



EHR IMPACT

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Report on

The socio-economic impact of the Kolín-Čáslav health data and exchange network

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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.

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The socio-economic impact of the Kolín-Čáslav health data and exchange network

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

Czech Republic

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Bonn, April 2009

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Disclaimer

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Abbreviations

AR	Anaesthesiology and Resuscitation
CBA	Cost Benefit Analysis
CPOE	Computerised Physician Order Entry
CR	Czech Republic
CT	Computerised Tomography
CZK	Czech Koruna
CZSO	Czech Statistical Office
DaSta	Data standard of the Czech Ministry of Health
DoB	Date of Birth
ENT	Otolaryngology
EHI	eHealth Impact study
EHR	Electronic Health Record
EHRI	EHR IMPACT study
EPR	Electronic Patient Records
epSOS	European Patients Smart Open Services
GHIC	General Health Insurance Company
GP	General Practitioner
HIS	Hospital Information System
ICD	International Classification of Diseases
IHIS CR	Institute of Health Information and Statistics of the Czech Republic
ICT	Information and Communication Technology
IT	Information Technology
MoH	Ministry of Health
MR	Magnetic Resonance
PACS	Picture Archiving & Communication System
PET	Positron Emission Tomography
PKI	Public Key Infrastructure
RHB	Rehabilitation
SOAP	Simple Object Access Protocol
WM	WinMedicalc
WSDL	Web Services Description Language
WTP	Willingness to pay

EXECUTIVE SUMMARY

The Kolín-Čáslav health data and exchange network in the Czech Republic 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 general conclusion from the case study is that investing in EHR systems and in the exchange of health data is a worthwhile endeavour, provided the investment is well grounded and an integral part of the organisations' strategies. The investment and all negative impacts are more than covered by the benefits of using the system.

The network consists of the regional hospital Kolín, the municipal hospital Čáslav, as well as 29 general practitioners (GP) and specialist practices in and around the town Kolín. Hospital Kolín is a secondary care facility providing services in twelve specialties. The regional hospital employs about 600 doctors and nurses, treating some 20,000 inpatients and 300,000 outpatients every year. Hospital Čáslav is a smaller secondary facility with five specialties - internal medicine, gynaecology, surgery, paediatrics, and geriatrics - and a staff of 300. The private practices in the network are run by 10 GPs, 6 paediatricians, and 13 specialists.

The Kolín-Čáslav health data and exchange network covers the hospital information systems (HIS) in the hospitals in Kolín and Čáslav, and the exchange of patient data between these two hospitals, and between Hospital Kolín and private-practice doctors. The HIS stores comprehensive electronic patient records (EPR), which also form the basis for the exchange of patient data. The EPR-centred HIS supports both clinical activities and administrative functions such as reimbursement and billing. The implementation of HIS at Hospital Čáslav started in 2001, followed by Hospital Kolín in 2004. In early 2007, Hospital Kolín and private practices in and around Kolín started exchanging medical data electronically. Hospital Čáslav joined the network in 2008, by exchanging data with Hospital Kolín. The use of HIS and the data exchange has been increasing steadily.

Improved efficiency and quality of care are the most prominent benefits of the HIS for the hospitals in Kolín and Čáslav. Efficiency gains mainly include time savings in documentation, coding and reporting for reimbursement purposes and the search for past records. The benefits from exchanging patient data also include time savings at hospitals and private practices and improved efficiency of service in the latter. Patients predominantly benefit from better informed consultations, examinations and care decisions. Through the data exchange system, they also experience time savings from faster treatment or avoided consultations. Healthcare professionals in the hospitals mostly benefit from being better informed. They are also relieved from unwelcome work, such as manual coding and typing reports. Hospital managers benefit from HIS providing additional information for decision making. Hospital staff, private practitioners, and their staff experience further alleviation of work from the data exchange service. The identified costs for HIS and the data exchange system include the financial investment for ICT, but also all negative impacts of implementing the system. As for HIS, the organisational cost include increased time requirements to digitalise external paper records, disruption of work due to capacity overload at workstations, and a temporary reduction in productivity during the period of adaptation. In comparison to HIS, the costs of the data exchange service are marginal.

The socio-economic evaluation, based on cost benefit analysis, shows the rapid realisation of annual net benefits in year three and five of the whole lifecycle, with a dip into net costs in between. This pattern is explained by the implementation of HIS in two different hospitals in 2001/2002 and 2004. The short time to reach a net benefit is below average timescales found in other sites and reflects the deployment of a mature and ready-to-use ICT system. The impact of the data exchange service accounts for only about 1% of annual costs and a similar share of annual benefits. Thus the start of data exchange in 2007 between Hospital Kolín and

GP/specialist practices and in 2008 between Hospital Kolín and Čáslav is a small part of the annual cost and benefit curves.

A positive cumulative net socio-economic benefit is achieved in 2006, only six years after the initiatives started. Due to the consecutive implementation of HIS, the cumulative costs curve displays two humps and increases gradually after 2006. The rate of increase of cumulative benefits also stabilises from year 2006 onwards, but at a rate significantly higher than the stable rate of increase in costs. The gap of only one year between the realisation of annual net benefits in 2005 and cumulative benefits in 2006 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 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 +0.54 at year three, turns negative in year four and rises to +1 and above at year four of the evaluation period. The first dip reflects the temporary reversal into net costs due to Hospital Kolín's investment in HIS. Another dip of the ratio is experienced in 2007, reflecting the negative impacts associated with the implementation of the data exchange service. The increasing annual ratio in the later years of the evaluation timeframe is unusual compared to other sites and shows the extra impact of exchanging patient data between healthcare facilities. The cumulative net benefit to cost ratio turns positive in 2006 and increases steadily. By 2010, the cumulative net benefit to cost ratio reaches +0.95, meaning that for every CZK 100 worth of negative impact, there are CZK 195 worth of positive impact. This indicates an overall socio-economic return from the health data and exchange network of more than 95% over a lifecycle of 10 years.

Estimated costs, including investment costs, are borne almost entirely by the hospitals with some non-financial input by GP and specialist practices as HPOs. Their benefits account for around 59% of the total benefits. Healthcare providers as individuals bear approximately 11% of the entire costs and reap 36% of the benefits. This unusually large share of the benefits reflects the extremely positive feedback by users of the system. Patients receive 5% of the overall benefits. Third parties are the only group that has constantly negative net benefits. This is explained by the potential increase in expenditure to insurance companies associated with more precise coding and billing, and the knowledge transfer carried by the vendor.

Similar to other sites, the financial classification of benefits shows that only 2% of the benefits, about CZK 4.8 million, is extra released finance. This compares to 22%, or some CZK 31 million, of extra financial costs related to the investment. The financial investments are more than offset by the redeployed and non-financial benefits amounting to a value of some CZK 270 million.

The Kolín-Čáslav health data and information network illustrates what interoperable electronic health record systems can do for healthcare provision in a hospital environment and how data exchange between healthcare facilities can evolve from existing eHealth infrastructure. At the same time, readers should be aware that results achieved in the network are above average; an artefact of the EHRI study design.

The success factors include the importance of integrating clinical and non-clinical systems into one EPR-centred HIS; a radical implementation strategy that fitted the system and the organisational culture; continuous user involvement; and ICT supporting cooperation in the network.

1 Background

1.1 Health system setting

The healthcare system in the Czech Republic is characterised by three main features:

- A social health insurance with universal membership, funded through contributions by individuals, employers and the state
- Diversity of provision, with mainly private ambulatory care providers and public hospitals, which have contractual arrangements with the insurance fund, and
- Joint negotiations by key players on coverage and reimbursement issues.

The Ministry of Health (MoH) represents the main decision making level for healthcare policy and controls some of the healthcare institutions and bodies participating in the protection of public health.

Healthcare services in the Czech Republic are provided by primary healthcare organisations and specialised outpatient physicians' offices, and hospitals providing secondary and tertiary care. Citizens are registered with a primary healthcare physician, a general practitioner (GP) of their choice, and can re-register with a new doctor every three months. Patients are also free to choose the specialists they want to be treated by. A referral by a GP is not necessary, yet recommended. Primary healthcare physicians, who have contracts with health insurance funds, usually work in solo practices outside of the hospital. Specialised ambulatory medical services are provided in various forms: in solo practices, in polyclinics, and in hospital outpatient departments, all of which function according to contracts with the health insurance funds.

Hospitals are owned either by the state or by private for-profit and not-for-profit organisations, and it can be distinguished among hospitals managed directly by the Ministry of Health, regional, municipal and town hospitals, private hospitals and church hospitals. At the end of 2006, there were 191 hospitals in the Czech Republic. 19 hospitals are directly administered by MoH and 3 hospitals by other central organisations. There are 70 hospitals that are administered by the regions, cities or municipalities. The other 77 hospitals are either private or run by the church.¹

The Czech healthcare system is funded through several sources. In 2007, statutory health insurance payments accounted for the largest share in the structure of total health expenditure (78.4 %), followed by out-of-pocket payments and private resources of finance (14.2 %), and taxes (7.4 %). The relative proportions of these components have remained roughly the same in recent years. Faster increase is only registered in private expenditure consisting mainly of expenses of households. Total expenditure on health increased from 2006 by CZK 15,723 million and amounted in absolute value to CZK 236,601 million in 2007. This total expenditure on health represents 6.7% of GDP in 2007.

There are currently nine health insurance funds, which collect the contributions, contract with providers and reimburse providers for their services. The largest health insurance fund is the General Health Insurance Company (GHIC).²

¹ Institute of health information and statistics of the Czech Republic (2008): Economic information on health care 2006 (in Czech), p.24. Available at http://www.uzis.cz/download_file.php?file=3396

² Institute of health information and statistics of the Czech Republic (2008): Czech Health Statistics 2007, p.191. Available at: http://www.uzis.cz/download_file.php?file=3472

The main form of reimbursement to primary care physicians is capitation³. Services such as preventive examinations or visits to patients' homes are paid under an additional fee-for-service system. In contrast to GPs, specialists are paid through fee-for-service payments only, with limits on the volume of services reimbursed.

Since 1997, hospitals have been financed through an annual budget, based on the resources employed during the previous calendar year. Reimbursement takes place by billing insurance companies for services, up to the set budget. Starting in 2001, hospitals receive a flat fee on the basis on the number of treated cases in each hospital in addition to the budget.⁴

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

In the Czech Republic, an eHealth strategy has been in place since 2002. This National Action Plan, eEUROPE+ Czech Republic, stresses the government's intent to promote the deployment of the latest ICT. It expresses the view that ICT use is an essential condition for improved affordability and quality of healthcare to citizens. Currently, the Ministry of Health has the greatest impact on policies related to eHealth development in the Czech Republic. However, insurance companies are also active in the field, driven by efficiency considerations. The objectives laid down in the eHealth strategy included among others⁵:

- The creation of an information network connecting points of care in the Czech Republic to other points in the EU, thereby enabling the sharing of public health data and coordination of activities in the event of life and health emergencies
- Ensure activity from the insurance companies to establish the electronic portal for reimbursement and help to make healthcare professionals become more capable and more extensive in their use of ICT.

In line with these objectives, the health insurance companies created a joint portal⁶, available to citizens and healthcare providers for dealing with the insurance and reimbursement system.

Since 2002, electronic health records and ePrescribing have advanced to the forefront of the political agenda. Their increasing importance is documented by various ongoing activities, including the set-up of an interdepartmental coordinating committee for the implementation of eHealth in the Czech Republic in 2007⁷. Numerous round table discussions and seminars toward the eHealth development in the Czech Republic have taken place under the auspices of the Minister of Health since 2007⁸. Herein, interoperability and data standards, as well as ePrescribing and electronic medical records played an important role. Other activities on the national level include the implementation of IZIP⁹, an electronic health record with internet

³ European Observatory on Health Systems and Policies (2005): Health Systems in Transition. HIT summary: Czech Republic. Copenhagen: World Health Organisation, Regional Office for Europe, p.5. Available at: <http://www.euro.who.int/document/e86823sum.pdf>

⁴ European Observatory on Health Systems and Policies (2005): Health Systems in Transition (HiT) Czech Republic. Health System Review. Vol. 7, No. 1., Copenhagen: World Health Organisation, Regional Office for Europe, p. 74. Available at: <http://www.euro.who.int/Document/E86823.pdf>

⁵ European Commission (2007): eHealth Priorities and Strategies in European Countries. eHealth ERA Report. Towards the Establishment of a European eHealth Research Area. Fact Sheet eHealth ERA (2007): eHealth strategy and implementation activities in the Czech Republic. Available at: <http://www.ehealth-era.org/database/database.html#czech>

⁶ <http://www.portalzp.cz/>

⁷ <http://www.mzcr.cz/Pages/345-informace-o-zrizeni-mezirezortniho-koordinacniho-vyboru-pro-zavedeni-ehealth-v-ceske-republice.html>

⁸ <http://www.ehealthforum.cz/dokumenty>

⁹ <http://www.izip.cz/>

access, as well as ongoing efforts in developing international patient summary and ePrescription services in the frame of the European Patients Smart Open Services (epSOS) project¹⁰.

Starting in January 2009, a national ePrescription project was launched under the responsibility of the State Administration for Drug Control¹¹. Doctors and pharmacies are expected to be connected to the ePrescription system by the end of 2009.

¹⁰ <http://www.epsos.eu/>

¹¹ http://www.who.int/goe/ehir/2009/21_january_2009/en/index.html

2 The Kolín-Čáslav health data and exchange network

2.1 Organisations involved

The cluster of organisations in the Kolín-Čáslav health data and exchange network includes:

- Regional Hospital Kolín (Kolín District)
- Hospital Čáslav (Kutna Hora District)
- Hospital Ricany (Prague-East District)
- 29 GPs and specialist practices in and around Kolín.

Kolín Hospital is a regional hospital with a bed capacity of about 550. The hospital employs some 600 doctors and nurses. Around 20,000 inpatients and 300,000 outpatients - including some 4,000 emergency patients - are treated at the hospital every year. The twelve departments at Hospital Kolín include internal medicine, geriatrics, neurology, paediatrics, gynaecology, surgery, anaesthesiology and resuscitation (AR), orthopaedics, urology, otolaryngology (ENT), ophthalmology, dermatovenerology and paediatric surgery¹².

The municipal hospital in Čáslav is a secondary care facility covering five specialties, internal medicine, gynaecology, surgery, paediatrics, and geriatrics. Ambulatory care is offered in the departments and in rehabilitation (RHB), psychiatry, and the pain clinic. Complementary services at the hospital include, among others haematology, biochemistry and radio-diagnostics. Running on an annual budget of CZK 160 million, the town hospital employs about 160 doctors and nurses and provides 190 beds. Every year, Hospital Kolín treats around 7,000 inpatients and 20,000 outpatients, among which are about 1,000 emergencies.

In the network are 10 GP, 6 paediatric, and 13 specialist practices in and around the town Kolín. GP practices usually serve about 1,750 and paediatricians 900 patients¹³.

Hospital Ricany has denied the offer to be part of the evaluation.

2.2 Context of the initiative and eHealth dynamic

2.2.1 Context and developments

Before having an integrated HIS, the hospitals in Kolín and Čáslav faced similar problems: Both hospitals operated in a semi-paper-based environment and ran separate IT systems that were scattered across the hospital. With their predecessor IT system, Hospital Čáslav maintained electronic patient records for outpatients only, while inpatients' paper records were stored in paper archives. The predecessor IT system at Hospital Kolín contained some limited clinical information, but did not cover all departments. The availability of patient data was confined to the single department and sharing of information inside the hospital was hampered by tedious search in different archives.

¹²Institute of health information and statistics of the Czech Republic (2007): Health Care in Statistical Data Region 2006 (in Czech), p14. Available at: http://www.uzis.cz/download_file.php?file=3218

¹³ European Union of General Practitioners (2007): Czech Republic - National Report 2007. Available at: www.uemo.org/members/docs/2007/07-046/UEMO%202007-046.doc

Hospital Čáslav rolled out the integrated HIS in October 2001, followed by Hospital Kolín in May 2004. In both cases, the decision for HIS was strongly management-driven and based on the belief that the use of IT will increase the quality of care and serve users and patients. Triggers for moving forward included healthcare professionals' burden of cumbersome work, such as compiling long medical reports, or manual coding of medical services for reimbursement from the health insurances.

Today, both hospitals use similar configurations of the same HIS, to which a number of additional IT systems are linked. The hospitals run PACS linked to HIS, with Kolín starting in 2004 and Čáslav in 2006. In addition to the clinical information modules, software for administration, stock management and billing, and a management information module are connected to the HIS. The latter forms the umbrella application linking and integrating clinical information on one side and administrative and economic data on the other. Thus, healthcare professionals and management staff can access the information they need from a single interface. A feature special to Čáslav Hospital is their "SharePoint" for all medical staff. SharePoint enables access to internal documentation, services for employees, and economic data from the management module. The links between management systems and clinical electronic patient records (EPRs) stored in the HIS at Kolín are currently less developed. The focus of these links in Kolín is on administrative, including reimbursement, aspects.

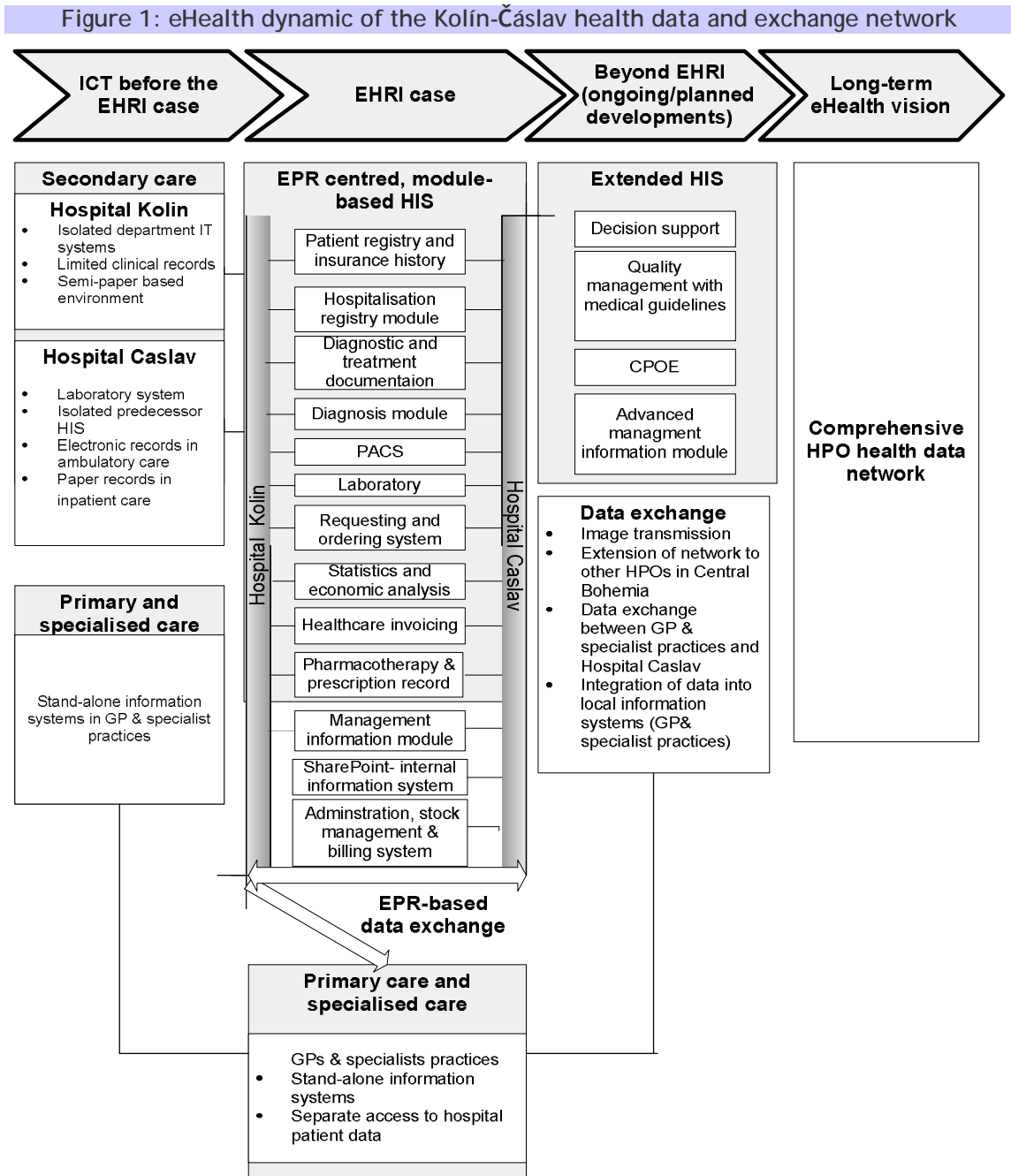
In early 2007, Hospital Kolín and private practices in and around Kolín started exchanging medical data electronically. Hospital Čáslav joined the network in 2008, by exchanging data with Hospital Kolín. Meanwhile, Hospital Čáslav has also started exchanging data with other private practices around Čáslav. The hospitals also have one-way ICT links to different laboratories. The lab test results are sent electronically and feed the patients' health records within the hospitals.

The idea to build an information exchange network between Hospital Kolín and GP and specialist practices was triggered by structural changes at the hospital. In 2003, GPs and specialists previously practising in the hospitals' premises and simultaneously working for the hospital had to choose between the two employment relations. A number of doctors established private practices. This created geographically dispersed healthcare provision to the same cohort of patients. To facilitate the information flow on these patients, Hospital Kolín invested in enabling electronic data exchange with GP and specialists' offices. One specialist has installed the single-practice version of the HIS used in the hospitals. This enables a two-way exchange and automatic integration of medical data into the respective local system. Other practitioners use a web application to view data sent by the hospital. By bearing the costs for connecting the private practices to the data exchange system, Hospital Kolín also aimed at creating a favourable environment for facing upcoming competition in healthcare. With medical data transferred conveniently through the data exchange server, Hospital Kolín expects private doctors to be more inclined to refer their patients to the hospital for clinical exams rather to private competitors.

With regard to the data exchange between hospitals, the expectation was to reduce the efforts associated with handling outgoing and incoming patient information, as well as improvement in the quality and speed of information exchange. As a regional hospital, Hospital Kolín has a broader range of medical facilities and devices than smaller hospitals in the regions, such as the one in Čáslav. Patients from other hospitals in the district are referred to Hospital Kolín for special examinations such as CT or ultrasound, triggering a significant need for data exchange.

eHealth dynamic and future developments

The developments with respect to the use of eHealth have created their own dynamic, depicted in Figure 1 below.



Plans for the future include the exchange of images between health service provider organisations (HPOs) and the extension of the data exchange network to more HPOs in primary and secondary care. Today, only the radiology reports are transmitted through the data exchange network. As for extending the network, several healthcare facilities in Central Bohemia (Nymburk, Kutna Hora, Mestec Kralove, IKEM Praha) are already planning to be connected in the near future.

Within the HIS, the dynamic of further refinement and development is also evident. Integrating the existing information and features further will allow an EPR-based decision support system, as well as more complex computerised physician order entry (CPOE) modules to be included.

2.2.2 The scope of the object of evaluation

The EHRI evaluation includes the EPR-based HIS in the hospitals in Kolín and Čáslav, as well as the exchange of patient data between these two hospitals, and between Hospital Kolín and private-practice doctors. Due to the historical development and the current level of advancement, the impact of HIS is disproportionately larger to the impact of data exchange. Compared to the HIS, data exchange is a relatively new activity at the evaluation site. Nevertheless, special extracts from the overall analysis will bring some insights on the effects of interoperability and connectivity between healthcare facilities. The primary object of evaluation, and thus its scope, is the joint impact - positive and negative - of the Kolín-Caslav health data and exchange network.

The focus of this evaluation is clinical patient data. At the same time, HIS connects to various non-clinical modules and thus sets the backbone for all information flows within the hospitals. The scope of the evaluation covers both medical and non-medical components of HIS.

Concerning data exchange, the analysis includes all direct exchange of parts of medical records, such as radiology reports. Email is excluded from the scope. The input of laboratory test result electronically received from laboratories external to the hospitals and private doctor practices are also outside the scope of the quantitative evaluation. The reason for this distinction is the focus on sharing EHR data, so information already included in an EHR.

As stated in section 2.1 above, there is third hospital connected to the data exchange network, Hospital Ricany in the Prague-East District. The evaluation team was not given access to this facility. Consequently, the Ricany hospital is outside the scope of the quantitative and qualitative socio-economic impact analysis.

2.2.3 Excursion: The Pilsen medical records network (Western Bohemia)

While the detailed case analysis focuses on Central Bohemia only, the description extends to another cluster of healthcare provider organisations in Western Bohemia. It has to be stressed that these are two distinct medical data sharing networks, using the same ICT products. While the network in Central Bohemia has Hospital Kolín as its hub, the one in Western Bohemia is surrounding the University Hospital Pilsen.

The cluster of HPOs surrounding the University Hospital Pilsen includes:

- Town hospital Stod
- Hospital Janov
- Hospital Cheb
- Dialysis centre Braun
- 1 GP office

The University Hospital in Pilsen has about 66,000 inpatients per year at three independent premises and provides some 980,000 outpatient consultations annually. The University Hospital is directly managed by the Czech Ministry of Health and ensures the basic medical care for the area of the Pilsen Region with a catchment area of about 550,000 inhabitants. It offers specialised and so-called super-specialised medical care for 850,000 inhabitants in the Pilsen and Karlovy Vary Region. Diagnostic services include computerised tomography (CT), magnetic resonance (MR) and positron emission tomography (PET).¹⁴

¹⁴ University Hospital Pilsen (2007): Overview of the University Hospital. Available at: www.fnplzen.cz/dokumenty/eng.doc

Town hospital Stod provides in- and outpatient care in the following basic medical disciplines: internal medicine, surgery, paediatrics, gynaecology and obstetrics. It also offers social care on its premises. The hospital has approximately 250 employees and provides over 200 beds. Situated 25km from Pilsen, the hospital in Stod closely cooperates with the University Hospital Pilsen.¹⁵

Hospital Janov is a hospital specialising in tuberculosis and respiratory diseases. The hospital has more than 200 beds and is run by a team of some 130 employees, providing both in- and outpatient care. Hospital Janov cooperates intensively with the University Hospital Pilsen in the field of highly specialised services.¹⁶

Hospital Cheb is an organisational unit of the Karlovy Vary Regional Hospital and has some 300 beds. The hospital provides basic and specialised care in a catchment area of 80,000 to 100,000 inhabitants.¹⁷

2.3 The health services affected

By its design, the EPR-centred HIS affects most hospital activities. This covers everything from registration, admission and re-admission, transfers, discharge, and consultations, to laboratory and other examinations, inpatient and outpatient treatment, surgery, and reporting to authorities for public health purposes as well as reimbursement. At Hospital Čáslav, further services affected include social care and rehabilitation.

The exchange of patient-specific, clinical information affects services provided both in primary and secondary care. These services include referrals between hospitals, especially for radiological examinations, and referrals from GPs and specialists to Hospital Kolín.

2.4 Components and functionalities

The component and functionalities of the eHealth implemented around the Kolín healthcare provision hub are directly related to the hospital information systems at the respective hospitals. On the inter-organisational level, the HIS with its integrated medical records form the basis for exchanging patient data, a first step towards seamless healthcare provision within and between healthcare providers.

Hospital information system and its EPR

The hospital information system can be described as the “backbone” to which different medical modules and applications are connected. The HIS is based on the principle of clinical events. A clinical event is an instance of contact between the patient and the healthcare provider, such as a diagnostic examination, a surgery, or a hospitalisation. Clinical events represent essential units in the health service delivery process. Clinical events can be categorised and presented to the healthcare professional according to:

- Patient - as a chronological summary of patients' procedures, examinations and treatment
- Clinical event type - as a summary of all selected procedures and treatments, e.g. all heart surgeries, all lab results

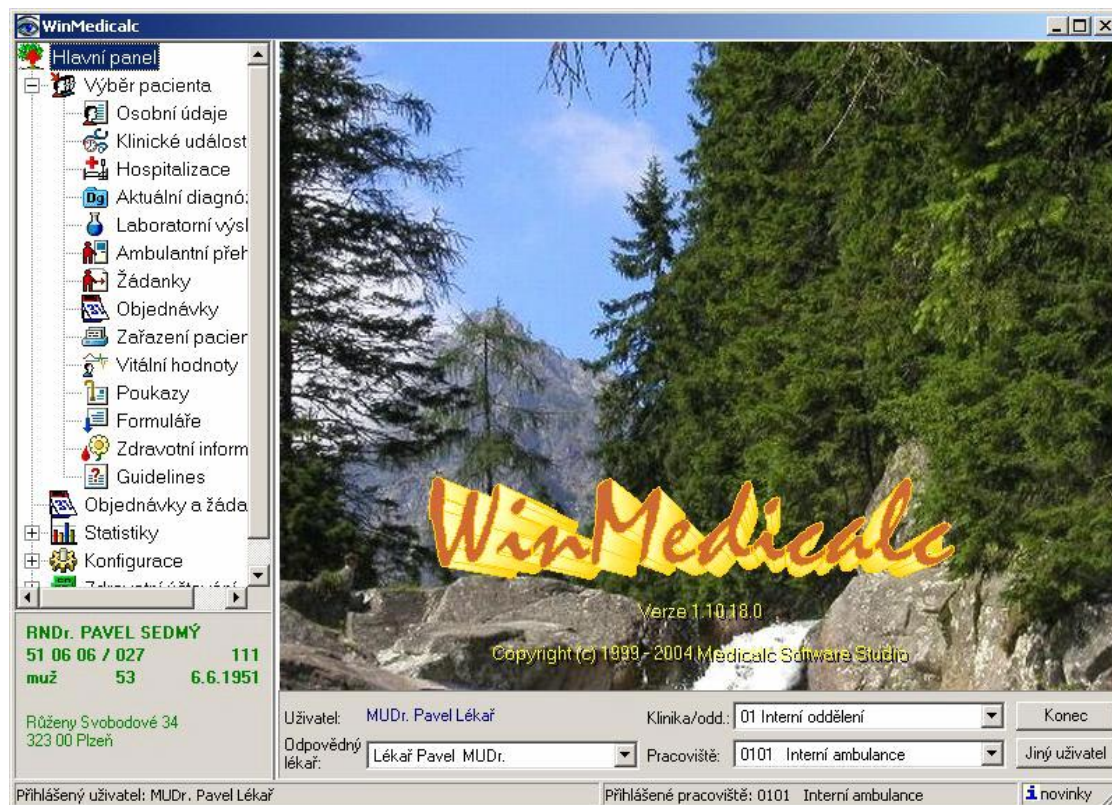
¹⁵ Hospital Stod (2007): Annual report 2007 (in Czech). Available at: http://www.nemocnice-stod.cz/soubory/vyrocnni_zp/VZ2007.pdf

¹⁶ Hospital Janov (2007): Annual report 2007 (in Czech). Available at: <http://www.janov.cz/>

¹⁷ Hospital Cheb (2008): Introduction. Available at: <http://www.kkn.cz/php/script/main.php?ac=uvod&typ=ch>

- Requesting department - as a list of examinations, which were ordered by a department
- Department in charge - a list of activity for the respective department
- Hospitalisation - as part of the clinical record
- Date and time of request, order and execution of the order.

Figure 2: HIS graphical user interface



Source: Medicalc software s.r.o.

The HIS consists of the following modules that store and administer the EPR and thus support the respective hospital activities:

- Patient registry and insurance history
 - Generalisation of insurance companies' code-books to the code-book of insured persons
 - Verification of insurance records at the General Health Insurance Company interface
- Registry of hospitalisation
 - Structured chronological overview on hospitalisation on hospital, department and ward level
 - Collection of medical and invoicing data
- Modules of diagnostic and treatment documentation
 - Information on orders, stage of completion, type of clinical event, medical staff involved, invoice and reimbursement status
- Picture Archiving and Communication System (PACS)
- Diagnosis

- Recording of in-coming and final diagnosis, operation diagnosis and evidence of patient actual and chronic diseases
- Clinical record
 - Centralised patients registry to which all medical documentation and data is bound
- Laboratory module
 - Automatic import of lab results from the data standard interface provided by Ministry of Healthcare
 - Transfer of lab results into medical reports
- Healthcare invoicing
 - Covers health accounts, invoicing, DRG optimisation, data transfer to health insurance companies, economic analysis etc.
- Statistics and general data queries
 - Support of economic analyses and clinical research
 - Provision of (managerial) statistics
- Pharmacotherapy and prescription record
 - List of current and past medications
 - Enabling price comparison and search for generic errors due to linkage to code book
- Requesting and ordering system
 - Creation of request forms for various types of examination or treatment
- Administration and application of General Health Insurance code books to hospital specific code-books.

Data exchange components & functionalities

The medical data exchange system enables the flow of information from hospitals to private practitioners and between hospitals. The data exchange between different healthcare provider organisations is based on the interplay between HIS, an exchange server and a client application.

Reports and data exchanged between the hospitals in Kolín and Čáslav is automatically integrated into the receiving hospital's records system. Most of the non-hospital healthcare providers use the web-based client application to query the exchange server for incoming data on their patients. Medical reports and laboratory results are then displayed over a standard web browser. These data are read-only and not integrated into the private doctors' patient information systems.

2.5 The system in practice

The HIS at Kolín is currently used by about 150 physicians, 480 nurses and 290 other hospital staff, such as paramedics and medical assistants. Hospital Kolín stores clinical records of approximately 360,000 patients and about 1.5 million clinical events. The HIS at Hospital Čáslav contains electronic health records on 120,000 patients and the system is used by 50 physicians, 148 nurses, 59 other hospital personnel.

Doctors and nurses are the main users of HIS at the hospitals. Nurses are authorised to access the patient records with the same level of detail as doctors, as long as the patient is treated

in their department. However, nurses are more focused on working with modules such as requests, ordering, and invoicing. Clinical entries into the records are predominantly done by doctors. This may include current diagnosis and prescription information, as well as entries from paper reports brought by patients from other HPOs.

The patient's journey throughout the hospital is continuously recorded by HIS. It records every clinical event on hospital, department and ward level. 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 listed in HIS. This documentation is an integral part of the information needed for diagnosis and treatment related decision making.

Depending on their information needs, doctors can use HIS to see a summary of all examinations and treatments. Alternatively, they can have the information ordered according to clinical event types on a certain patient. A set of demographic and essential medical patient information like name, date of birth (DoB), insurance status, and known allergies are always displayed on the interface, regardless of the specific module currently accessed by the user.

The diagnosis module in HIS allows doctors to document a diagnosis for clinical, but also for invoicing or statistical purposes. Here the doctor can easily select the International Classification of Diseases (ICD) code for the diagnosed medical condition, or enter free text. The diagnosis can be further used and copied into medical reports. When creating medical reports doctors are supported by the following options:

- Fall back on pre-defined templates
- Choose from and use previously provided examinations and test results
- Select pre-defined texts as well as the patient's diagnoses and information from the patient's medication list.

Selected lab and examination results, as well as the final diagnosis, can be easily edited and transferred into the discharge letter through the clinical record module in HIS.

Based on the patients' 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 used for invoicing to health insurance companies.

Specific to Hospital Čáslav is the extensive use of an interconnection of medical and economic data for management purposes. The hospital management utilises this connection to monitor the development of patient numbers and events over time, the services provided in every part of the hospital, or the utilisation of medical devices. Another practice unique to Hospital Čáslav is to record „unusual events“ in HIS. Healthcare staff can choose from a list of one of 18 pre-defined categories, or use free text to document events, varying from the breach of rules by patients to an outbreak of nosocomial infections.

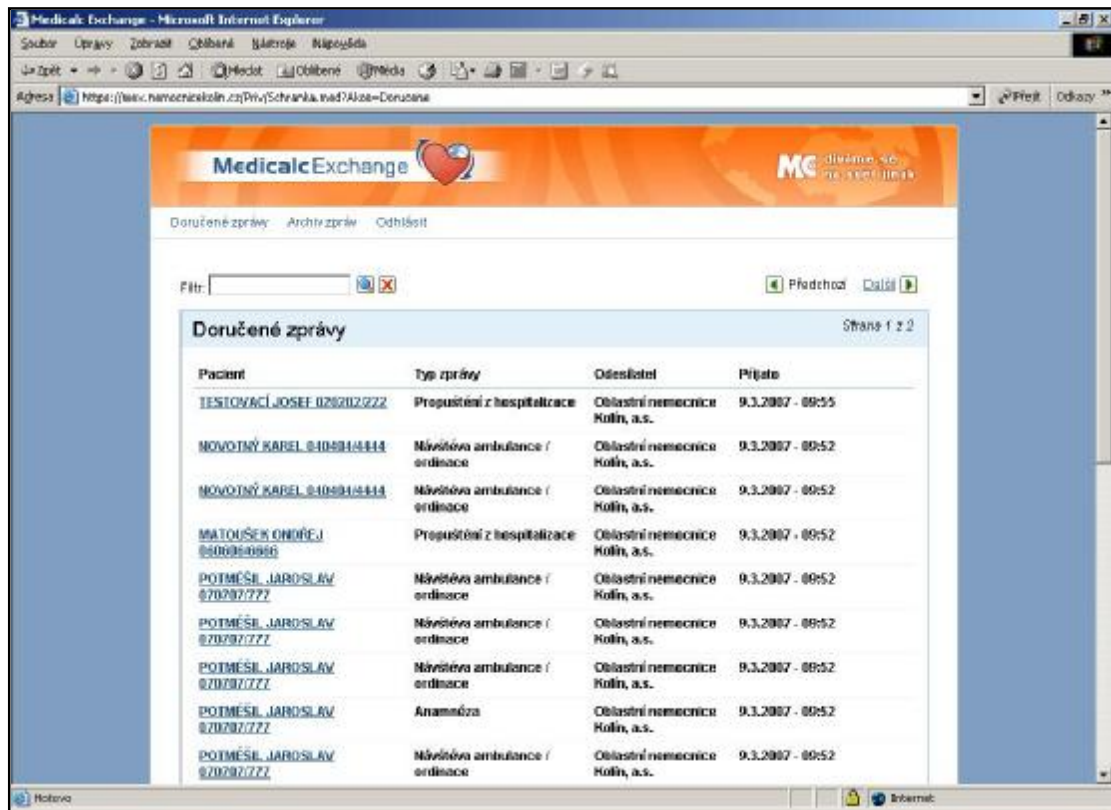
Data exchange system

The data exchange system is used by healthcare professionals in the hospitals Čáslav and Kolín to request and to receive specific medical reports on patients from each other. The exchange between these HPOs is based on the respective information systems, linked via the medical exchange server. The flow of data is mainly from Kolín to Čáslav as patients are sent from Čáslav to the regional hospital for highly specialised tests available only at Kolín.

In primary care and specialist practices, the flow of data is primarily one-way with the hospitals sending medical data to the medical exchange server. Most of the practices use a client application to the exchange server, accessed via secure internet connections. Every time a patient registered with the GP or specialist is treated in the hospital, the respective doctor is made aware of this through the system. By logging into the online application, doctors and support staff can view a list with their patients, the type of data received, the

origin of the sender, and the time the item was sent. The user can then click on every single item in order to view the full medical report. The web-browser view is illustrated by the screenshot in Figure 3.

Figure 3: User interface of data exchange client application



Source: Medicalc software s.r.o.

The number of data items exchanged with Hospital Kolín has increased from some 18,300 in 2007 to over 44,500 in 2008 indicating a growing potential and usefulness of the service.

Of the 29 GPs and specialists in their private practices, one dermatologist uses the ambulatory version of the HIS implemented at the two hospitals. This practice can send and receive data to and from Hospital Kolín and integrate incoming information into the own system, ensuring a two way data exchange.

2.6 Technology

The HIS and the components enabling data exchange were developed and implemented by a small Czech private software company called Medicalc software s.r.o.¹⁸ Both at Hospital Kolín and at Hospital Čáslav, additional software from other vendors are still being used or have been added after implementing HIS. These include laboratory information systems and non-clinical administrative software, partially or fully integrated with the HIS.

¹⁸ www.medicalc.cz

2.6.1 Architecture

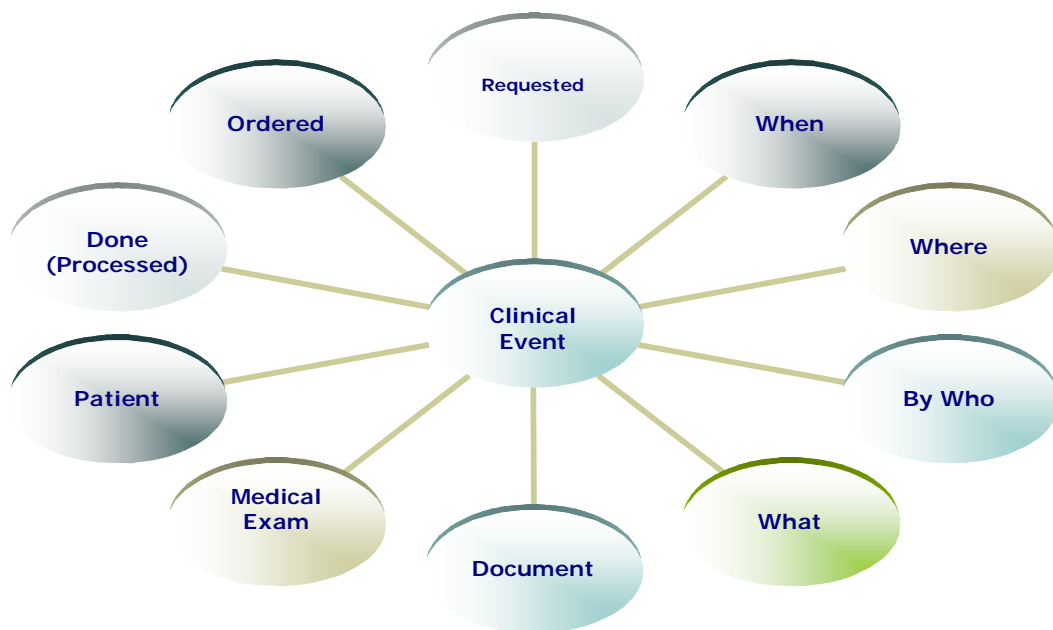
The Kolín-Čáslav health data and exchange network is based on the following products:

- The hospital information system WinMedicalc (WM)
- WMPacs - picture and multimedia archiving and communication system, using the DICOM3 standard
- MediGain - management information system
- MEx - an exchange server application for secured sending of clinical records.

Architecture of HIS

The HIS architecture is represented by a hierarchically structured data model, which follows the principle of clinical events. Thus the architecture resembles the organisation of data in a paper-based environment. Each clinical event is defined by meta-data, such as demographic patient data and indicators of the source and timing of data entry, and data carrying clinical information, such as examination results, discharge letters and other clinical reports. Figure 4 provides an overview.

Figure 4: Definition of clinical events



Source: Medicalc software s.r.o.

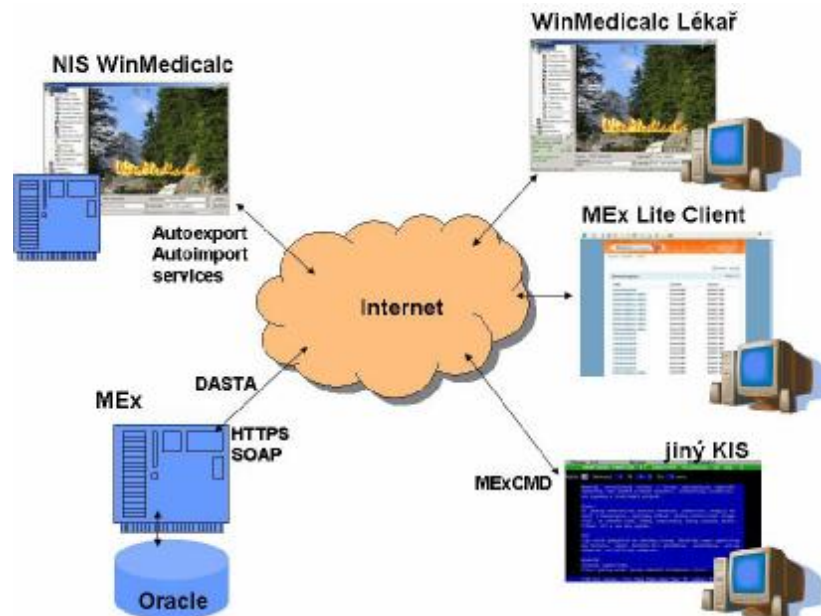
The data defining the clinical events is stored in an Oracle database and forms the core of the metadata model. All structured information is derived from this core data. Particular modules (see section 2.5) are connected to this core data. Based on these modules and their separation, it is possible to create new medical modules, which can be interlinked to already existing ones.

Architecture of the data exchange network

As described in section 2.5, the data exchange between Hospital Kolín, Hospital Čáslav, and private GP and specialist offices is based on the HIS and the data exchange server. In the HIS at the hospitals, medical records are stored in an Oracle database. Selected parts of these records are then transferred to and stored in a separate database through a secured medical

exchange server. The data is transferred in the DaSta format, the data standard defined by the Ministry of Health, version 3 and higher (DaSta 3). The web services are based on Simple Object Access Protocol (SOAP) for communication and Web Services Description Language (WSDL) for the interface to the data exchange server.

Figure 5: Architecture of data exchange network



Source: Medicalc software s.r.o.

The data stored on the data exchange server database can be automatically imported into the receiving hospital's HIS. This data is then integrated into the respective patient's record.

GP and specialist practices in the data exchange network access the client application on the Internet, with a basic access certificate. The access certificate is located on the side of the server and on the side of the client. The server checks the authenticity of the client certificate and the classification of certificate of the connection client. At the private practices, access certificates are saved on a Public Key Infrastructure (PKI) chip card and therefore located outside the personal computer. Using the client application, medical data are view-only and not transferred into the private practitioners' ambulatory systems automatically. Technically, data integration would be possible with an additional application linking the data exchange server with stand-alone GP or specialist IT systems.

2.6.2 Security and confidentiality

At the Hospitals Kolín and Čáslav, the electronic patient records are securely stored in an Oracle database. The data is saved directly to the server. No data remains on the PC, eliminating the risk of data loss or misuse related to incidents at the easily accessible local level.

Security and confidentiality on the hospital level is ensured by the usage of passwords, access control, and secured Internet access using an encrypted channel and a firewall. Every access to HIS, including both reading and data entry is documented in a log.

The security and confidentiality of patient data determined for data exchange is based on the transfer via a secured exchange server. All data is being sent through a HTTPS secure communication channel and thus in encrypted form. On the side of GPs and specialists, the

access to the client application is secured by a password, a client certificate, and a PKI chip card. This certificate has to be renewed every 12 months. With every log-in, the user's client certificate is verified with the certificate located on the data exchange server before any patient data is made visible to the user.

2.7 Level of interoperability

Of the three EHR IMPACT (EHRI) interoperability classifications of potential interoperability, limited connectivity, and extended actual connectivity, the health information network surrounding Hospital Kolín falls partly in the second category of **limited connectivity** and partly the third category of extended **actual connectivity**. Real interoperability exists on hospital level, as selected parts of the EPR are exchanged between the hospitals and directly integrated into the respective HIS. This part of the network supports both semantic and technical interoperability. The interoperability, interoperation, and thus facilitated collaboration cover teams of doctors, nurses, other health professionals, and management at the Hospitals Kolín and Čáslav. Informal cares and patients have no direct access to the EPR in HIS, which is in line with the design of HIS - to support health professionals and managers in their daily work.

As for the data transfer between hospitals and primary care providers, only potential interoperability exists. The patient information systems at private practices are mainly stand-alone systems. Thus, in terms of the level of interoperability, the HIS is classified as having **local and regional connectivity**. The entire data exchange system including private practices, however, has not reached regional connectivity yet.

Table 1: Scope of interoperability of the health data and exchange network

Type of connectivity	Characteristics	Kolín-Čáslav health data and exchange network
Single site	People within teams and between teams in one organisation	Yes
Multi-site	People within teams and between teams in one organisation	No
Regional	People, teams and organisations in one region	Yes (between hospitals)
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 methodology¹⁹: Patients, informal carers and other people, health service teams, health provider organisations and third parties. These actors can be affected by the hospital-specific HIS, the data exchange, or both components of the health information network.

Patients, informal carers and other people

Out of the first category, mainly patients are affected by both, HIS and data exchange. This includes in- and outpatient at the Hospitals Kolín and Čáslav and patients at private GP or specialist practices.

Patients are not users of the system. Generally, they cannot access their patient records and list of clinical events. However, they are directly affected as the HIS and the data exchange service changes the quality of, and access to care, and provides new options for care.

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

Health service teams

This group of stakeholders includes mainly healthcare professionals at the hospitals, but also hospital management. The health professionals' teams at the two hospitals include a total of about 200 doctors, 600 nurses and 340 other hospital staff. They represent the primary users of HIS. Hospital managers mainly use the non-clinical parts of HIS such as the management information system. Due to the focus of HIS on doctors' rather than nurses' working practices, HIS affects doctors to a larger extent. Nurses also utilise HIS in daily work, but have to perform some of their duties without the assistance of HIS. For example, nursing paths are not yet a part of HIS.

The healthcare professionals at Hospital Kolín and Čáslav also represent the primary users of the data exchange system. The data exchange service involves additional users in primary care, namely the 29 private doctors in GP and specialist practices and their support staff.

In this stakeholder group, we regard the healthcare team members as individuals, and not as employees of the hospitals or the private practices. Only the impact on their private lives and their private experience are included in this theme. It is 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 or not even allowing any overall positive impact to be realised.

Health provider organisation

The stakeholders in this group are the Hospitals Kolín and Čáslav as well as 29 GP and specialist practices. In contrast to the health services teams, the focus is on the organisations and the effects of HIS and the data exchange on them. Here healthcare team members, being part of the HPO, are viewed as employees of hospitals and private practices rather than private persons.

¹⁹ EHR IMPACT, D1.3: Methodology for evaluating the socio-economic impact of interoperable EHR and ePrescribing systems

Third parties

Third parties in this case include the General Health Insurance Company (GHIC) and other insurance companies, as well as the software vendor providing the technology for the HIS and data exchange services. The Institute of Health Information and Statistics of the Czech Republic represents a potential third party as it obtains health-related data and statistics from the HPOs.

3.2 Process change

The information network within and between the HPOs does not fundamentally change the traditional health service delivery model from a patient's point of view. There are, however, several important changes associated with the use of the information systems and network in the details of workflow, clinical practices, and working practices. The main differences in the hospitals in comparison with the pre-HIS situation include:

- Instant availability of information previously scattered across different departments
- Change from manual to automatic coding for reimbursement
- Computer-assisted compilation of medical reports.

The main opportunities compared to the time before electronic data exchange are:

- Sending and receiving data between geographically separated locations electronically
- Fast access for private practitioners to information on patients being treated at the hospital.

3.2.1 Workflow

Hospital information system

In the hospitals, the core changes in the workflow of doctors and nurses include the now redundant step of searching for patients' past records, the previously time-consuming typing of medical reports and discharge letters, as well as manual coding for reimbursement purposes.

In the past, nurses had to search for patients' past records in the department, or even central archives. Sometimes records were looked for, but not found. Even when found, records were by no means always complete. Images and reports were sometimes lost or located separately from the rest of the patient record. Another problem was that patient records were scattered across different department's local archives. So patients had to be asked for their previous treatments, or previous discharge letters had to be screened for hints on where to search for old patient records. Today, doctors can see all clinical events when they need them, without additional waiting time. The patient record is more complete and reliable.

Doctors previously had to spend considerable amounts of time on typing medical reports. This job is now facilitated through pre-defined templates in HIS. Parts of medical reports can be simply extracted and re-used in the discharge letter. At the same time, a new step has been introduced into the workflow, as data from external paper records has to be manually entered into HIS. In the past, these paper records would have simply been put into the patient file.

The change from manual coding for reimbursement to automatic coding of hospital services according to health insurers' codebooks represents a drastic change in the workflow. In most of the cases, the step of manual coding previously done by nurses is now redundant. Only complex cases need human attention.

The patient flow in the hospitals has changed insofar as it is organised in a more efficient way. For example, the preparation for hospitalisation at the ward is faster, as healthcare staff are informed by HIS that a new patient is coming. However, the single steps and stages, from registration, through admission, transfer, and discharge, have remained the same.

Data exchange

The data exchange between hospitals and between hospitals and non-hospital care has induced some minor changes in the workflow. Data items, such as radiology and lab reports are now electronically transferred. Paper documents still have to be signed and mailed. This double process will continue until the documentation is fully electronic and digitally signed. At present the exchange of images is not yet technically supported. Thus only descriptions of images can be sent via the data exchange server. At the hospitals, the workflow has also been extended by the process of requesting data items from another hospital. Only then, information can be automatically imported from and exported to the respective HIS.

A significant change for private practices concerns the patient flow from non-hospital care practices to hospitals and back. As GPs and specialists can view their patient's hospital exam results sent via the data exchange server, some patients do not have to come back for a consultation with their GP or specialist. With faster access to discharge letters and other medical reports, the workflow at private practices is shortened by the step of calling hospitals for examination results or clarifications.

3.2.2 Clinical and medical practices

With HIS, the foundation on which decisions on diagnosis and treatment are made is available faster and is more comprehensive. Instead of waiting for relevant patient records to be found in the hospitals' archive the information is accessible immediately at every department and it is reliable. As a result, time loss can be avoided and the quality of the results improved. For example, the information stored in the system helps narrowing down the differential diagnosis when a patient is unconscious. Complications of diseases can sometimes be foreseen and addressed before they occur.

In the past, the insecurity about whether records will be found in a reasonably short time, or be found at all, sometimes led to the decision *not* to search for records before treating the patient. Today the HIS prevents doctors from being faced with the decision on whether to ask for past records or not.

As a result of the data exchange service, private practitioners are informed more promptly and receive a more comprehensive overview of their patients' medical history. For example, they are informed about their patients' hospitalisation the moment their discharge letter is created, and are thus prepared for the further treatment of the patients earlier.

3.2.3 Working practices

Hospital information system

Important changes to working practices include the way to enter data in patient records and the way to access information, such as past diagnostic results, radiology reports, discharge letters and other clinical information on patients.

Previously, hospital doctors would spend large amounts of time on typing medical information for every report and discharge letter. Today, this process is facilitated by the HIS as it provides pre-defined templates and structure. The practice today goes beyond merely free text entry and allows diagnoses to be selected from a drop-down list. Information from

medical reports can be transferred into the final report without re-typing. Structured data entry leads to physicians and nurses improving the quality of data already at the entry stage. The structure and re-usable text blocks also allow for composing reports faster than without HIS.

On the information access side, the main change in the hospitals concerns the way of accessing past patient records. Because of the HIS, healthcare staff do not depend on the archive's office hours. Previously, older patient records were only available during office hours, and not on weekends. With the system, past records are accessed immediately at the point of care by the professional who needs them. More recent records, up to five years old, were stored at the departments and available 24/7. However, this applied only to the information stemming from the respective department. HIS allows all information to be consulted and any time, regardless of its origin or time of creation.

A change of working practice that is unique to Regional Hospital Kolín involves the provision of teaching to doctors training to specialise in radiology. According to internal standards, these doctors have to undergo training by analysing 1,500 images in the first five years of clinical practice. With the HIS in place, training is facilitated by the availability of images and the respective medical reports. Senior doctors thus do not have to spend as much time as in the past to explain images to their young colleagues.

A working process that has changed fundamentally is reporting to the GHIC and other health insurances for reimbursement purposes. Before the implementation of the HIS, a list of procedures and their respective reimbursement codes had to be written on paper and sent away at the end of every month. This task was performed by nurses and involved manual coding. With HIS, a predetermined list of codes is already integrated in the patient records, and codes are displayed next to every clinical event. As a result, the total of services performed on each patient can be identified faster and more easily. Further, the risk of omitting performed services in the reimbursement statement is reduced.

Another process changed by HIS is the shift change between doctors. The patient summary overview provided by HIS allows the doctor taking over the shift to see the list of patients to be treated, their medical condition and a prognosis by the previous doctors on the patients' condition in the next days. The overview complements the coordination between doctors when handing over the patients for the next shift.

There are some additional changes in working practices at Hospital Čáslav. These result from the extensive use of the management information system in HIS and the linkage of clinical and economic data. Information processed with the management information system includes statistics on medical equipment utilisation, staff capacity utilisation, and cost of treatment. In contrast to the situation without HIS, the hospital management at Čáslav is able to derive a volume of information several times larger than before.

HIS facilitates the construction of specific reports for management, like trends over time in terms of patient flows, costs, and productivity. Another example is statistical reports to the Institute of Health Information and Statistics. Instead of manually processing thousands of paper records in order to construct specific reports for these purposes, the reports are now made available through a few mouse clicks. Furthermore, HIS provides reliable information on the utilisation levels of medical devices, thus facilitating decisions on replacements or the volume of purchases in the future.

Data exchange

Through the data exchange between hospitals, less medical information has to be sent by mail or by fax. All medical items, such as laboratory results or radiology reports stay at the hospital that provided the service, but are also made available to other HPOs. The pre-eHealth system did not allow for this automatic multiplication of data. This change will

significantly gain on importance, once images are also being sent via the data exchange network, allowing all HPOs to access the image simultaneously.

At private practices, GPs and specialists access their patient's hospital exam results and medical reports online. In the past, they would only see a printout of the exam results when the patient hands them in or had to make phone calls to the hospital. Further, the GP or specialist is informed about a patient's hospitalisation as soon as he sees the discharge letter through the medical data exchange server. In the past, the doctor would not know this unless he is told by the patient at the next regular consultation.

Finally, GPs and specialists with a stand alone IT system have the chance to directly copy and paste information from the records sent by the hospital into their own system, rather than typing it in from a paper document.

3.2.4 Reaction and acceptance of users

Hospital information system

At the hospitals, the decision for HIS was strongly management-driven. The implementation followed a rather radical approach by involving all hospital departments within less than 12 months. The healthcare staff had to adapt their working procedures to the system rather than using a system that is gradually developed according to their working processes. The hospital management at Čáslav acknowledged that this was a considerable intervention into the physicians' autonomy and quite a painful process.

In spite of the initial problems, HIS was integrated into daily routine after only a short transition period of three to four weeks. Today, the acceptance of HIS by the users at both hospitals is prevalent throughout all hospital activities. As confirmed by interviews with doctors and nurses, the users "cannot imagine working without HIS anymore".

Part of the explanation for the extremely positive feedback by users is the structure of records along clinical events. This structure seems to be the preferred option for doctors and other professionals, as it maps the paper processes they are used to.

Most doctors interviewed point out the ease of using HIS and that information can be presented according to their needs. All feedback consists of suggestions for further improvements and fine-tuning of the system. For example, nurses at Hospital Kolín consider the HIS better adapted to doctors' focus on patient treatment, rather than the needs of nurses. Therefore they suggest integrating nursing care pathways into HIS.

Data exchange

The acceptance of the data exchange service on the side of GPs and specialists is indicated by the development of the exchanged data volume. The number of data items exchanged with Hospital Kolín has increased from some 18,300 in 2007 to 44,500 in 2008 and the number of referrals to the hospital has doubled.

Another indicator of the acceptance of using the data exchange system is that not all GPs and specialists were actively approached by Hospital Kolín for inclusion in the data exchange network. Some of the GPs and specialists would be willing to pay for the access to the data exchange system themselves.

3.3 Timeline and milestones

Our analysis is focused on the timeframe between 2001 and 2010, which includes the implementation of the integrated HIS in its current form in the two hospitals, Kolín and Čáslav, as well as the development and early implementation phase of the data exchange network around the hub of Hospital Kolín. The following milestones are more comprehensive and provide a summary of the story behind the evaluated eHealth solution.

1991: Hospital Čáslav started its ICT development with 4 PCs and 4 printers

1992: Predecessor hospital information system in use at Hospital Čáslav, focus on patient administration and outpatients

1993: Laboratory system in use at Hospital Čáslav

1994-1997: Internal hospital network at Hospital Čáslav

1996: First IT system, including some clinical information, in use at Hospital Kolín

2001: Integrated HIS introduced in October as a trial in Hospital Čáslav. Routine operation started in December

2003: Introduction of the business management software at Čáslav Hospital

2004: HIS running at Hospital Kolín as of May, including PACS and partial integration of management information system with focus on revenue monitoring

2004: Patient catering system at Hospital Čáslav

2005: Management information module added to HIS at Hospital Čáslav and connected to the business management software

2006: Laboratory information system at Hospital Čáslav exchanged

2006: PACS implemented at Hospital Čáslav

2007: SharePoint, an internal information portal for hospital staff introduced at Hospital Čáslav

2007: Data exchange between GP and specialist practices in Kolín and Hospital Kolín introduced

2008: Data exchange between Hospital Čáslav and Hospital Kolín started

2008: 62,500 data items sent and received in the data exchange network.

3.4 Supporting take-up

The take-up of HIS in both hospitals has been facilitated and driven by a supportive and leading management. Initial adaptation problems in Kolín partly resulted from healthcare professionals being used to the predecessor IT system. Although a legacy IT system may have contributed to general IT literacy, in this case it caused considerable irritation to healthcare professionals. In both hospitals, extensive IT support was provided to help the users during HIS implementation. In addition to up to 12 hours of training, the healthcare staff and other users received on-site support from their IT departments and the software vendor during the first week of system roll-out. The software vendor organises workshops at the hospitals whenever a new feature of HIS is released and also provides on-demand support in case of problems during routine operation.

A system for feedback and development requests has been set up. It involves doctors assigned to be HIS representatives in every department. They collect suggestions and experiences of HIS users and communicate them to the software vendor. At Hospital Čáslav HIS representative sent user feedback electronically to a HIS clipboard as a request and receive a note when the request has been processed.

The take-up of data exchange was mainly driven by Hospital Kolín, as the hospital management provided private practices with the technical access without extra charges. While private doctors were approached in the beginning to join the network, some doctors have started to ask to be included in the network. Doctors, nurses and medical secretaries at private practices also received a short training session, yet this did not require any significant efforts, since the scope of complexity is not comparable to the HIS.

3.5 Benefits

This chapter deals with the benefits from the EPR-based HIS on the one hand and those from the exchange of patient data on the other hand. As discussed in section 2.2.2 this analytic separation is meant to allow some insights on the effects of interoperability and connectivity between healthcare facilities to be gained.

Analysing the benefits resulting from the HIS at Hospital Kolín and Hospital Čáslav against the background of the three main types of eHealth benefits, quality, access and efficiency, the most prominent ones are improved efficiency and quality of care. While time savings and cost avoidance can be primarily assigned as HPO benefits, patients mainly benefit from the quality of care and improved timeliness. Healthcare professionals mostly profit from being better informed, investing their time in activities more closely related to their job, and better work satisfaction.

The benefits from data exchange were on a smaller scale than those resulting from HIS. They also fall primarily into the benefit categories of improved efficiency of service, as well as timeliness of care received at private practices and hospitals.

3.5.1 Patients, informal carers and other people

The hospital information systems allow patients and informal carers, such as family members of patients, to benefit from faster access to care and improved quality of health services.

On the quality side, patients benefit directly from better-informed consultations, examinations, and care decisions. The up-to-date and around-the-clock availability of past hospitalisation and patient specific information, such as allergies and medication regimes, reduces the risk of adverse events potentially leading to longer hospitalisation periods. Fast and complete data availability is particularly helpful in emergency cases when the patient is unconscious. In this situation, information from HIS helps physicians to narrow down the differential diagnosis, allowing a more focused treatment. Another tangible benefit to patients is avoided radiation from avoided duplicate radiology examinations - a benefit particularly pronounced at Hospital Kolín. As pictures are available at any time, decisions to take a new picture are sometimes revised when older images of the patient exist and are found to be sufficient.

Further, as documentation is available before the patient arrives, doctors can prepare better for consultations and thus reduce the amount of time spent on going through records brought by, or simultaneously with the patient. The spared time is devoted to more attention to the patient.

Finally, there is a financial impact on patients related to avoided additional days at the hospital due to adverse events. Patients can avoid the co-payment of CZK 60 per day of hospitalisation. This impact is restricted to Hospital Čáslav, as Hospital Kolín does not take advantage of the opportunity to collect these private co-payments from patients.

Patients in non-hospital care mainly benefit from better care as a result of better informed GPs and specialist doctors. They also experience time savings through the data exchange system. Exam results of patients undergoing medical exams at Hospital Kolín are immediately available to their GP or specialist. Patients can be treated faster, as medical information can be viewed by the GP or specialist even before the patient comes in. Some consultations can be saved, when patients do not have to come back to their GP with a print-out of their examination results.

At Hospital Čáslav, it is mainly outpatients benefiting from fast data exchange. Some results of medical tests taken at Hospital Kolín are available at Hospital Čáslav faster than before the data exchange network was established. This is particularly the case for lung scan reports from Hospital Kolín, which can be described by a physician in a few sentences. In these cases, the patients can be treated earlier. In other cases, examinations may entail longer descriptions, which is why it may take a couple of days before the description is finished at Hospital Kolín and can be sent to Hospital Čáslav via the medical data exchange server.

3.5.2 Health services teams

The most important benefit to individuals in this stakeholder group is a general alleviation in their work environment, which is related to the availability and quality of patient-specific information. Both are 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 semi-paper-based predecessor systems at Hospital Kolín and Hospital Čáslav. Access is no longer confined to the archive's office hours and the cooperation willingness and possibility of other departments. Nurses can conveniently consult patient data instead of asking patients the same questions again and again.

The second aspect, quality of data, refers to the fact that the data stored in the HIS is more detailed and complete than the information previously available on paper or in the predecessor systems. This partly results from the obligation of healthcare staff to document every single clinical event in HIS. Sometimes, in the past, healthcare staff wouldn't know where older medical records were located, unless they learn from the patients or look it up in the previous discharge letter. This problem was specific to Hospital Kolín and resulted from the practice to store patient records in different archives at the department or hospital level.

In the past, radiology images from patient records were easily lost, misplaced or never returned to the place they belong. With pictures almost always available (loss-rate <1%) within HIS and other patient-specific data, the system allows the physician to take better-informed decisions and thus be reassured when taking the responsibility for them. Professionals' work is further facilitated by using tools in HIS to find, sort, and group information.

Furthermore, doctors and nurses are relieved from unwelcome work such as typing and re-typing medical reports or manual coding for reimbursement purposes. In the past, doctors had to type in medical reports on a typewriter, which took up to 40 min for patients with complex medical histories. Now they can use pre-defined templates in HIS to compile a report and re-use parts of the medical reports for the discharge letter, reducing the time usually less than 10 minutes. As for reimbursement, coding has largely been automated through HIS, which gives nurses the chance to focus on other tasks, better related to their profession and

specifically their patients. Before HIS, at any one time of the day, one nurse per department was busy with manual coding.

Hospital managers also benefit from HIS and the extended possibility to derive information for activity, financial, and other analyses. Thus, HIS alleviates their work by providing support in decision making.

Hospital staff experience further alleviation of work with the use of the data exchange service. With medical information being sent digitally, healthcare professionals and administrative staff spend less time on preparing and sending letters and faxes. At Hospital Kolín, nurses can now spend less time answering inquiries from private practices and from Hospital Čáslav. At Hospital Čáslav, doctors benefit from receiving information over the medical data exchange server as well. Without this form of data exchange, they would have to feed the information from paper documents into the local HIS manually.

GP and specialists as individuals, as well as their assistants, benefit from extra convenience created by data exchange. Doctors and assistants do not have to call hospitals for examination results and clarifications, and are better informed about their patients' whereabouts. Finally, private doctors have the chance to copy and paste electronically received patient information into their own patient information system instead of typing in all the information.

3.5.3 Healthcare Provider Organisations (HPOs)

Hospital information systems

At the Hospitals Kolín and Čáslav efficiency gains make up the largest part of the estimated benefits from using HIS. A major block of benefit indicators consists of time savings and thus improved productivity.

On the part of nurses, time savings include mainly savings related to the search of past records, and coding and reporting to insurance companies for reimbursement purposes. In the past, the time to search for patient records, which were located at different parts of a hospital, ranged between 5 and over 30 min per record. Also, due to constant data availability in HIS, nurses do not have to ask patients the same questions again and again. Further, nurses save time for carrying examination results from one place to another inside the hospital, which is particularly relevant for a large hospital like Hospital Kolín. Now, lab results can conveniently be looked up at every workstation in the hospital.

Even larger time savings occur from automating coding in the reimbursement process. Before HIS, a list of procedures had to be collected for every patient and coded appropriately. The manual coding was so time consuming that several nurses or administrative staff members per hospital were assigned to this task. With HIS, a predetermined list of codes is already integrated in HIS and codes are displayed next to every clinical event, such as a certain examination or surgery. As a result, the total of services performed on each patient can be identified faster and more easily. Billing has also become more precise, incurring fewer mistakes and thus avoiding potential losses to the hospitals when recording health service items for reimbursement. It is important to stress that the time previously used for coding, searching for records, or manual creation of clinical reports does not result in redundancies. Rather, the time can now be allocated to patient care or other productive activities.

The largest time saving item was found in the process of data entry, since doctors re-use pre-typed texts, instead of having to re-write everything. A number of structured drop-down menus, such as in the diagnosis module, and the option to transfer previously recorded information into the discharge letter speed up the process significantly. This saving can accumulate to up to three hours per doctor per day in some cases. The time saved for the

healthcare teams through the HIS can be reallocated to meet more important healthcare demands.

A significant benefit at Hospital Čáslav related to the documentation in HIS is the time avoided for doctors to clarify their handwriting to others. A time saving in Hospital Kolín stems from using HIS and the integrated PACS for teaching apprentice doctors specialising in radiology. Instead of spending many hours on explaining images to apprentice doctors, senior doctors can use the documentation and complete sets of images in the PACS to make training more efficient and effective.

Additional benefits are generated by the management information module in HIS. HIS has facilitated the provision of information to management and third parties such as the Institute of Health Information and Statistics of the Czech Republic. The benefits derived from improvements in administrative management are particularly pronounced at Hospital Čáslav. The volume of information increased to such an extent, that 3 additional full time equivalents would be necessary to produce the same amount of information without HIS. In addition to recording all clinical events with the exact time of entry, including all orders and requests, HIS also enables the manipulation of clinical and economic data in order to analyse activity, financial implications, and quality indicators. Patient numbers can be broken down to each department, ward and doctor. This allows the hospital management to analyse the provision of care and to plan resources accordingly. The management knows through HIS and the management information module when additional staff is needed, without conducting additional surveys among staff. For example, managers can make changes to staff scheduling if unusual levels of activity are detected at certain times. Decisions on future investments in clinical devices are facilitated by precise utilisation statistics, as they help identify returns and payback periods. The system also informs the hospital management about patient flows, allowing some conclusions on the quality of care provided at the hospital. Furthermore, HIS at Hospital Čáslav contains an extensive list of “unusual events” ranging from breach of rules to nosocomial infections. These events are recorded in HIS and allow the hospital management to better analyse the service provision and general activity at the hospital.

At Hospital Čáslav, the HIS has even paved the way to a budget increase. With HIS and the integrated management information system, the Hospital management was able to demonstrate an increase in the number of certain patients, which reflected the closure of a department in another hospital in the region. By displaying the number of patients from the other hospital's catchments area, Hospital Čáslav is now much better prepared for negotiations with health insurance companies. Further budgetary benefits arise from the better coding processes. The automatic coding and billing procedures reduce the amount of services not billed for. For a number of reasons, time pressure being a main one, some clinical procedures never entered the paper-based activity reports used for reimbursement purposes. The change has again not led to additional income yet, but is putting hospitals in a better negotiation position.

Data exchange

Hospitals and private practices benefit from data exchange in different ways. At hospitals, time savings are the main direct benefit. Nurses at both hospitals spend less time on the phone, either inquiring into missing exam results or answering to requests and inquiries. Doctors at Hospital Čáslav save time from not having to manually enter exam results or medical reports from Kolín, which - without data exchange - would come in paper form only. Additional benefits to Hospital Kolín may arise in the future. With the advent of digital signatures and the transmission of images with a picture standard, workflow could be reduced by the step of physically sending medical reports.

A motivation for Hospital Kolín to build the network for data exchange was to increase or at least maintain the stream of patients being referred from GPs and specialists for healthcare

services at the hospital. With private competition increasing, this is expected to be an important asset in the hospital's competitive position. However, this effect can only be observed in the future and is thus not included in the quantitative benefit estimates within the timeline of this evaluation.

GP and private practices mainly benefit from improved efficiency of service, as some consultations of patients can be avoided after an exam at Hospital Kolín. In these cases, private doctors have seen the exam results over the data exchange server already. Because of the primarily capitation-based reimbursement system, this results in actual benefits for the GP practices. In addition to this, GP and specialist practices save time in the process of data entry when they copy and paste medical reports and laboratory results directly into their own systems. Finally, the private practices benefit from cost savings on their telephone bill and the time spent on the phone. With medical information on patients coming in from data exchange, there is less need to inquire into exam results or ask for clarifications.

3.5.4 Third parties

Even though the insurance companies and the Institute of Health Information and Statistics of the Czech Republic receive reports prepared by the hospitals, there is no additional benefit for these organisations from HIS. 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 hospitals.

3.6 Costs

The identified costs of HIS and data exchange services include the financial investment for ICT, but also any negative impacts of implementing the systems. The latter include non-financial effects such as irritation to staff during implementation, as well as the engagement of HIS users in the improvement of the system.

3.6.1 Patients, informal carers and other people

The costs for patients are nil.

3.6.2 Health services teams

In both hospitals, health service teams first had to adapt from semi-paper-based record keeping to a new system. The availability of legacy systems caused some irritation in the beginning, since abandoning it meant a change from something people were used to. In Hospital Kolín, it was the first time to introduce a comprehensive HIS. At Hospital Čáslav, the HIS replaced an older IT system, which, however, was a much less complex system focusing mainly on outpatients. The initial inconvenience caused by HIS is a significant negative impact. At the Hospitals Kolín and Čáslav, the HIS users needed on average some three to four weeks to adapt to the system.

Doctors also have to cope with some continuous inconvenience caused by HIS. While the HIS has alleviated their work by facilitating compiling medical reports, it forces doctors to enter data from external paper records into HIS as well. In the past these paper records would have simply been put into the patient file.

As with HIS, data exchange is also associated with some initial inconvenience at hospitals and with individuals at GP and specialist practices. However this is a small negative impact when compared with the inconvenience caused by HIS.

3.6.3 Healthcare Provider Organisations (HPOs)

The largest share of the costs involves the implementation and maintenance of HIS. In contrast to the HPOs, patients, informal carers and other people did not have to contribute any costs, and healthcare professionals had to invest mainly non-financial efforts.

One part of the negative impacts consist of expenses for ICT, the other of organisational costs that go beyond the financial expenditure on the operation of HIS, hardware and other ICT. The ICT costs for HIS and the data exchange service account for about 18% of the total costs to the HPOs, or 16 % of total costs. With the implementation of a hospital-wide HIS, expenses had to be made on new workstation and servers. The obsolescence cost of ICT is taken into account. When the hospitals switched from a predecessor ICT-systems to the integrated HIS, the replacement costs were covered with the service contract. These replacement costs include the costs for migrating existing patient data into the new ICT system.

The rest of the costs to the HPOs are found in organisational issues. Interestingly, the most significant is the negative impact of extra time healthcare professionals spend on using HIS. At Hospital Čáslav, doctors need to feed the HIS with the content of paper records that patients bring into the hospital. Digitalising paper records represents the largest portion of organisational costs occurring to Hospital Čáslav. At Hospital Kolín, HIS has become so essential in daily work routines, that capacity overload has occurred at some workstations. Nurses often find themselves waiting for a workstation to become free, which interrupts their work.

Other non-ICT costs include the resistance to change and adaptation period, in which productivity is reduced for an average of 3 months for most team members, and up to a year in rare cases. A non-recurring cost was the time for the initial training of users, with doctors receiving approximately 12 hours and nurses about 8 hours in their working time. The recurring part of training costs is continuous training in 3 to 4 workshops per year. Another recurring cost includes the involvement of the HPO's IT personnel in the implementation and maintenance of HIS. The engagement in formal and informal exchange with hospital staff and feedback work of HIS representatives at each hospital represents another recurring cost to HPOs.

In comparison to the HIS, the ICT costs for data exchange with the medical exchange server were much less pronounced. These include the licence fees for using the data exchange server and extra costs for using data exchange services via the client application connected to the data exchange server. The ICT expenses for connecting GP and specialist practices were entirely borne by Hospital Kolín and were part of the contractual obligation of the HIS vendor. ICT costs account for about 80% of the total costs of the network. This result can be attributed to the scarcity of organisational issues arising from data exchange at the level currently implemented. Compared to implementing and using HIS at the hospitals, adapting to the data exchange service required relatively little effort. Also, training sessions at GP and specialist practices were much shorter than in the case of HIS, due to the simplicity of the user interface and functionalities.

3.6.4 Third parties

Cost incurred to health insurance companies are found in the improved billing processes at the Hospitals. With HIS replacing manual coding, fewer reimbursable items are lost in the

process of coding and billing. Thus, more items can be billed to health insurance companies representing a potential financial cost to the latter.

The planned unscheduled budget increase in case of Hospital Čáslav should not incur extra costs to the health insurance, since it is rather a reallocation of finances from a closed down hospital department to Hospital Čáslav.

The vendor of HIS, Medicalc, also bears a share of overall costs. Since the HIS was based on the knowledge and experience gathered in developing the system and deploying it at other sites, an estimated price mark-up that would have been required without this prior experience has been taken onto account.

3.7 Socio-economic analysis

3.7.1 Summary of methodology

The theoretical foundation for an EHR IMPACT (EHRI) evaluation is cost benefit analysis (CBA)²⁰. The UK Treasury's Green Book²¹ and Germany's WiBe²² 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 2001 to 2010 for this 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 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. 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 described in the above sections 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' involvement 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 the bases for the estimated ICT 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

²⁰ EHR IMPACT (2008): Methodology for evaluating the socio-economic impact of interoperable EHR and ePrescribing systems, Bonn (Available online: http://www.ehr-impact.eu/downloads/documents/EHRI_D1_3_Evaluation_Methodology_v1_0.pdf)

²¹ HM Treasury (2003): The Green Book: Appraisal and Evaluation in Central Government; available at: http://www.hm-treasury.gov.uk/media/05553/Green_Book_03.pdf

²² <http://www.wibe.de/html/konzept-uberblick.html> (4.8.2008)

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. The same technique is also used for intangible negative impacts such as irritations and inconvenience. 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. Details on the impact indicators and the quantification methods involved in this particular case study are presented in Appendix 2.

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 70% 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 (cf. section 3.7.4 on sensitivity of results).

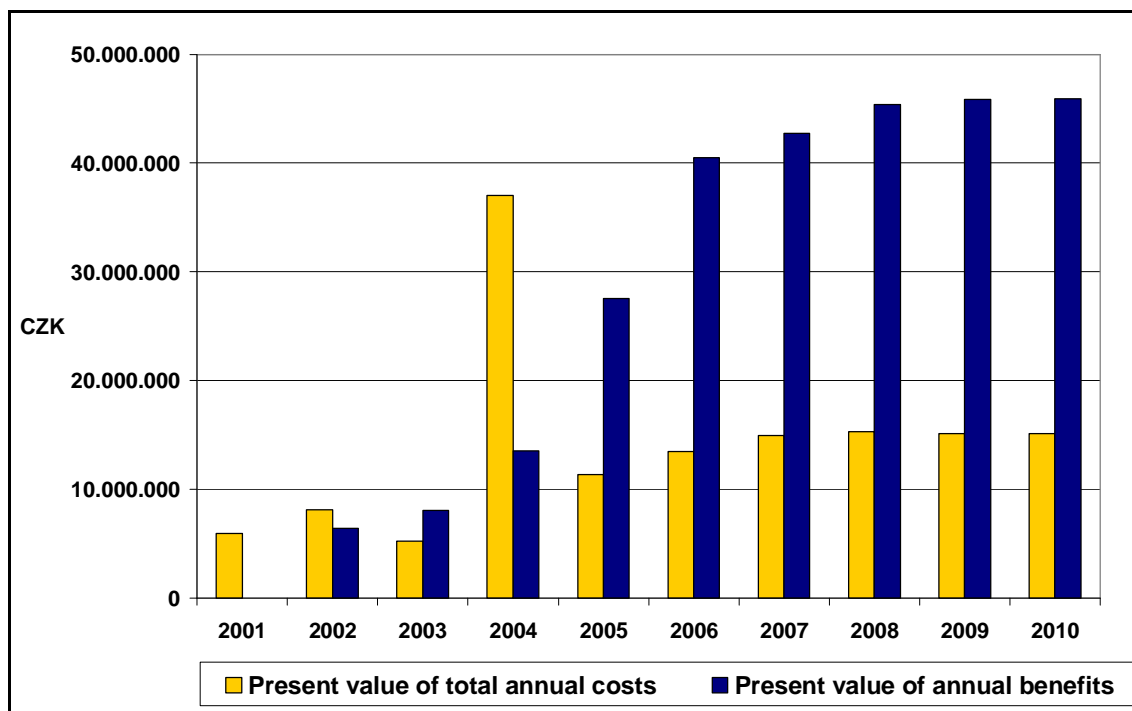
The sections below comprise the analysis of the whole health data and exchange network, including HIS and the data exchange services, and some special commentaries on the impact of the exchange of patient data. These commentaries highlight the effects and potential of interoperability and connectivity between healthcare facilities.

Implementation of HIS at different sites took place at different times. At the same token, the impact of data exchange cannot be interpreted without acknowledging that the HIS forms the foundation of the data exchange system.

3.7.2.1 First year annual net benefits

Chart 1 below shows the present values of estimated costs and benefits of the health data and exchange network for each individual year over the relevant life-cycle.

Chart 1: Estimated annual costs and benefits



With regard to the whole health data and exchange network, estimated annual net benefits were first realised only two years after the implementation of HIS at Hospital Čáslav, in 2003. The positive trend is reversed in 2004, when costs exceed benefits due to the investment and negative implementation impacts at Hospital Kolín. The high cost, relative to the investment in Čáslav, is a result of PACS being introduced at Kolín together with HIS. Net benefits are realised again only a year later. From year 2005, year five onwards, the margin is sustainable and rapidly increasing indicating a strong, sustainable positive impact. Taken individually, the HIS at Hospital Čáslav achieves a net benefit in the third and Hospital Kolín in the second year of HIS implementation. Each individual hospital displays sustained net benefits after the first year of net benefits. These individual timescales are shorter than the average timescales found in other eHealth IMPACT evaluations²³.

The start of the data exchange service in 2007 between Hospital Kolín and GP and specialist practices, and in 2008 between Hospital Kolín and Čáslav, is not clearly reflected in Chart 1, as it is marginal compared to the overall values for the two hospitals. The impact accounts for less than 1% of annual costs and a similar share of annual benefits. The benefits are reflected in a slight, unusual increase in total annual benefits in the years 2008-2010. The socio-economic impact of data exchange is positive, despite the early stages the network is in.

The rapid realisation of net benefits in 2003 and 2005 reflects the deployment of a ready to use and mature IT system at the two hospitals. The major development phase of HIS was already completed when first implemented in Hospital Čáslav. In both hospitals, Kolín and Čáslav, HIS was implemented in a radical fashion and used from day one. This meant taking a risk of stronger resistance to change, yet shortening the implementation and adaptation period.

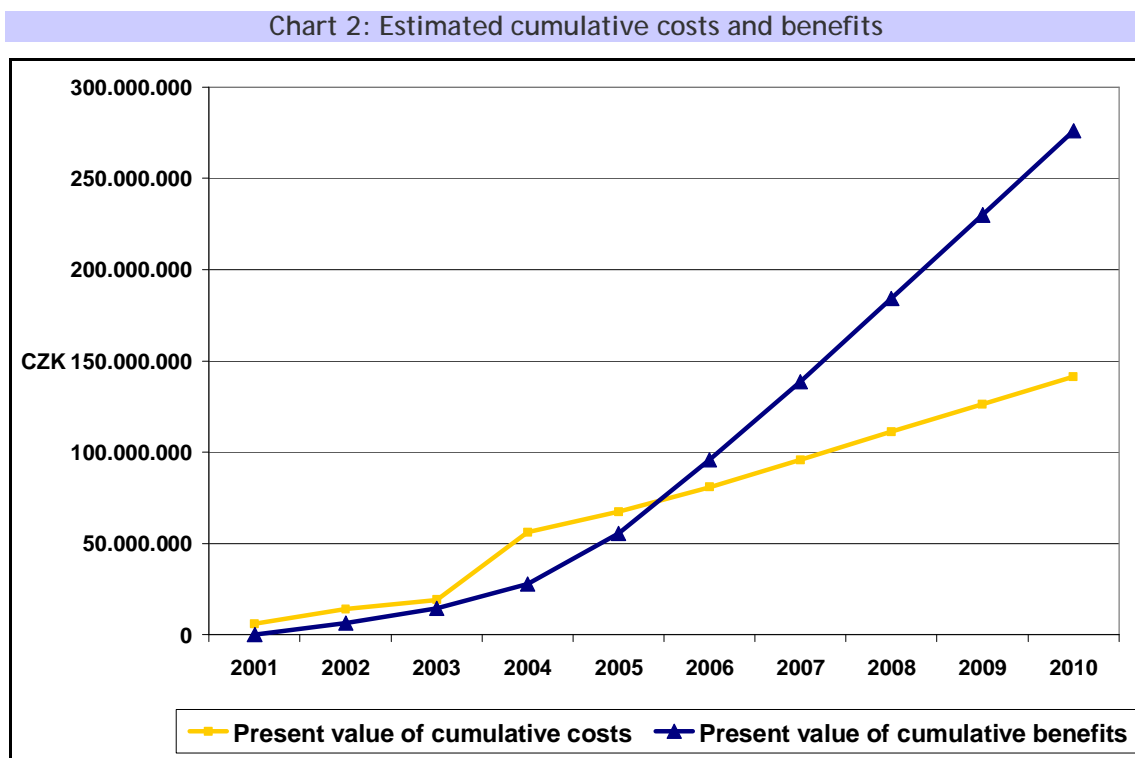
The significant net benefit margin achieved from 2005 onwards is critical for long-term economic viability. Having realised the benefits, they are likely to be sustained above this

²³ The eHealth IMPACT average time to annual net benefits was 4 years, cf., reports at www.ehealth-impact.eu

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 cumulative net benefits

Aggregating the annual costs and benefits to cumulative values shows the overall socio-economic impact of the health data and exchange network over time. The respective costs and benefits curves are depicted in Chart 2.



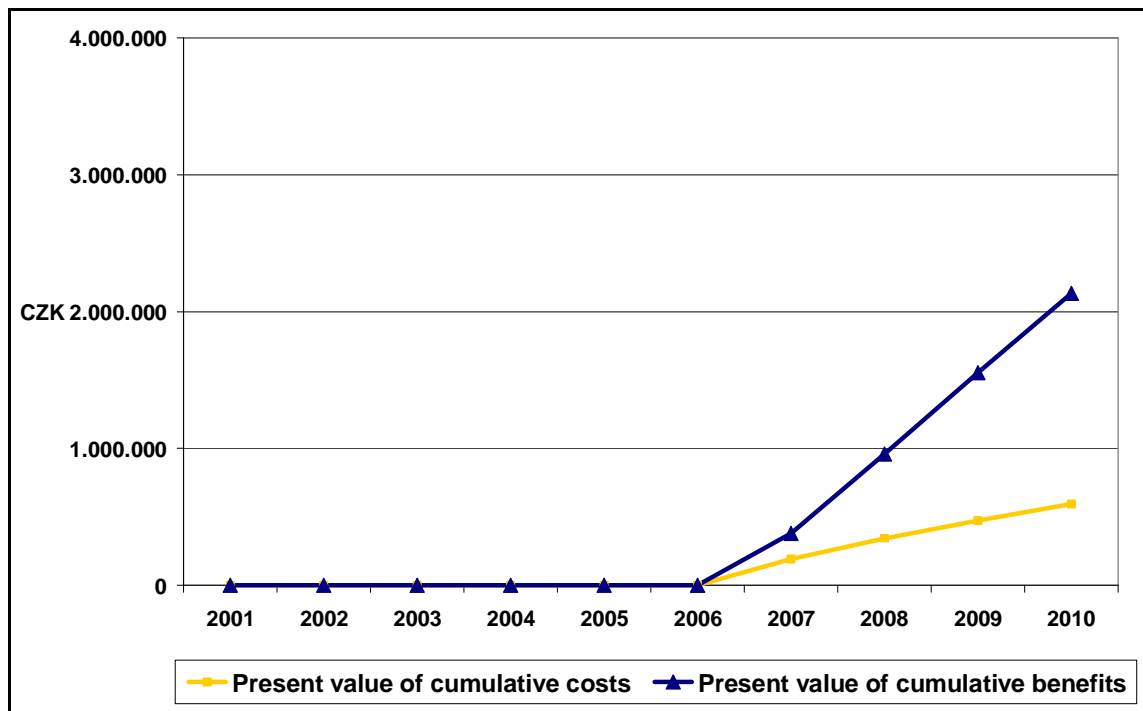
The EPR-centred HIS and the data exchange system yield a positive cumulative net socio-economic benefit in 2006, six years after the initiatives started. The two humps in the cumulative benefit curve again reflect the consecutive implementation of HIS at two different sites in 2001/2002 and 2004. After 2006, the cumulative cost curve increases gradually. The stable rate of increase of cumulative costs reflects the stabilised level on annual basis, shown in Chart 1. The rate of increase of cumulative benefits also stabilises from year 2006 onwards, but at a rate significantly higher than the stable rate of increase in costs.

The gap of only one year between the realisation of annual net benefits in 2005 and cumulative benefits in 2006 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.

An interesting observation concerns the time to cumulative net benefits in each of the two hospitals individually. Whereas Hospital Kolín is estimated to realise net benefits only two years after implementation, Hospital Čáslav takes about four years to arrive at cumulative socio-economic returns. This is explained by the relatively equal cost of HIS, regardless of the hospital's size. With higher activity rates and staff benefiting from the system, Hospital Kolín is able to enjoy a higher value of annual positive impacts.

The cumulative values of costs and benefits from data exchange are depicted in Chart 3.

Chart 3: Estimated cumulative costs and benefits of data exchange



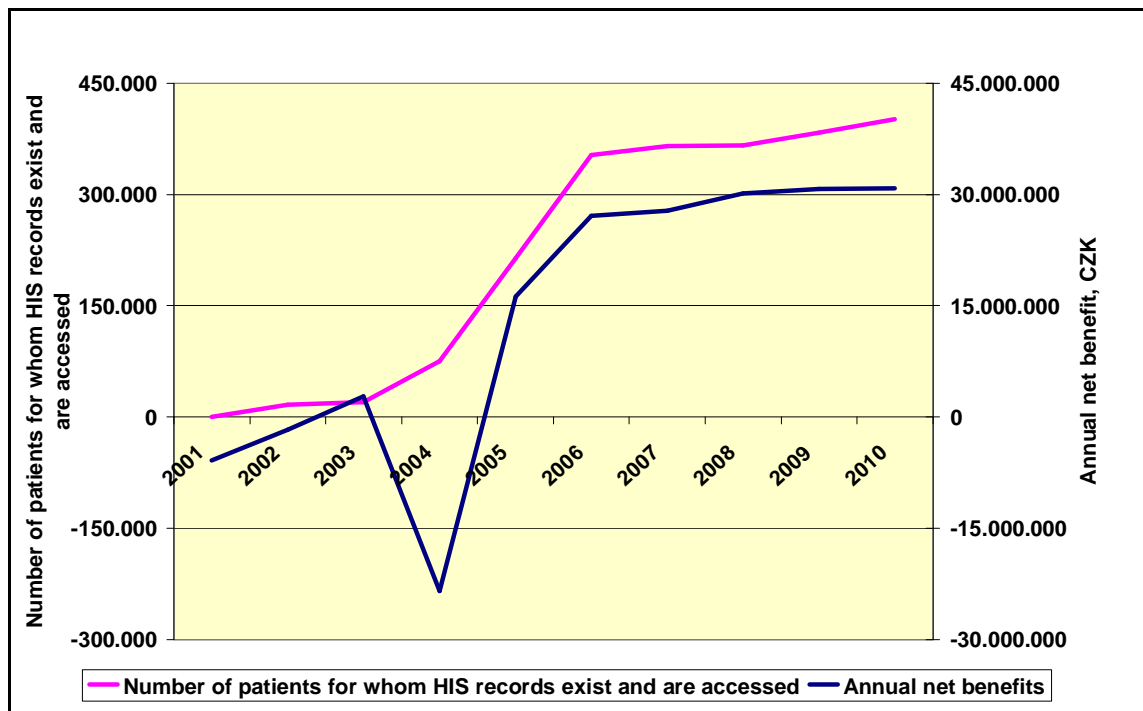
As net benefits are achieved from the start of the data exchange service in 2007, the cost and the benefit curves do not cut across each other. The rate of increase of the cumulative costs curve is significantly lower than the corresponding benefit curve. This reflects the marginal cost of data exchange once the technical and organisations pre-conditions have been achieved through more complex and powerful local information systems.

3.7.2.3 Net benefits and utilisation

Generally, annual benefits and utilisation can be seen as broadly correlated. Chart 4 below demonstrates the link between the net benefits and the utilisation of HIS at the hospitals in Kolín and Čáslav. 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 curve after the implementation can reveal some of these relationships. In the case at hand, the numbers of patients with already existing records in HIS are used as a proxy for the utilisation of the electronic patient records, as records are consulted for every patient.

Before the implementation of HIS, annual net benefits are negative, with utilisation at zero, as seen in Chart 4. With an increasing number of patients that have existing records in HIS and the use of these records, the annual net benefit curve switches into positive in 2003. The increase of utilisation in 2004 is matched by temporary slump in the annual net benefit. This result is explained by the initial investment and implementation costs of HIS at Hospital Kolín. The utilisation curve rises from the point of first implementation in 2001 at different rates. This reflects the subsequent implementation of HIS in both hospitals and the number of patients visiting the hospitals.

Chart 4: Link between net benefits and utilisation



The correlation of utilisation to benefits is about +0.99 and to net benefits about +0.90. They indicate that, despite the temporary divergence in the year of substantial investments in Kolín, the positive socio-economic impact of the HIS has been supported by its increasing utilisation.

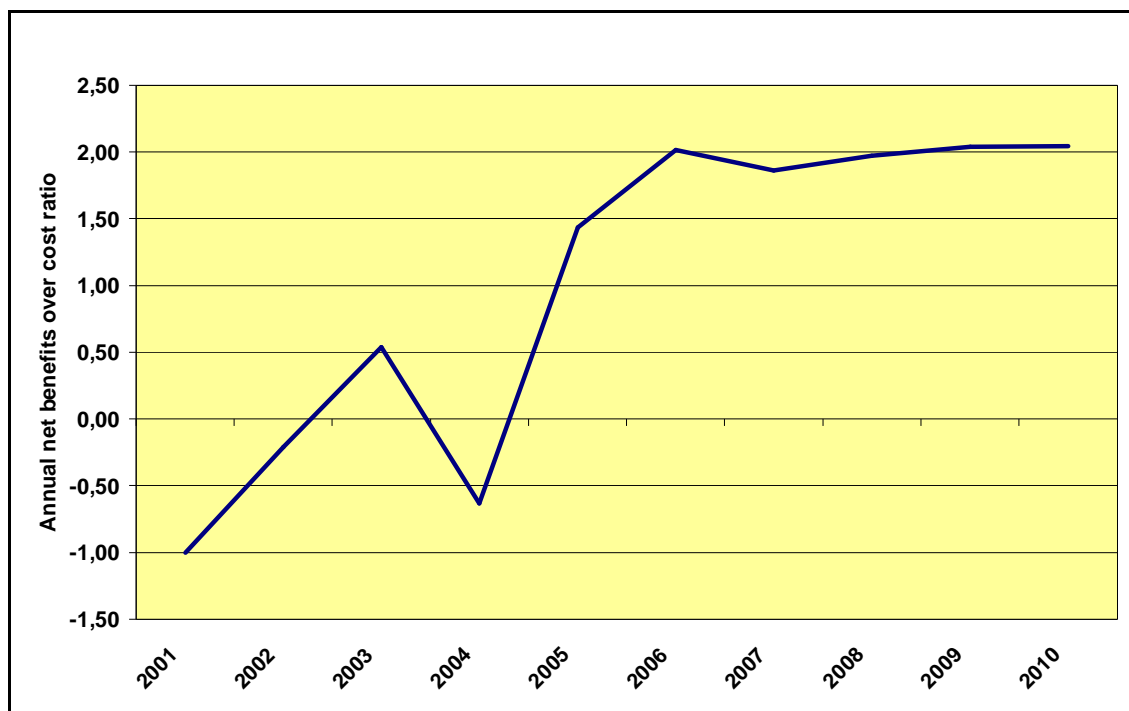
3.7.2.4 Net benefit to cost ratio

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.

As displayed in Chart 5, the annual net benefit to costs ratio turns strongly positive with over +0.54 in 2003. In 2004 it is negative again, reflecting the already discussed temporary reverse into net costs due to Hoapital Kolín's investment. Already in 2005, however, the trend returns to normal levels of above +1 and rising.

A second dip is observed in 2007, when the ratio drops from +2.02 to +1.86. This reflects the initial investment and other negative impacts associated with the introduction of the data exchange network. The increasing annual ratio in the later years of the evaluation timeframe is unusual compared to other sites. It shows the extra impact of exchanging patient data between healthcare facilities. Taken alone, the annual net benefit to cost ratio for data exchange services is already at +0.97 in year 1 of the network, reaching an impressive +2.82 in the following year, and +3.82 in 2010. The increase in 2008 illustrates the impact of exchanging patient data between Hospital Kolín and Hospital Čáslav in addition to the data exchange between Hospital Kolín and GP and specialist practices.

Chart 5: Annual net benefit to cost ratio



The cumulative net benefit to cost ratio turns positive in 2006 and increases steadily over the lifecycle. By 2010, the cumulative net benefit to cost ratio reaches +0.95, meaning that for every CZK 100 worth of negative impact, there are CZK 195 worth of positive impact.

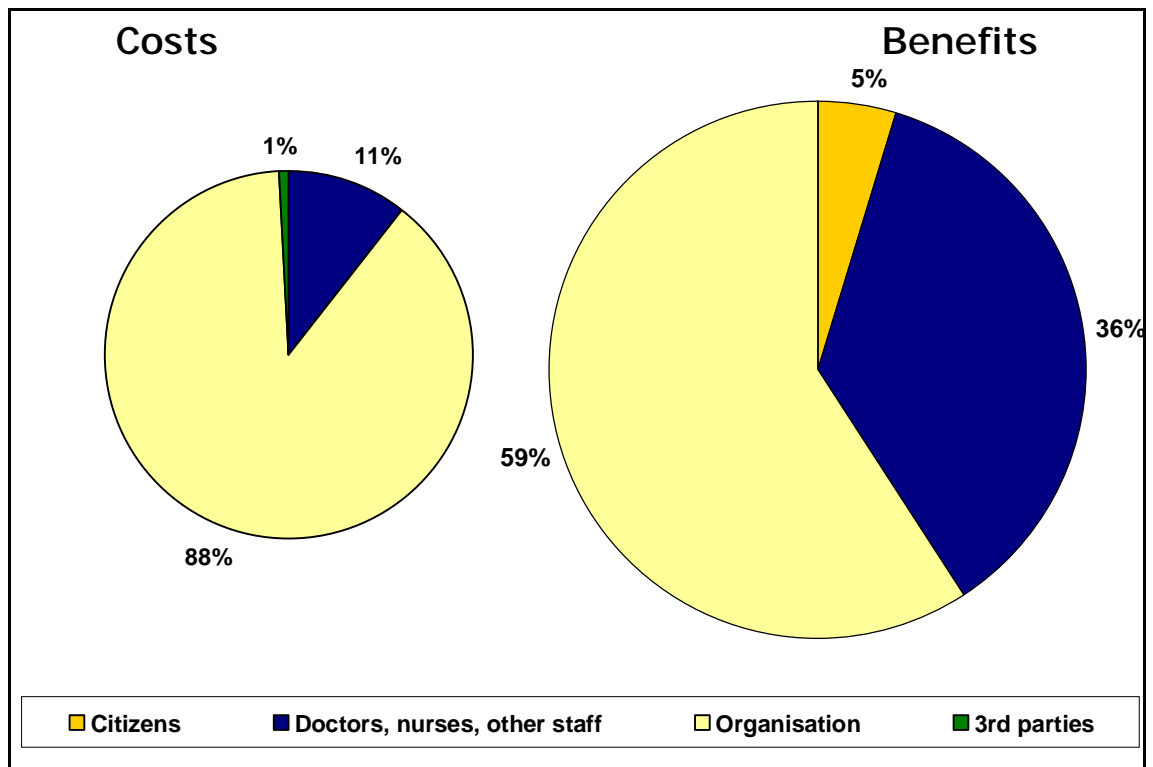
The ratio can also be understood as a rate of socio-economic, yet not purely financial, return over a given period. This indicates an overall socio-economic return from the health data and exchange network of more than 95% over a lifecycle of 10 years.

The equivalent cumulative return of data exchange alone over the same period is over 260%. These results provide some new insights on the health data and exchange network. The isolated net benefits from data exchange may be small in absolute terms compared to those from the entire information network. However, the net benefits to cost ratio is much larger for data exchange, indicating a relatively higher socio-economic return, even if the sophistication of the exchange network is still limited. This example shows the high potential of exchanging and sharing patient information between healthcare providers, provided that a basic information infrastructure already exists and can be connected. This infrastructure generates its own returns, which is important. Comparing the benefits from data exchange with the total investment cost required, without the HIS infrastructure already in place, would yield prohibitive results.

3.7.3 Distribution of costs and benefits to stakeholders

Chart 6 shows the distributions of costs and benefits of the health data and exchange network between the main stakeholder groups. The organisations in this case represent Hospital Kolín and Hospital Čáslav, as well as private GP and specialist practices. The category “doctors, nurses and other staff” refers to the hospitals’ 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. “Citizens” in this case refers to patients both at Hospital Kolín and Čáslav, as well as GP and specialist practices, as well as some informal carers. Third parties include the vendor of HIS, Medicalc, and health insurance companies.

Chart 6: Costs and benefits per stakeholder group



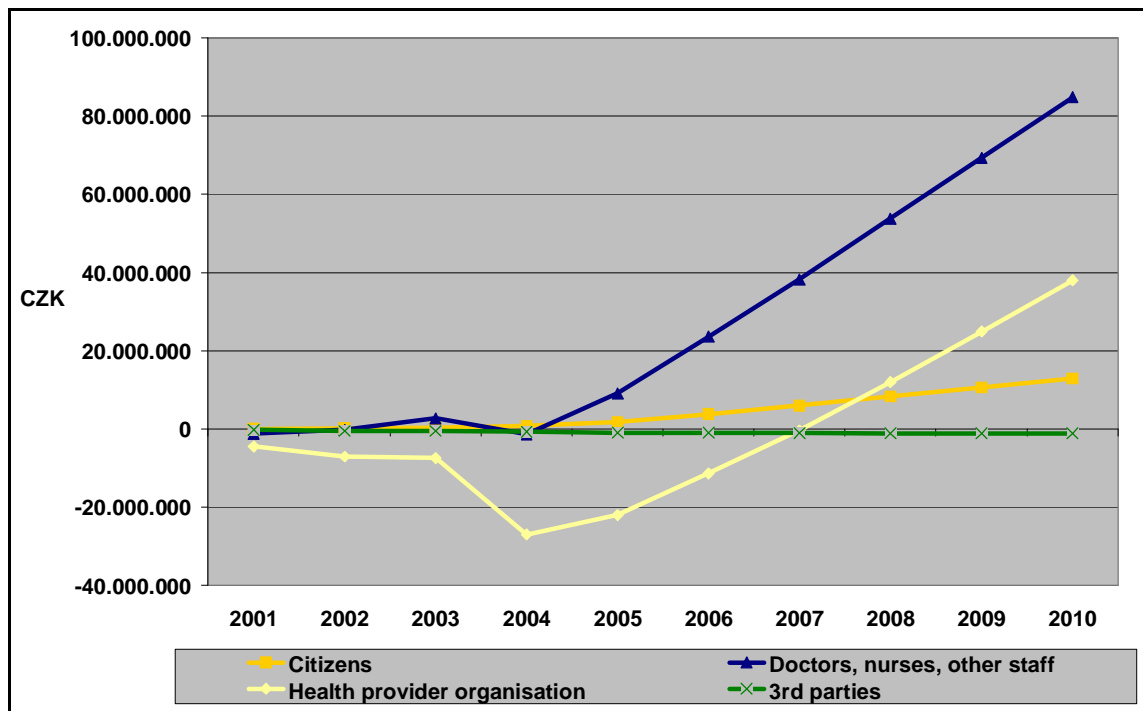
Estimated negative impacts, including investment costs, are borne almost entirely by the hospitals, with some input by GP and specialist practices as HPOs. As already addressed, the investment costs in the exchange of patient data are fully covered by Hospital Kolín.

Disruptions and inconveniences to care providers account for about 11% of the total costs. A relatively small share of the costs - around 1% - is borne by third parties. These costs include a potentially increased bill to health insurers due to more accurate coding procedures at the hospitals, as well as the transfer of knowledge by the vendor.

The distribution of benefits largely reflects the cost distribution, which is a distinct feature of successful eHealth implementations. Healthcare staff profit from a larger share of the benefits than their share of the costs. This is unusual, but it reflects the extremely positive feedback by doctors and nurses interviewed by the evaluation team. The value to users is indeed impressive, which is part of the reason for success. Patients and informal carers receive only 5% of the overall benefits. This is in line with expectations, since the design of the investment focuses on the healthcare professionals and HPOs.

Chart 7 below summarises the net impact on each stakeholder group. The only group with consistently negative net benefits are third parties. The vendor's contribution can be seen as a long-run investment in business development, the fruits of which can only be expected beyond the time horizon of this evaluation. Regarding the insurance company, the small negative impact is an artefact of the reimbursement system, which limits the reimbursed amount per HPO to a set budget. Without this, reduction in duplicate activity would have a positive impact on insurance companies, offsetting the potential increase in expenditure associated with more precise coding and billing. All other stakeholder groups enjoy a positive net benefit over the life cycle, as expected by theory.

Chart 7: Cumulative net benefits per stakeholder group



A more interesting picture emerges when regarding the distribution of benefits from data exchange services alone. Most of the direct gains are the alleviation of work for doctors, nurses, and support staff at HPOs. The second largest beneficiary group are patients, with some 16% of the benefits. On first sight unusual, this phenomenon can be interpreted as reflecting that direct impacts on these stakeholder groups realises immediately, whereas impacts on the organisations take more time - beyond the evaluation time scope. Such benefits include the competitive advantage aimed for by Hospital Kolín (Cf. section 3.5.3), as well as second order effects that are excluded from the evaluation. An example of such effects is the impact of higher work satisfaction of staff on productivity.

3.7.4 Sensitivity analysis

The sensitivity analysis consisted of 43 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 the positive impacts 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 15% and 300%, 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 and/or cumulative net benefits by one year; in one occasion by two years. 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 0.66, still leaving a comfortable positive result of 0.28.

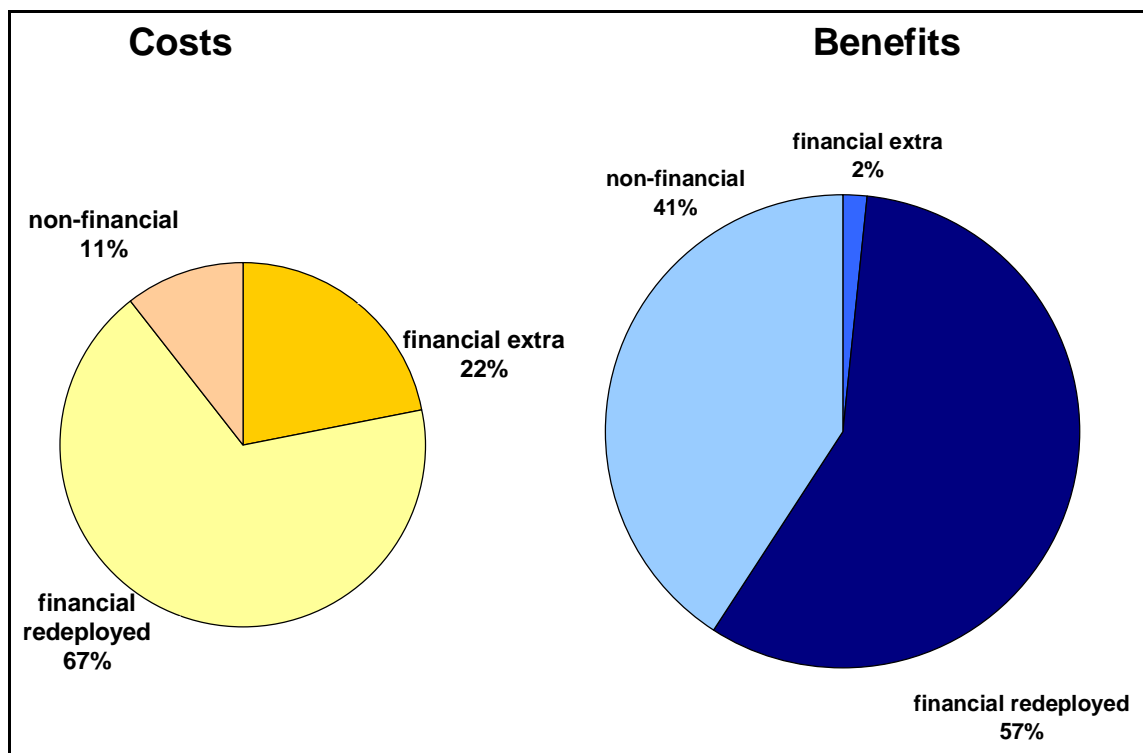
The results of the sensitivity analysis thus show that the conclusions drawn from the socio-economic analysis are robust, and do not depend on individual estimations or assumptions.

3.8 Financing and financial impact

3.8.1 Financial impact

The joint financial impact of HIS and the exchange of patient data 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 8 below.

Chart 8: Financial and non-financial impact



Similar to other sites, the financial classification of benefits shows that only 2% of the benefits, about CZK 4.8 million, is extra released finance. These financial benefits include avoided extra staff for providing information for management and reporting purposes, more accurate billing to the health insurances, as well as cost savings on communication between healthcare facilities. This is compared to 22%, or some CZK 31 million, of extra financial costs related to the investment. Thus, the overall absolute net financial impact is negative. This, however, is not an unusual feature of eHealth investments. The negative financial returns are not a reason to abandon similar projects in the future. From a social planner's perspective, the invested financial resources are more than offset by the redeployed and non-financial benefits amounting to a value of some CZK 270 million. The investment is justified on the grounds of improving patient safety and quality of care, as well as improvements in efficiency and effectiveness. But no sufficient cash inflow to cover expenditure should be expected.

About 67% of the costs are redeployed resources from other activities, which is a relatively high proportion. The respective benefits, which can potentially be redeployed into productive resources, represent 57%. However, these benefits are found in many small pockets and cannot easily be redeployed as a set of corporate decisions. This is a challenge to hospital managers.

Non-financial benefits represent a higher than average share of 41%. This is related to the high personal satisfaction levels among HPO staff.

3.8.2 Financing arrangements

The HIS at the hospitals Kolín and Čáslav were both financed out of the regular hospital investment budget. No extra public money was allocated. The total financial burden to the hospitals is in the range of an estimated 0.4% to just over 0.5% of their total combined annual budget. The whole resource investment, including redeployed resources, remains below 2% of the combined annual budget, with one exception - the peak in 2004.

The data exchange between hospital Kolín and private GP and specialist practices using the web-based client application is entirely financed by Hospital Kolín. Hospital Kolín plans to continue the financial support to private practices and to extend the data exchange network to even more primary and specialist care providers in the area.

3.9 Legal aspects

3.9.1 Data protection

The HIS contain records with both patient-related and staff-related personal information. A part of these records is shared in the data exchange network. As with paper records, this information is subject to data protection regulations. Additionally, internal data protection regulations apply at the Hospitals Kolín and Čáslav, binding all employees contractually to the general data protection act and to specific codes of conduct for the medical profession.

Although personal medical information is transferred between HPOs, no major additional data protection issues arise compared to the situation before the data exchange. Before exchanging medical information electronically, these items were simply sent by mail or fax or communicated by telephone. As before, the information infrastructure is restricted to healthcare facilities, without patients or third parties having access to the network.

3.9.2 Information governance

With the change from a semi-paper-based environment to HIS, the information governance structure had to be adapted to the new environment with its opportunities and risks. Previously restricted by physical barriers, access to information had now to be restricted by the definition of access rights within the system. One aspect of access rights control is compliance with data protection regulations. Another theme is the protection of healthcare team members from unnecessary exposure to risk and liability, since information carries a certain obligation to act. Technically, the access rights can be set in dependence of:

- The type of documentation
- The author of documentation - the healthcare professional in charge
- Whether the document is in „open“ or „absolutely closed“ mode.

At Hospitals Kolín and Čáslav, the access to HIS is restricted by department, matching the pre-HIS arrangement of paper records. Access rights are permanent, also mirroring the pre-HIS setting, and doctors and nurses have the same scope of access to the records of patients treated at their department. Following Czech data protection regulation, carers are only permitted to access patient data in case of an existing care relationship. However, this leaves the technical possibility to access all information - a fact that has also been pointed out by interview partners as a potential risk for misuse.

Partly dealing with this risk are technical specifications in HIS, including an alert window warning the user when he or she is about to search for data outside their default authority. Access is granted and logged, requiring justification in case of an inquiry. Additionally, patients may choose to hide records on specific clinical events on demand. VIPs and hospital staff tend to hide their whole record, apart from temporary access permission to a treating doctor and nurse during treatment.

Users log into the system with their personal username and password. They have the responsibility to log out whenever they leave the computer, in order to prevent non-authorised persons from accessing HIS. The system can be set so that the same users can be logged in on up to two workstations at the same time only. Automatic log out after a certain period of inactivity is another security feature. The HIS has a log function documenting the name of the user, the time of access, and the activity performed by the user, allowing full traceability of activity.

As with HIS at the hospitals, the access to patient information sent with the data exchange server is restricted to the intended users. Every healthcare professional sending patient data can be held responsible for his action, which can be traced back in the log. Doctors and their assistant staff in private practices need a password, a client certificate and a PKI chip card to view the information. In order to be part of the data exchange network, GPs and specialists need to send letters of request to the Hospital Kolín. This is followed by a contract on data sharing. Finally the private practitioner can be added to the list of healthcare facilities in the network by the hospital's IT department.

4 Conclusions

The health data and information network illustrates two aspects:

- It shows what electronic health records can do for healthcare provision in a hospital environment
- It demonstrates how data exchange between healthcare facilities can evolve from established HIS, to the benefit of the stakeholders involved.

This case study shows good practice that can be taken as a benchmark for similar investments. At the same time, readers should be aware that results achieved in the network are above average; an artefact of the EHRI study design. The general conclusion from the case study is that investing in EHR systems and in the exchange of health data is a worthwhile endeavour, provided the investment is well grounded and an integral part of the organisations' strategies. The investment and all negative impacts are more than covered by the benefits of using the system.

4.1 Future potential

Current achievements in successful sites are never a reason to stop further developments. This case study is no exception. There are two main themes of development that promise to deliver even more returns in the future - developments regarding HIS, and developments regarding the patient data exchange network. Some details of the specific plans have already been described in section 2.2.1.

At Hospital Kolín and Hospital Čáslav, the HIS will be extended to cover decision support for prescriptions and other additional modules, such as a full CPOE system, in the long term. Hospital Kolín is in the process of extending the management information module in HIS. Thus, additional benefits from improved information provision are expected in the future. At present, the HIS is better adapted to doctors' work than to the everyday routines of nurses. Thus the potential of HIS is yet to be unfolded with integrating nursing care plans and other tools specific to nurses' work.

Even more future potential has been identified in the data exchange network. The network has already indicated its enormous potential. Some delayed effects, which go beyond the EHRI evaluation time period, would enhance the current position even further. Such benefits include the competitive advantage aimed for by Hospital Kolín (Cf. section 3.5.3), as well as second order effects that are excluded from the evaluation. An example of such effects is the impact of higher work satisfaction of staff on productivity.

The relatively short history of the data exchange network has also shown the perspectives for the enormous opportunities further developments create. For example, GPs' and specialists' patient information systems are not yet interoperable with the hospitals' HIS. Benefits arising from data exchange could be boosted if data was automatically integrated into local information systems, as is already the case between the hospitals.

The further development of the data exchange system to enable the transfer of images in addition to the corresponding reports is already underway and promises significant benefits in the future. By receiving an image rather than just the description and interpretation from physicians of different specialisations, doctors can further improve the quality of care. For example radiologists interpret an image from a different point of view than surgeons. Image exchange would also create the opportunity to better utilise capacity in out-of-hours services

at different hospitals. Patients at one hospital could then easily receive a first opinion on their x-ray from a radiologist located at another hospital. This would allow a smaller number of radiologists to be on duty in the region, without sacrificing the quality of out-of-hours care.

The mid to long term vision of the data exchange network also includes a larger network with more hospitals, and GP and specialist practices in the region. The more organisations exchanging patient data, the further will the region get along the way to providing seamless, truly patient-focused healthcare services.

4.2 Transferability

Usually, technological transferability refers to the possibility to install the ICT in another setting. In the case of the Kolín-Čáslav health data and information network the HIS and the data exchange solutions have already proved their technical transferability. As described in section 2.2.3, a very similar data exchange network, based on several hospitals' HIS and the data exchange server of Medicalc, is already in routine operation since 2007 in the Pilsen region. This particular network has the University Hospital in Pilsen as a hub, and covers the smaller hospitals in Stod, Janov and Cheb, as well as a private dialysis centre and a GP practice. Unlike non-commercial, proprietary products, the HIS was not developed for a specific hospital. This facilitates the technical transferability to different hospital contexts. The flexibility of configuration helps to adapt the technology to different organisational settings.

The structural arrangement of data exchange surrounding University Hospital Pilsen resembles that of the Kolín-Čáslav health data and exchange network. There is one larger hospital providing information to several smaller facilities. In contrast to the Kolín-Čáslav health data and exchange network, not all of the hospitals in this cluster use the HIS of the same vendor. Smaller hospitals around Pilsen use the read-only web-access to the data exchange server, like the private practitioners in the Kolín-Čáslav network. This example shows that both technical and organisational transferability is possible. The example also shows, however, that organisational transferability is a challenge: the links between hospital and primary care in Kolín-Čáslav are already much more advanced than in the Pilsen region. This is not a technology, but rather a strategic matter for the healthcare facilities involved.

A more general conclusion regarding the transferability of data exchange and sharing networks concerns the necessary availability of local information infrastructure. As discussed in section 3.7.2.4, the high potential of exchanging and sharing patient information between healthcare providers depends on a basic information infrastructure already existing. This infrastructure generates its own returns, which is important. Starting from zero may lead to the need to invest in basic infrastructure as well as in data exchange technology and organisational issues. The benefits from the infrastructure part of the investment may be smaller or not realised at all, which introduces an additional risk factor for the whole investment. A better strategy is to design the local infrastructure in a way that allows connectivity at marginal costs at a later stage of the endeavour, but carefully managing the benefits from the information infrastructure on local level first.

4.3 The role of interoperability in realising the benefits

There are two sides of interoperability, technical as well as semantic, that are addressed in this case study. First, there is the interoperability between systems, modules, and teams within hospitals. With an integrated HIS, existing IT systems and new modules work together, facilitating availability of the right information at the right time, at the right place. This integration leads to a socio-economic net benefit that would not have been achieved with a simple EPR system.

The second side to interoperability concerns the data exchange network. Here, full connectivity between facilities using the same HIS is achieved, yet integration of data is not automatic at facilities using a local system from a different vendor. Given that there are standards defined by the Czech government, the technical integration, or at least connection is only part of the challenge. The organisational issues are more difficult. The problems have not yet been of significant importance, since the scope of data exchange is still limited. This will change in the future.

Nevertheless, the special focus commentaries in this report underline the promising potential for benefits to quality of care, as well as efficiency and access, from more interoperability. The technical interoperability at the network clustered around Hospital Kolín is modest, yet the organisational interoperability is advanced, which drives the net benefits from data exchange.

4.4 What it means for decision makers

The case at hand provides useful experience both for EPR-based hospital information systems and the exchange of patient records between organisations. The following aspects can be useful for decision makers in planning and managing investments in interoperable EHR systems.

HIS versus EPR system

An EPR system in a hospital setting should not be implemented on its own, but integrated with other applications supporting clinical and non-clinical practices. This conclusion is consistent with the experience at other, comparable sites. The interplay between the clinical record and administrative and economic modules has led to significant benefits. The support of billing has reduced the administrative burden to healthcare staff enabling them to focus on better care. The other side of the same aspect is more accurate billing and cost control, which could potentially even generate, or release some extra finance.

Leadership and continuous user involvement

In contrast to some other cases of eHealth implementation, the HIS at the hospitals in Kolín and Čáslav followed a rather radical approach. The process of replacing the semi-paper-based system was kept exceptionally short. A strong leadership was exerted in order to minimise costs from parallel processes and to prevent a prolonged period of confusion. This approach proved successful as it fitted into the specific organisational culture. Also, the features of HIS allowed for this implementation strategy. Users were given a simple system that was intuitive and suited their needs. As the logic of clinical events paralleled the logic of paper documentation, healthcare professionals could quickly adapt to the system.

With a ready to use system, built on the basis of extensive user involvement at other sites, the need for pre-implementation involvement of users at the two analysed hospitals was limited. However, continuous training and user involvement by engaging doctors as permanent HIS representatives has proven to be a success factor. In addition to that, the focus was put on direct support for users and continuous improvements of the system functionalities. This has helped to quickly develop an information culture in which users ask for more information through more eHealth. The lesson learnt is that the implementation strategy and the system have to fit together. In this case, the risk of failure and user resistance was mitigated by identifying the usefulness and the usability of the system in advance.

Economic sustainability and financial returns

Economic sustainability is a primary indicator of success. The Kolín-Čáslav health data and exchange network has already demonstrated a stable upward trend in cumulative net benefits. A feature of the Kolín-Čáslav health data and exchange network is the relatively short period of time until estimated annual net benefits were realised after the implementation of HIS. This is the result of implementing a ready-to-use system that was not developed specifically for the respective hospitals.

A finding from the evaluation similar to other eHealth implementations is that the net socio-economic benefit is not matched by a corresponding purely financial impact. The positive side of this is that although good eHealth costs money, it can have significant non-financial benefits for citizens, patients, healthcare professionals and HPOs. The negative financial returns are not a reason to abandon similar projects in the future. From a social planner's perspective, the invested financial resources are more than offset by the redeployed and non-financial benefits.

Enabling networking for seamless healthcare provision

The Kolín-Čáslav health data and exchange network demonstrates how exchange and cooperation between primary and secondary care can be fostered. Hospital Kolín assumed leadership in building the network, which was consistent with the hospital's role of being a regional hub for patients requiring more complicated diagnoses and treatment procedures. This case study shows that ICT can facilitate networking and cooperation between healthcare facilities, even across primary and secondary care. This enabling role, however, should not be misunderstood as being a creating one. The strategic decision to work together for the benefit of the patient is a more viable starting position for sustainable cooperation. Interoperable, interconnected EHRs can only support such cooperation, but not enforce it.

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Appendix 1: Summary of evaluation data

<i>EHRI generic data summary</i>	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	CZK	CZK	CZK	CZK	CZK	CZK	CZK	CZK	CZK	CZK
Estimated COSTS										
<i>Citizens</i>	0	0	0	0	0	0	0	0	0	0
<i>HPOs</i>										
Doctors, nurses, other staff	1.185.637	1.486.738	26.975	9.317.659	277.260	177.009	515.947	658.040	647.336	645.001
Organisation	4.469.930	6.379.260	5.199.625	27.457.441	10.806.839	13.217.996	14.375.643	14.577.573	14.421.111	14.412.451
Third parties	240.652	240.188	9.426	224.720	237.182	37.422	38.240	40.281	38.918	37.602
Present value of total annual costs	5.896.218	8.106.187	5.236.026	36.999.820	11.321.281	13.432.427	14.929.830	15.275.894	15.107.366	15.095.054
Present value of cumulative costs	5.896.218	14.002.405	19.238.431	56.238.251	67.559.532	80.991.959	95.921.789	111.197.683	126.305.048	141.400.102
Estimated BENEFITS										
<i>Citizens</i>	0	147.456	228.943	394.668	1.004.055	2.011.229	2.193.621	2.324.982	2.313.960	2.296.868
<i>HPOs</i>										
Doctors, nurses, other staff	0	2.445.869	3.008.687	5.195.107	10.721.360	14.666.302	15.181.616	16.213.378	16.169.129	16.121.211
Organisation	0	3.810.356	4.802.964	7.913.680	15.823.537	23.833.227	25.362.679	26.867.099	27.389.892	27.491.192
Third parties	0	0	0	0	0	0	0	0	0	0
Present value of annual benefits	0	6.403.681	8.040.593	13.503.455	27.548.951	40.510.758	42.737.916	45.405.459	45.872.981	45.909.271
Present value of cumulative benefits	0	6.403.681	14.444.275	27.947.730	55.496.681	96.007.439	138.745.355	184.150.814	230.023.795	275.933.066
Net benefits										
Present value of annual net benefits	-5.896.218	-1.702.506	2.804.567	-23.496.365	16.227.671	27.078.331	27.808.087	30.129.565	30.765.616	30.814.216
Present value of cumulative net benefits	-5.896.218	-7.598.724	-4.794.156	-28.290.521	-12.062.851	15.015.480	42.823.567	72.953.131	103.718.747	134.532.963
Net benefits over cost ratio - annual	-1,00	-0,21	0,54	-0,64	1,43	2,02	1,86	1,97	2,04	2,04
Net benefits over cost ration - cumulative	-1,00	-0,54	-0,25	-0,50	-0,18	0,19	0,45	0,66	0,82	0,95
Number of records	83.580	93.370	98.920	173.343	318.917	458.413	473.969	480.376	502.773	525.170
Number of patients for whom HIS records exist and are accessed	0	16.152	20.030	75.448	213.940	353.299	365.596	365.927	383.867	401.807
Distributions	Costs		Benefits				Type of costs		Type of benefits	
<i>Citizens</i>	0,0%		4,7%				financial extra	22%		2%
<i>HPOs</i>							financial redeployed	67%		57%
Doctors, nurses, other staff	10,6%		36,1%				non-financial	11%		41%
Health provider organisation	88,6%		59,2%							
Third parties	0,8%		0,0%							
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	Initial inconveniences	Inconveniences nurses had to bear initially due changes in the working processes resulting from HIS	Number of nurses; estimated value of inconvenience related to adaptation to the system; length of adaptation period
		Initial inconveniences	Initial inconveniences nurses had to bear while adapting to data exchange module	Number of nurses; estimated value of inconvenience related to adaptation to the system (estimated WTP); length of adaptation period
	Doctors	Initial inconveniences	Inconveniences doctors had to bear initially due changes in the work procedures resulting from HIS	Number of doctors; estimated value of inconvenience related to adaptation to the system (estimated WTP); length of adaptation period
		Initial inconveniences	Initial inconveniences doctors had to bear while adapting to data exchange module	Number of doctors; estimated value of inconvenience related to adaptation to the system (estimated WTP); length of adaptation period
		Negotiation and adaptation	Private doctors' spare time spent on negotiation with hospital representatives and on adaptation to the data exchange module	Number of doctors; amount of spare time; share of wage
	HPO - ICT costs			
		Operational costs	Service contract with vendor for information system operation, data exchange service & support	Annual contract value
		Work stations	Hardware	Number of work stations; historical costs
		Obsolescence	Replacement of outdated technology	Relevant IT costs; obsolescence rate
		Servers		Historical costs
		Access to data exchange	Provision of IT equipment and service to GPs/specialist offices paid by Hospital Kolín	Share of annual contract value dedicated to data exchange
HPO - organisational				
		Training time costs	Training time for nurses during working time, initial and continuous	Number of nurses; training time; share of FTE nurse

Stakeholder group	Cost indicator	Clarification	Variables
issues	Training time costs	Training time for doctors during working time, initial and continuous	Number of doctors; training time; share of FTE doctor
	Training time costs	Training time for other staff during working time, initial and continuous	Number of other staff; training time; share of FTE other staff
	Digitalisation of paper documents	Extra effort for doctors to type in paper documents into HIS	Number of patients; time spent on retyping paper documents; share of FTE doctors
	Doctors' engagement as HIS representatives	Engagement of doctors during working time in collecting and communicating user feedback on HIS	Number of HIS representatives; number of hours devoted to representative duties; share of FTE doctors
	Foregone patient co-payments	Avoided adverse events prevent prolonged hospitalisation and the resulting patient co-payments to the hospital.	Relevant number of patients; rate of patient co-payment
	Waiting time at work stations	Time nurses spend waiting at the work stations due to capacity overload	Number of nurses; waiting time; share of FTE nurse
	Temporary decrease in productivity	Due to nurses' initial resistance to working with HIS the system's potential was not fully realised	Number of nurses; loss of productivity; share of FTE nurse
	Temporary decrease in productivity	Due to doctors' initial resistance to working with HIS the system's potential was not fully realised	Number of doctors; loss of productivity; share of FTE nurse
	Temporary decrease in productivity	Due to other staffs' initial resistance to working with HIS the system's potential was not fully realised	Number of doctors; loss of productivity; share of FTE other staff
	Procurement costs	Procuring hospital information systems	Time spent on procuring; share of FTE manager
	IT department	Share of IT department manpower devoted to HIS and data exchange	IT department resources; estimated share of time devoted to HIS; share of FTE IT staff
	Adaptation time	Initial time involved until doctors and nurses have adapted their working procedures to data exchange	Number of doctors and nurses; adaptation time; share of FTE doctor/nurse
Third parties	Knowledge transfer	Knowledge and experience transferred from HIS and data exchange implementations at other sites	Estimated mark-up on development costs
	Insurances: Extra expenditure due to higher bills	More precise recording of reimbursable items in HIS allows for higher bills to insurance companies	Equivalent to respective benefit to hospitals

Table 3: Benefit indicators and variables

Stakeholder group	Benefit indicator	Clarification	Variables	
Patients, informal carers & other people	Better care	As a result of better informed decisions by doctors at the hospitals and in private practices	Relevant number of patients; estimated WTP patients	
	Patient safety	Patient safety is increased by the medical record, allergy record and the general availability of information leading to a reduced risk of an adverse event	Relevant number of patients; estimated WTP for the reduced risk of adverse events	
	Time saving	The doctor is better prepared for consultation when past patient information is available	Relevant number of patients; time saved per consultation; value of time for patients	
	Time saving	Reduced risk of an adverse event for inpatients with past information leads to avoided extra time spent in hospitals	Relevant number of patients; probability of an adverse event; length of stay that can be avoided; value of time for patients	
	Cost avoided	Co-payments avoided that would have occurred in case of hospitalisation after an adverse event	Relevant number of patients; probability of an adverse event; length of stay that can be avoided; co-payment rate per day	
	Time saving	Avoided consultation at GP/specialists' office after exams in a hospital after the GP/specialist sees results through the data exchange service	Relevant number of patients; value of time for patients	
	Cost avoided	Avoided consultations saving travel costs to the GP/specialists' office	Relevant number of patients; average travel costs	
HPO healthcare staff	Nurses	Alleviation of work	Decrease of bureaucratic workload such as manual coding for reimbursement purposes increases work satisfaction	Number of nurses; estimated WTP for alleviation of work
		Alleviation of work	Using the data exchange services decreases bureaucratic workload such as phone calls and clarifications	Number of nurses; estimated WTP for data exchange service
	Doctors	Alleviation of work	Assurance in decision-making and decrease of unwelcome work such as report typing	Number of doctors; estimated WTP for alleviation of work
		Alleviation of work	Data exchange services increases convenience of work, e.g. by automatically feeding HIS with external information	Number of doctors; estimated WTP for alleviation of work

Stakeholder group		Benefit indicator	Clarification	Variables
	Hospital management	Alleviation of work	Assurance in decision making, based on better financial and other analyses	Number of management members; estimated WTP for alleviation of work
	GPs & specialists	Alleviation of work	Data exchange services increases assurance in decision-making and reduces bureaucratic workload	Number of doctors; estimated WTP for alleviation of work
Health service Provider Organisations		Liberated resources	Reduced risk of an adverse event for inpatients leads to resources being available for other patients. Additional days at the hospital can be avoided. Measure is the opportunity cost of having a hospital bed occupied	Relevant number of patients; cost of hospitalisation to hospital; estimated length of stay avoided
		Nurses' time saving	From not searching past patients' paper records	Number of nurses; observed time saving; share of FTE nurse
		Nurses' time saving	For not repeatedly questioning patients about medications etc.	Number of patients; average time for nurses asking patients about medications and other details from now available in HIS; share of FTE nurse
		Nurses' time saving	Time for manual coding for reimbursement purposes is saved	Time of nurses avoided; share of FTE nurse
		Nurses' time saving	Time saved for picking up lab results now available in HIS	Relevant number of patients; time saved; share of FTE nurse
		Nurses' time saving	Time for answering inquiries or inquiring on patients from or to other healthcare provider organisations is saved	Relevant number of patients; average duration of phone call; share of FTE nurse
		Improved productivity-Doctors	Time saved on typing in all the information into reports and discharge letters	Relevant number of doctors; time saved; share of FTE doctors
		More efficient training of training doctors	Liberated resources by using HIS and integrated PACS as a teaching tool for training doctors	Relevant number of senior doctors; time saved; share of FTE doctors
		Doctors' time saving	Time saved on outpatient consultations because of better information and faster documentation in HIS	Number of consultations; time saved per consultation; share of FTE doctors
		Doctors' time saving	Time saved from clarification of handwritten records	Number of doctors; time saved on clarification; share of FTE doctors
		Cost savings	Cost savings in hospitals' telephone bill from reduced need to inquire into patients treated at another hospital	Relevant number of incidents; average cost per phone call

Stakeholder group	Benefit indicator	Clarification	Variables
	Doctors' time saving	Time saved from not typing in external paper records now sent electronically with the data exchange service	Relevant number of patients; time saved on entering patient data into HIS; share of FTE doctors
	Cost saving	Avoided duplicate tests (x-rays) lead to cost savings for hospitals	Number of tests saved; average cost of test
	Extra income	Resulting from better billing procedures. Less items are lost when using HIS instead of manual coding	Estimated value of previously not billed items; estimated probability of budget adjustment by health insurance companies
	Extra income	Hospital budget increase due to better monitoring of patient streams from a different catchment area. This data provided by HIS helps in budget negotiations with the insurance companies.	Proposed value of budget increase; estimated probability of budget increase
	Cost avoided	Avoided staff needed to provide the amount of information HIS is providing today - a proxy for the increased availability and quality of information relevant for decisions	Number of staff avoided; FTE staff
	Cost savings	Cost savings on private doctors' telephone bill from reduced need to inquire into patients treated at the hospital	Relevant number of patients; average cost per phone call
	Medical assistants' time saving	Time for inquiring into treated, hospitalised or discharged patients can be saved	Relevant number of patients; average duration of phone call; share of FTE medical assistant
	Private doctors' time saving	Time saved from copying patient information from the data exchange service into the private doctors' patient information system instead of typing everything	Number of referred patients; time for typing in patient information; share of FTE doctor
	Efficiency of service	Resulting from patients that do not have to come back for consultation after an examination in the hospital due to the data exchange service	Relevant number of patients; average duration consultation; share of FTE doctor