO healthcare staff	***Nurses***	Alleviation of work	Decrease of bureaucratic workload increases work satisfaction	Number of nurses; estimated WTP for alleviation of work
	Doctors	Alleviation of work	Assurance in decision-making	Number of doctors; estimated WTP for alleviation of work
	Doctors	Quality of life	Avoided overtime to cope with increased demand	Number of doctors; estimated overtime avoided; value of time for doctors
	Technical / medical secretaries	Alleviation of work	No illegible handwriting leading to irritating clarification work	Number of technical / medical secretaries; estimated WTP for alleviation of work
	Information department staff	Alleviation of work	Reports don't have to be prepared manually, reducing boredom and increasing work satisfaction	Number of staff members; estimated WTP for alleviation of work
	Management	Alleviation of work	Assurance in decision making, as based on better financial and other analyses	Number of management members; estimated WTP for alleviation of work
HPO - organisation		Liberated resources	Avoided admissions lead to resources being available for other patients. Measure is the opportunity cost of having a hospital bed occupied	Relevant number of patients; hospitalisation day cost to hospital; avoided length of stay
		Liberated resources	Reduced risk of an adverse event for inpatients leads to resources being available for other patients. Measure is the opportunity cost of having a hospital bed occupied	Relevant number of patients; hospitalisation day cost to hospital; avoided length of stay
		Liberated finance	Integration of EPR with ward stock management modules reduced stock levels of consumables	Reduction in stock level: accounting value

Stakeholder group	Benefit indicator	Clarification	Variables
	Liberated finance	Improved financial management & cost control helps to reduce cost of patient stay	Relevant number of patients; cost reduction per patient
	Cost saving	Avoided costs for information department staff for manually preparing reports	Estimated number of staff avoided; FTE information department staff
	Cost saving	Avoided costs for hiring encoders to comply with clinical pathways coding for reimbursement	Number of encoders avoided; FTE encoders
	Head nurses' time saving	More efficient implementation of new regulations on quotas for consumables & clinical pathways	Number of head nurses; time saved from improved stock control; share of FTE head nurse
	Improved productivity	Proxy: avoided overtime for doctors to cope with the increased demand	Relevant number of doctors; estimated avoided overtime; share of FTE doctor
	ICU doctors' time saving	From not having to ask re-admitted patients for current medications, etc.	Relevant number of doctors; time saved; share of FTE ICU doctor
	Doctors' time saving	From not having to clarify handwritten records with medical secretaries	Number of doctors; time saved; share of FTE doctors
	Nurses' time saving	From not searching past patients' paper records	Number of nurses; observed time saving; share of FTE nurse
	Nurses' time saving	From transfer from the main site to the rehab centre	Relevant number of nurses; time saved in transfer procedures; share of FTE nurse
	Technical / medical secretaries' time saving	From avoided re-writing of available repeat-info into records	Relevant number of patients; time saved per record; share of FTE technical / medical secretary
	Technical / medical secretaries' time saving	From not having to clarify handwritten records with doctors	Number of technical / medical secretaries; time saved; share of FTE technical / medical secretary
	Information department staff's time saving	From preparing reports by HIS queries instead of manual compiling	Relevant number of staff; time saved; share of FTE information department staff
	Information department staff's time saving	From not searching for records in archives	Relevant number of staff; time saved; share of FTE information staff

Stakeholder group		Benefit indicator	Clarification	Variables
3rd parties	***NHIF***	Liberated finance	Avoided costs from avoided admissions	Relevant number of patients; reimbursement rate for hospitalisation
	Judicial system / Police	Time saving	From having reports for police & judicial enquiries electronically prepared, instead of manual compiling	Time saved; share of FTE judicial / police staff