



EHR IMPACT

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Report on

The socio-economic impact of the regional integrated EHR and ePrescribing system in Kronoberg, Sweden

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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 nine independent quantitative evaluations and two qualitative reports on good practice cases of interoperable electronic health record (EHR) and ePrescribing systems in Europe and beyond. The goal of the study is to support ongoing initiatives and implementation work by the European Commission, Member States governments, private investors, and other actors. The study aims to improve awareness of the benefits and provide new empirical evidence on the socio-economic impact and lessons learnt from successfully implemented systems.

Full project title

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

Number and title of deliverable

This report is deliverable D2.3h of the EHR IMPACT study. It addresses the socio-economic impact evaluation of the regional integrated EHR and ePrescribing system in Kronoberg, Sweden

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EHR IMPACT

The socio-economic impact of the regional integrated EHR and ePrescribing system in Kronoberg, Sweden

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

Sweden

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Bonn, September 2009

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Disclaimer

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Abbreviations

A&E	Accident & Emergency services
API	Application Programming Interface
BIF	Base Services for Secure Information Supply
CBA	Cost Benefit Analysis
CEN	Comité Européen de Normalisation
COSMIC	Compliant Open Solutions for Modern Integrated Care
DRG	Diagnosis-Related-Group
ECG	ElectroCardioGram
EHR	Electronic Health Record
EHRI	EHR IMPACT study
FASS	Swedish basic pharmacological stock lists information
GP	General Practitioner
HIS	Hospital Information System
HISA	Healthcare Information Systems Architecture
HPO	Health Provider Organisation
HSA	Health Services Address registry
ICT	Information and Communication Technologies
ISO	International Standards Organisation
NDR	National Diabetes Register
NHS	National Health Service
NPÖ	National Patient Summary (Swedish)
OOH	Out-Of-Hours
PACS	Picture Archiving and Communication System
PAS	Patient Administration System
PDSA	Plan-Study-Do-Act
PKI	Public-Key-Infrastructure
RAM	Random-Access Memory
SALAR	Swedish Association of Local Authorities and Regions
SAN	Storage-Area-Network
SITHS	Secure IT in Health Services
SOA	Service-Oriented Architecture
SQL	Structured Query Language
SSL	Secure Sockets Layer
SVR	Sjukvårdsrådgivningen (Sick care advice)
TCP	Transmission Control Protocol
VPN	Virtual private network

EXECUTIVE SUMMARY

The regional integrated EHR and ePrescribing system in Kronoberg, Sweden, presents a benchmark from which many other European regions can learn a great deal. It is analysed as one of nine independent quantitative evaluations of 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.

The EHR and ePrescribing system subject of this report is implemented across the Kronoberg county in southern Sweden, which spans eight municipalities with a total of 182,000 inhabitants. The county has the authority over 2 hospitals, 31 healthcare centres, 3 mental health units and 25 dental care centres. These facilities employ 5,700 staff and manage annually 413,000 consultant visits and 504,000 visits to other healthcare professionals.

The EHR system is implemented in all healthcare facilities in the county and affects services across the whole healthcare system. These include primary, secondary and long-term care. It enables a seamless patient journey through healthcare provider organisations (HPOs) and between different levels of care.

Plans for a county-wide EHR solution including administrative and clinical information started in 1999, followed by the introduction of a patient administration system in 2000. Implementation of the EHR system started in 2003. Paper records were gradually replaced by one shared electronic health record and stand-alone IT systems were either replaced or complemented with new EHR components. Today, all healthcare professionals use the system and 98% of the population have an EHR.

The two major positive impacts are improved quality of care and efficiency gains. Quality of care includes higher levels of patient safety, better continuity of care, better informed decisions and increased effectiveness of health services. Efficiency gains result from time savings, avoided waste of resources and some limited financial savings. Additionally, healthcare professionals profit from better employed time and better work satisfaction due to improved availability of information in real time. Negative impacts consist mainly of cost for pre-development planning, set up and maintenance, which are mainly borne by the county council. Further costs arise from initial inconvenience of users when introducing an eHealth application. eHealth also creates new risks of mistakes, which is also accounted for.

The socio-economic evaluation estimates that annual net benefits were first realised in 2006, the third year of implementation. This timescale is inline with other initiatives of comparable scope and complexity. The long period of continuous costs without benefits prior to the implementation reflects the time of careful planning and searching for an IT solution that matches the requirements of Kronoberg's health system. The advantage was a better focus on robustness and reliability of all implemented features of the system, and thus minimisation of the risk of failure. The success of this approach is reflected in the quick realisation of net benefits after implementation.

The first year of cumulative net benefits is already reached in 2007, only one year after the estimated value of annual benefits exceeds annual costs for the first time. Although it takes time for technically and organisationally complex eHealth activities to be set up, once utilisation begins, benefits tend to increase fast.

The annual net benefit to cost ratio, which compares the net socio-economic impact to the costs with zero as a break even point, turns positive in 2006. It increases further to reach +1.46 in 2010. This indicates a worth-while endeavour from a socio-economic perspective. The cumulative ratio reaches +0.52 by 2010. This can be interpreted as a rate of socio-

economic return of about 52% over a period of 12 years. This includes both financial and non-financial components. The interpretation is that for every SEK100 worth of negative impact, there are SEK152 worth of positive impact.

The estimated costs are distributed between all stakeholder groups, except third parties. Risks associated with using EHRs, as well as procedures for providing consent, drive the costs for citizens to just over 1% of total costs. Inconveniences and initial adaptation efforts for users comprise some 11% of the total value of costs. The fact that the county council bears the bulk of costs is neither surprising, nor concerning. In a centralised health system, such as in Sweden, investments of such kind lie in the responsibility of the public sector.

The county council and the HPOs that belong to it also reap the largest share of benefits - about 54% of the total. Professionals are major beneficiaries from the integrated EHR system. Their non-financial investment of some 11% of all costs is modest compared to their equally non-financial benefits of 38% of total. The benefits to citizens are exceeding their proportion of costs.

Similar to other sites, cash gains are relatively modest at 15% of the benefits, while 47% of the costs are of a financial nature. Many benefits come as improved quality of care, which has considerable value but is difficult to convert to actual financial flows. Additional financial benefits such as efficiency gains, which could potentially be redeployed into productive resources, are substantial at 43% of all benefits, but are found in many small pockets and cannot easily be redeployed on the corporate level. Releasing this potential financial benefit is a challenging managerial task.

Lessons from this case study include:

- Commitment of management at all levels is essential to cope with the fundamental changes in processes and practices associated with connecting different levels of healthcare
- The hybrid of bottom-up and top-down system development and implementation approach ensures engagement leading to useful IT solutions and firmness in seeing the implementation through to routine service
- A successful approach to change is quick implementation of the least distorting parts of the eHealth application, aiming at fast returns for users, with a subsequent long-term commitment to changing processes and standardising clinical and working practices
- A substantial amount of pressure on technology comes from the fact that it is complicated and dangerous to work with parallel routines over long periods
- Organisational risks, often stemming from hidden processes and the automatic increase in transparency brought about by the implementation of a comprehensive EHR system, are a bigger challenge than technology risks, as they are less predictable.

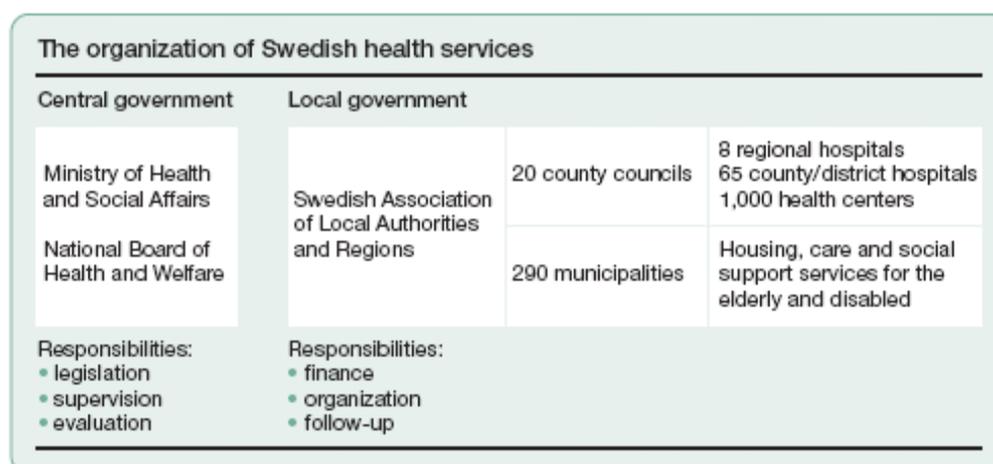
The overall conclusion from the evaluation of the EHR and ePrescribing system in Kronoberg is that it presents a benchmark from which many other European regions can learn a great deal. Although still being developed, the system already achieves impressive results in a number of areas. The socio-economic performance is robust. The EHR system spreads across all levels of healthcare in routine operation. The high value to users, made clear in numerous interviews, proves sustainable acceptance levels and a positive impact on healthcare services.

1 Background

1.1 Health system setting

The Swedish healthcare system is organised into three levels: national, regional and local. Figure 1 shows the organisation of the Swedish healthcare system on these levels. At the national level, the Ministry of Health and Social Affairs (Socialdepartementet) is the main actor of the Swedish healthcare system. Its responsibilities cover health and medical care, public health, social insurance, policy for the elderly, child policy, social services and disability policy. Its policy responsibility includes a supervisor role on activities in the county councils. Furthermore, the National Board of Health and Welfare (Socialstyrelsen), a semi-independent public authority, has a supervisory function over the policy areas of social services, public health protection, infectious disease control and health and medical care.¹

Figure 1: The organisation of Swedish health services



Source: Swedish Institute

At regional level, 18 county councils, two regional bodies (Västra Götaland and Skåne) and one municipality (Gotland) manage the healthcare delivery system from primary care to hospital care, including public health and preventive care. For tertiary care the county councils collaborate in six healthcare regions, each of which operates at least one university hospital with highly specialised care². At local level, there are 290 municipalities with their own areas of responsibility, including home care, nursing homes, and school health services.³

¹ European Observatory on Health Systems and Policies (2005): Health Systems in Transition. Sweden. Health System Review. Vol. 7, No. 4., Copenhagen: World Health Organisation, Regional Office for Europe, Available at: <http://www.euro.who.int/Document/E88669.pdf> (08-07-09)

² Swedish Institute (2007): Fact sheet Swedish health care. Available at: http://www.sweden.se/upload/Sweden_se/english/factsheets/SI/SI_FS76z_Swedish_Health_Care/FS76z%20FINAL_Hi_res.pdf (08-07-09)

³ European Observatory on Health Systems and Policies (2005): Health Systems in Transition. Sweden. Health System Review. Vol. 7, No. 4., Copenhagen: World Health Organisation, Regional Office for Europe, Available at: <http://www.euro.who.int/Document/E88669.pdf> (08-07-09)

Responsibility for mental healthcare and rehabilitation is shared between the counties and municipalities⁴.

Primary care in Sweden is delivered in healthcare centres, most of which are owned and operated by the county councils. General practitioners (GPs) and other staff work as salaried employees. Payment of public primary care providers is largely based on capitation, topped up with fee-for-service and/or target payments. Around 25% of health centres are privately run by enterprises, and commissioned by the county councils⁵. For these private providers fee-for-service arrangements with cost and volume contracts is more common⁶. The traditional model, in which health centres provide primary care to residents within a geographical area, is being replaced, with increased possibilities for residents to choose their provider and physician.

Primary care has no formal gate keeping power. Nevertheless, residents are encouraged to visit their primary care provider before accessing secondary and tertiary care. In contrast to GPs, specialist physicians provide healthcare in hospitals only. This is reflected by the traditionally large outpatient departments in hospitals. Hospital physicians and other staff are salaried employees. Payment of hospitals stems from the respective county and is usually based on DRGs (diagnosis-related groups) combined with global budgets. Private healthcare providers and dental clinics use a mixture of salaries, capitation, and fee-for-service payments for professional staff. The Swedish Social Insurance Agency reimburses private dentists and physicians, as well as medications⁷.

The Swedish healthcare system is publicly financed. 71% percent of healthcare is funded through local taxation. Both the county councils and the municipalities levy proportional income taxes on their respective residents. Around 26% of healthcare funding comes from state contributions and other sources. Only 3% are patient fees⁸.

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

eHealth solutions have, until 2006, been developed in Sweden in cooperation between national and regional authorities on a voluntary basis, without a national eHealth Strategy. The organisation "Carelink", established in 2000, was entrusted to operate as a link between regional initiatives, advancing the use of IT in healthcare. Its board of directors consists of representatives from municipalities, counties, the National Board of Health and Apoteket AB, the Swedish public pharmacy chain. One of the largest eHealth projects before the emergence of a national eHealth strategy is Sjunet, a joint telecommunication network dedicated to healthcare and administered by Carelink, since 1 January 2008 a part of Sjukvårdsrådgivningen (SVR). Since 2002, the network is linking together county councils and

⁴ European Observatory on Health Systems and Policies (2005): Health Systems in Transition. Sweden. Health System Review. Vol. 7, No. 4., Copenhagen: World Health Organisation, Regional Office for Europe, Available at: <http://www.euro.who.int/Document/E88669.pdf> (08-07-09)

⁵ Swedish Institute (2007): Fact sheet Swedish health care. Available at: http://www.sweden.se/upload/Sweden_se/english/factsheets/SI/SI_FS76z_Swedish_Health_Care/FS76z%20FINAL_Hi_res.pdf (08-07-09)

⁶ The Common Wealth Fund (2008): The Swedish Health Care System. Available at: <http://www.commonwealthfund.org/Content/Resources/2008/Mar/Health-Care-System-Profiles.aspx> (08-07-09)

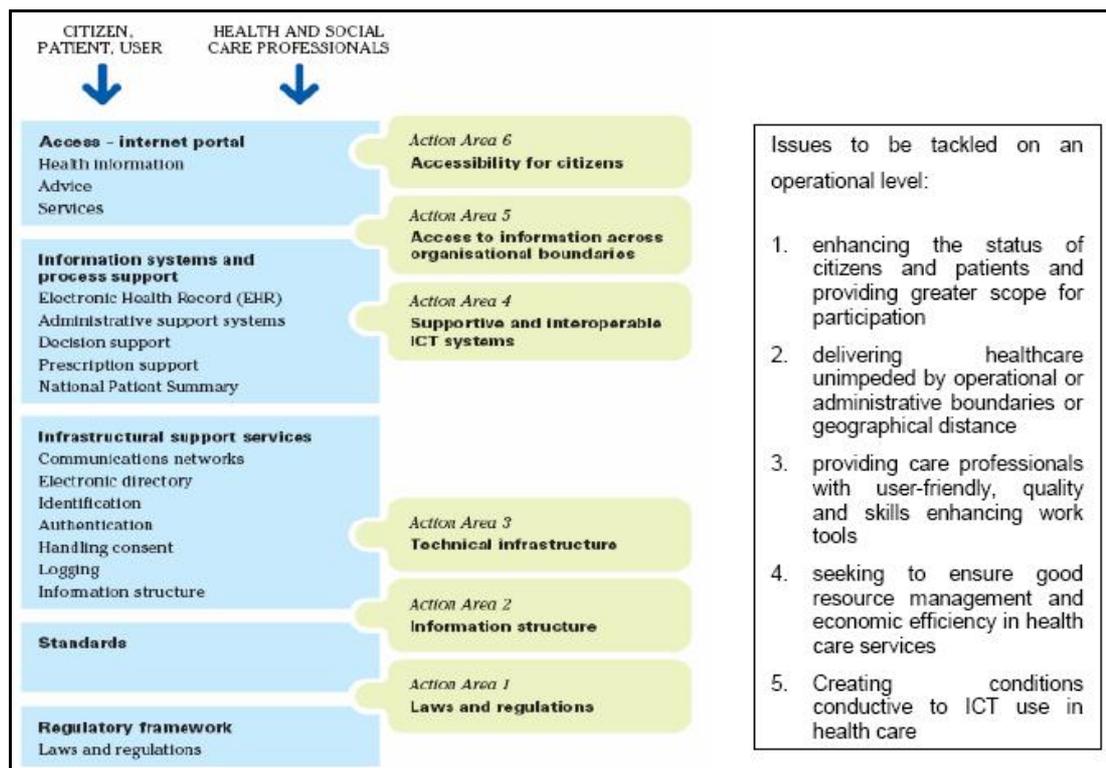
⁷ European Observatory on Health Systems and Policies (2005): Health Systems in Transition. Sweden. Health System Review. Vol. 7, No. 4., Copenhagen: World Health Organisation, Regional Office for Europe, Available at: <http://www.euro.who.int/Document/E88669.pdf> (08-07-09)

⁸ Swedish Institute (2007): Fact sheet Swedish health care. Available at: http://www.sweden.se/upload/Sweden_se/english/factsheets/SI/SI_FS76z_Swedish_Health_Care/FS76z%20FINAL_Hi_res.pdf (08-07-09)

regions, pharmacies as well as several other healthcare enterprises. The national ePrescription system represents just one of the different eServices supported by Sjunet^{9,10}.

An eHealth strategy was approved during spring 2006 by the board of the Swedish Association of County Councils and Swedish Association of Local Authorities (since 2007, merged into SALAR), and by the Government. The strategy points to six action areas at the national level, as well as issues to be tackled on practical level to create the conditions for safe, secure, and efficient use of ICT in health and social care. As displayed in Figure 2, EHRs, ePrescribing and interoperability play an important role in the Swedish eHealth strategy¹¹.

Figure 2: Action areas of the Swedish National Strategy for eHealth



Source: Swedish eHealth Strategy (2006)

At regional level, all county councils have adopted the Swedish strategy for eHealth and the joint action plan to realise it. Collaboration between councils takes place through SALAR's ordering function¹², and is accompanied by legislative changes. The 2008 new Patient Data Act is expected to drive developments towards coordinated record-keeping. This means that authorised personnel - with the consent of the patient - can access digital information held by other care providers, regardless of the principal. For example, authorised staff in municipal social care are now allowed to read information in the county councils' ICT systems.

⁹European Commission (2007): eHealth Priorities and Strategies in European Countries. eHealth ERA Report. Towards the Establishment of a European eHealth Research Area. Fact Sheet Sweden, p. 71. Available at: <http://www.ehealth-era.org/database/documents/factsheets/Sweden.pdf> (08-07-09)

¹⁰eHealth IMPACT - The economic benefits of implemented eHealth solutions at ten European sites (2006). Apoteket and Stockholm County Council, Sweden - eRecept, an ePrescribing application. Available at: http://www.ehealth-impact.org/case_tool/data/binary/d9448cc8ce8d4b44ab01f211908dd02f.pdf

¹¹Ministry of Health and Social Affairs, Swedish Association of Local Authorities and Regions and National Board of Health and Welfare (2008): Swedish Strategy for eHealth 2008 Status Report. Available at: <http://www.sweden.gov.se/content/1/c6/11/48/75/39097860.pdf> (08-07-09)

¹²Ministry of Health and Social Affairs, Swedish Association of Local Authorities and Regions and National Board of Health and Welfare (2008): Swedish Strategy for eHealth 2008 Status Report. Available at: <http://www.sweden.gov.se/content/1/c6/11/48/75/39097860.pdf> (08-07-09)

Major recent projects and activities to realise the Swedish eHealth strategy include:

- National Patient Summary (NPÖ)
- Health Services Address Registry (HSA, e-directory)
- Base Services for Secure Information Supply (BIF)
- Secure IT in Health Services (SITHS)
- Web-based care - personal services platform.

In addition to these, many activities have been undertaken on the regional level covering different aspects of eHealth applications and services. For example, 16 of the Swedish counties have implemented EHRs by 2009, seven of them with one single regional system¹³.

¹³ Jerlvall, L, Pehrsson, T. (2009). IT-stöd i landstingen. Inventering på uppdrag av SLITgruppen. Available at: <http://www.ski.se/artikeldokument.asp?C=7925&A=50448&FileID=268231&NAME=Rapport+IT%2Dst%F6d+i+landstingen+SLIT+aug+2009.pdf> (10-09-09)

2 The regional integrated EHR and ePrescribing system in Kronoberg, Sweden

2.1 Organisations involved

The entity on which this evaluation focuses is the Regional Healthcare Authority of Kronoberg County Council, referred to as “the county council”. It is the primary provider of healthcare services in the county of Kronoberg.

The county spans eight municipalities (Ljungby, Växjö, Lessebo, Uppvidinge, Alvesta, Markaryd, Älmhult and Tingsryd) and covers 182,000 inhabitants in an area of 9,400 km². The Regional Healthcare Authority of Kronoberg comprises 2 hospitals, 31 healthcare centres, 3 mental health units and 25 dental care centres. In total, all these facilities employ 5,700 persons, and manage annually 413,000 consultant visits, 504,000 visits to other healthcare professionals, and 27,000 care contacts. Social care, including home care and nursing homes, are provided in municipal facilities and by district nurses and social carers employed by the municipalities.

The two hospitals in Kronoberg, Växjö and Ljungby, are in the process of merging. This is why they are often referred to as “one hospital with two entrances”. The hospitals offer inpatient and outpatient care and dispose of 415 beds for somatic and 190 for psychiatry patients. The hospitals cover all common specialties, including all specialised ambulatory services. Laboratory services are provided inside the hospitals. Psychiatric care is also provided in psychiatric clinics in Växjö, the county capital, and in Ljungby. The healthcare centres in primary care represent group practices with usually 3-7 GPs, assistant GPs, nurses, medical secretaries, and assistant nurses. Healthcare centres may employ also psychiatric nurses, physiotherapists and other specialists, who employ their knowledge in GP consultations. Not all of Kronoberg’s healthcare centres are public. 8 of the 31 healthcare centres are privately run and accredited by the Regional Healthcare Authority. All healthcare centres provide basic health and medical services, advisory services, preventative measures, rehabilitation, child health services and psychiatric expertise¹⁴.

A national organisation also playing a role in the healthcare delivery in Kronoberg County is 1177, Sweden’s equivalent to England’s NHS Direct¹⁵ or Scotland’s NHS 24¹⁶. 1177 is a telephone consultation service providing medical advice to patients and matching their needs with the right level of care. 1177 is a part of the regional healthcare system, as it directs patients to different healthcare provider organisations (HPOs) in the county.

¹⁴ Kronoberg County (2009) Dental Care. Available at:

http://www.ltkronoberg.se/upload/Dokument/Languages/engelska/07%20-%20tandv%C3%A5rd_en.pdf (08-07-09)

¹⁵ eHealth IMPACT - The economic benefits of implemented eHealth solutions at ten European sites (2006). NHS Direct, UK: NHS Direct Online (NHSDO) information service. Available at: http://www.ehealth-impact.org/case_tool/data/binary/8cc5698bc7b29c5c6faff984417d8a85.pdf

¹⁶ EHR IMPACT (2008): The socio-economic impact of NHS Scotland’s Emergency Care Summary. Available at: <http://www.ehr-impact.eu/cases/cases.html> ((08-07.09)

2.2 Context of the initiative and eHealth dynamic

2.2.1 Context and developments

The shared electronic health record is the result of a decades-long planning process. The initial vision of a shared EHR system was born within a group of IT managers in the county's IT department and healthcare professionals in the early 1990s. Local EHR solutions were supported by some healthcare professionals in the county and were already implemented in some GP practices in early 1993. That was the first attempt with a local EHR-system, with one database per HPO. The county council was responsible for the project. The aim was to roll it out in the entire county, but it was not possible to transfer that system from the county that had developed the system and the vendor was not able to support it in the right way. Kronoberg only installed in at two healthcare centres. No solutions that fitted the requirements of a county-wide EHR system were found until 2004. This led to a long phase of waiting, in which doctors and IT professionals sometimes disagreed on the further directions. The strategic decision for shared EHR stood in contrast to many other Swedish counties with local medical record system.

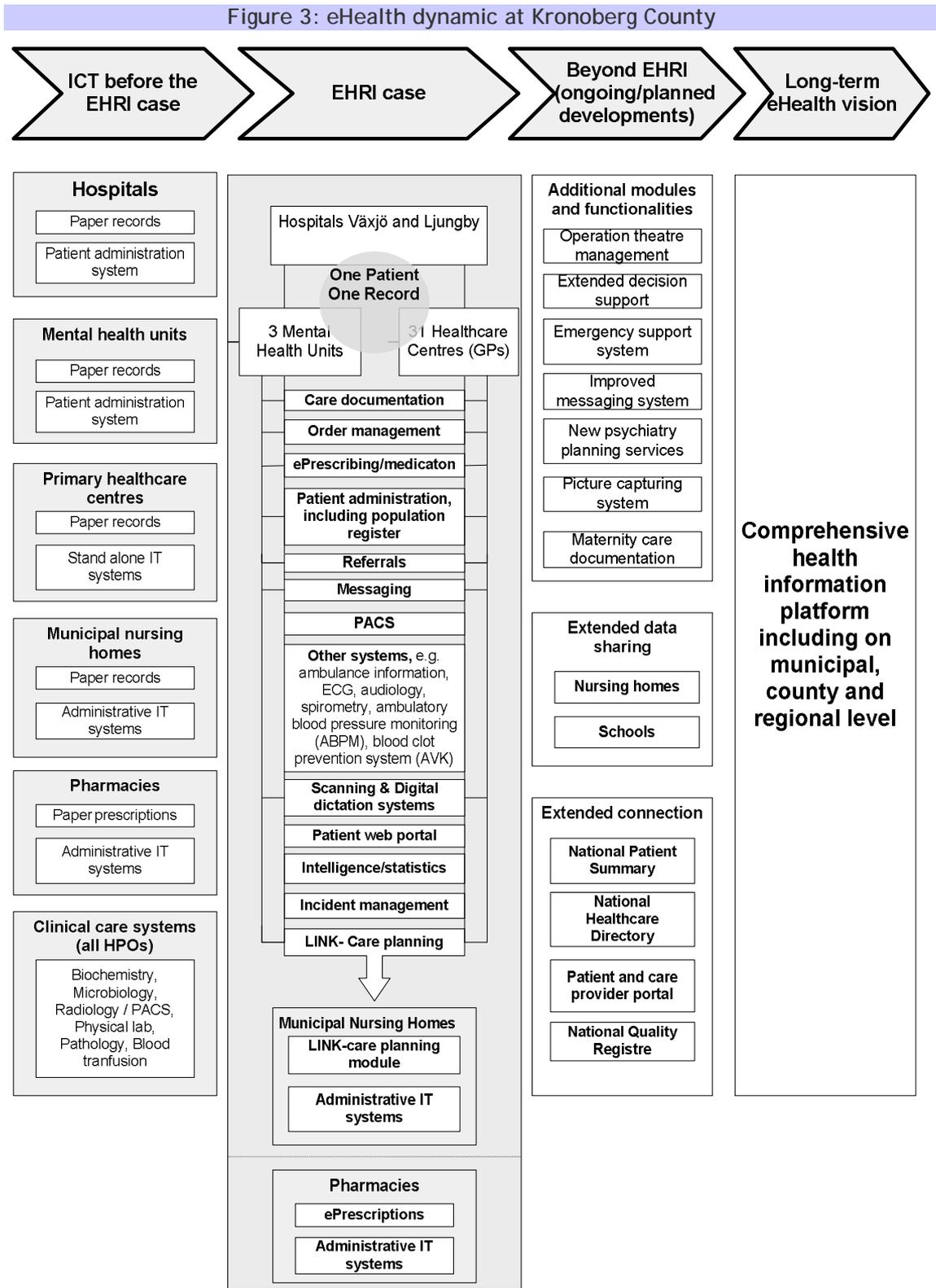
Proponents of local EHR systems and the mounting demand to support healthcare with ICT created considerable pressure on the advocates of a shared EHR system. There was a trade-off between small and limited, but immediate benefits from a local EHR and large-scale, but long-term benefits of a shared EHR. In spite of this difficult situation, the county council IT department succeeded to convince the county council of the advantages of a shared record. In 2000 the county introduced a patient administrative system - Cambio 2000, delivered by Cambio Healthcare Systems - but no company succeeded in delivering a ready-to-use solution for the clinical part, confirming initial fears. In spite of this setback, the attempt for a county-wide EHR was repeated one more time in 2003.

The drivers of this large eHealth investment in Kronoberg comprised several aspects:

- The need to link each patient with only one healthcare record for all healthcare professionals and across the entire county
- The need to improve access to healthcare records - anytime, anywhere
- The desire to save time by efficient recording of patient events
- A drive to increase patient security
- A drive to improve service for patients
- The need to improve co-operation in the healthcare process
- The need for better tools for development of quality and content in operations.

The maintenance of paper records had become increasingly difficult over the years. No longer were paper records able to keep up with the increase in activity in the healthcare system. An estimated increase of 300 meters of paper files per year created not only logistical problems. The vast amount of information on paper hampered the exchange of information that was needed to improve patient safety. Double treatments due to the lack of transparency and cooperation between healthcare providers were also a most pressing concern. An integrated EHR system, together with ePrescribing, promised to address all these problems.

The developments in the county of Kronoberg have created their own dynamic, depicted in Figure 3 below.



Source: EHR IMPACT study

Gradually, paper records have been replaced by one shared electronic health record available to more and more healthcare providers. Stand-alone IT systems have either been replaced or complemented with the EHR system. Plans for the future include three main themes:

- Improving and extending the functionalities of the EHR system

- Extending the EHR system to additional stakeholders
- Aligning the regional EHR system with national eHealth developments.

Modules to be introduced in Kronoberg's hospitals in the near future include operation theatre management, emergency support, maternity care documentation, and a picture capturing system. The extended decision support and the improved messaging system will be used in all healthcare centres and hospital departments. Especially the improvements in messaging are expected to further facilitate the cooperation between primary and secondary care. Further modules currently being improved are the medication and the referral part of the order management module. Departments for psychiatry and mental health units are about to introduce a new module supporting legal compliance in this specific area.

Efforts are underway to include additional stakeholders in the EHR system. Municipalities/municipal nursing homes, as well as schools are expected to join the network. Nursing homes already use the care planning module, but they have the option to switch from their patient care documentation system to the county-wide EHR system as their primary IT system for care support and administration. One municipality have already started. The offer of using the full access to the EHR system has been extended to healthcare professionals at offices in municipal schools. The idea behind this is to improve cooperation between actors on county and municipal level and to provide seamless care.

Kronoberg's EHR system is also being further developed to cooperate in a series of national eHealth projects. In 2010, it is planned to connect the county-wide system with the National Patient Summary (NPÖ) and more national quality registers. All diabetes patients in the county already are reported to the national diabetes register (NDR). Clinical data is registered in a template for each visit, with lab and medication data drawn automatically. The relevant data is transferred to the national quality register every night. Web-based care in form of a personal services platform for citizens is already been used and will extend its functionalities in the future. It will be possible for patients to book visits over the Internet.

2.2.2 Scope of the evaluation

The EHR system in Kronoberg County covers a multitude of organisations, functional components, and services. This complexity requires certain boundaries to be drawn for the purposes of the evaluation.

From the technical point of view, the EHR system represents a management and clinical system. The overall system consists of clinical and non-clinical parts, such as economic and administrative sub-systems or modules. Based on the medical information on patients, both parts work together and are thus difficult to separate. However, the evaluation focuses on the clinical/medical parts of the systems. In the EHR solution, particular attention is paid to the ePrescribing system. ePrescribing represents a central and well established service to most of the organisations affected by the EHR system. The evaluation includes the impact of ePrescribing on pharmacies in Kronoberg only. Pharmacies outside of Kronoberg are also able to receive ePrescriptions from Kronoberg. However, these organisations are outside the evaluation scope.

The scope of evaluation covers all organisations described in section 2.1, except for dental practices. The intention is to focus on the most common activities in Kronoberg's EHR system. The evaluation acknowledges that dentists in the county use the medication and ePrescribing module in the EHR system. However, as only 1% of all prescriptions in the county come from dentists, these HPOs are excluded from the quantitative analysis. Another limit concerns the municipal nursing care. To date, only one of the eight municipalities in Kronoberg - Markaryd - use the EHR system for care documentation. The rest use stand-alone patient administration and care documentation systems that are not integrated with the county-wide EHR system.

The cooperation of the municipalities with the county healthcare providers relies on the care planning module (“Link”) of the EHR system. Additional modules used in Markaryd municipality represent the exception. The quantitative assessment is confined to the impact of the care planning module used in municipal nursing homes and home care.

2.3 The health services affected

The EHR system is used in hospitals, healthcare centres, mental health units, dental practices and nursing homes. Thus, the system affects services across the whole healthcare value system, including primary, secondary, and long-term care. Tertiary care is provided outside the boundaries of Kronoberg and therefore not affected by Kronoberg’s EHR system.

In hospitals, healthcare centres and mental health units, the EHR system is essential for organising most working processes, including diagnostics and treatment, care planning, and transfer of patients to nursing homes and home care. In primary care, the EHR system affects services such as patient registration, consultation, referrals, prescriptions, laboratory and other examinations and administration and billing.

The services affected at the hospitals include the services mentioned above and further services specific to hospitals, like admission, discharge, inpatient and outpatient treatment, and surgery.

Pharmacies cannot access the EHR and the patients’ medication list. However, the drug dispensing process has been changed by processing ePrescriptions from HPOs that use the medication and ePrescribing module of the EHR system.

2.4 Components and functionalities

Overview

The county-wide EHR system consists of clinical modules and administrative modules. Central to both medical and administrative parts is the electronic health record. This includes the patient’s demographic, diagnostic, therapeutic and other administrative information. Even though all healthcare providers connected share common elements, the record at each HPO is adapted according to different configurations and healthcare services. The respective range of applications varies across the different healthcare providers in Kronoberg. For example, hospitals may fall back on a larger range of administrative and management support modules than healthcare centres.

Figure 4 provides an overview of the system structure, reflecting the range of different components.

Figure 4: COSMIC system structure



Source: Cambio Healthcare Systems AB

The core element of the EHR system is its engine, upon which different modules are built.

Clinical components and functionalities

The clinical components of the electronic health record system include:

- Care documentation module, containing the medical record, care plan and report sheets
- Order management module, including:
 - Referrals
 - Lab tests (biochemistry, microbiology)
 - Radiology
- Medication module, comprising of:
 - Medication list
 - Prescription and decision support
- “Link” module for interaction between institutional care and community care
- Emergency care module including emergency record
- Theatre management module (in development/implementation)
- Maternity support module (in development/implementation)
- Integration to external systems, including:
 - PACS (x-ray, eye bottom)

- ECG system
- Ambulance information system
- Audiology system
- Scanning (paper-based records)
- Blood transfusion system
- Blood clot prevention system.

The care documentation module provides essential functionalities for clinical care support. The medical record is where all care data is collected in a chronological order. This record contains also summarised information created by other modules, such as order management and medication. The care plan in the care documentation module is a process-oriented planning and documentation tool for treatments and activities. The information gathered herein is divided into pre-defined pre-admission, status, care plan and final summary sections. The report sheet is used for patients who are being cared for on a ward. Here the healthcare staff can document all expected and unexpected events, measures and results. The medical report, care plan, and the report sheet are similar in that the templates for documentation are simple to modify and can be adjusted to suit the needs of different care providers.

Other tools used in care documentation include:

- **“Digital dictation” software**

Digital dictation is used by doctors and other healthcare professionals for medical notes and reports. The subsequent audio file is then transcribed by a medical secretary into the medical record.

- **“Scanning software”**

Scanning of paper forms and old paper-based records. Scanning and viewer are integrated with COSMIC care documentation.

- **“Image viewer”**

The care documentation module is linked to a viewer application to view images, such as X-ray pictures.

- **“Common documents”**

The common documents tool allows for marking information from the medical record. This information, usually patient characteristics that do not change often, becomes visible for all care providers and can be displayed in various overviews.

- **Unsigned and non-certified care data**

Unsigned and non-certified care data is placed on a shared list. The care provider can sign their medical record notes from this list. This also allows for changes to the record before they are signed.

- **“Groups”**

“Groups” enables the shared information handling of groups with patients, for example physiotherapy treatment groups. A treatment regime for a group is placed in each individual medical record for patients who are members in the group. It is also possible to add treatments for the entire group.

- **“Forms”**

“Forms” is a tool to deal with forms for sick notes, doctors’ opinions, and certificates of various sorts. The software product allows for individual configurations. In Kronoberg, all new forms are centrally created and administrated, and then used locally by all users. Thus, new forms are designed in a way useful for all potential users from across the healthcare facilities. The user can write a certificate using keywords in the medical record from the first visit, and

then simply renew the same certificate on the next visit. This is done via a form window where all forms that have been written for the patient concerned are collected together. With just a few clicks, the care provider can renew the form or certificate and can also modify it, when required.

The **order management module** enables the request and receipt of laboratory and radiological tests and results. It is also a tool to process incoming and outgoing referrals, which are connected to care request and, more importantly, care commitment. The order status view is used to follow up on the progress of tests and referrals. Test results are received in an in-tray. Care providers can access this information and - depending on their access rights - sign that they have read the results. The results are stored in list form, one for each speciality. The clinical values are shown numerically and can be displayed graphically and across time.

As for **referrals for consultation**, the receiving health providing unit can define its own selection of centrally administrated referral templates to which information entry is connected. With the help of these templates, the receiving unit defines the information they need before processing a referral.

The **medication module** is build up around a common list of medications comprising current prescriptions, past medications as well as previous prescriptions. The module offers functionalities to create, change, suspend or terminate medication regimes. The decision support in the prescribing process consists of access to the basic pharmacological stock lists, detailed information pertaining to the medicine in question, warnings, recommended medication and general directives. The prescription is fully electronic and is transmitted to the Swedish national ePrescription database, which is accessed by every pharmacy in Sweden. The same functionalities of the medication module are also available for drug administration on the ward.

The **“Link” module** provides functionalities for joint care planning between secondary, primary and nursing home care. This module allows authorised staff in the care chain to gain access to patient information, case-record information, medical and nursing epicrisis, rehabilitation reports and drugs lists. Using this module, registration messages, notices to attend care-planning meetings, and discharge messages can be managed entirely electronically.

Non-clinical components and functionalities

Administrative and other non-clinical modules include:

- Patient administration module
- Statistics module
- Incident management system (separate application).

The **Patient Administration System (PAS)** module provides functionalities for resource planning, everyday administration, pricing and billing, scheduling, etc. The functions can be applied in inpatient, outpatient and primary care. It is a central module that is closely linked to other parts of the EHR system such as the medical record or the medication list. The care administration tool in this module is used to register patients. The information for the contact created in the reception is linked to the clinical applications in the EHR system. This reception and admission information also serves as a basis for invoicing.

The patient administration system also gives care providers an overview of visits and planned care activities or admissions or planned admissions. Other functions include resource planning and scheduling.

The intelligence or **statistics module** and the **incident management system** represent the more economic and management-oriented components in the EHR system. The statistics module uses clinical and administrative information processed in the other modules to create reports and analyses. Business Objects is the tool for analysing and for reporting statistics, while COSMIC Intelligence is a module for exporting data to a data warehouse for analysis. The external incident management system provides functionality to report clinical incidents.

2.5 The system in practice

2.5.1 System utilisation

The EHR system in Kronoberg County is used by 4,500 of a total of 5,700 employees of the Regional Healthcare Authority, or some 7 % of the working population in Kronoberg. About 1000 users are employed by the municipalities¹⁷. System access amounts to about 1,400 concurrent users within a period of 10 minutes. Users include doctors, nurses, district nurses, assistant nurses, and other professionals such as physiotherapists, as well as support staff. All seventeen nurses working in the 1177 service in the county use the EHR system.

Managers on all levels, controllers, and doctors use Business Objects for reporting and analysing data transferred from the EHR-system to a data warehouse. The EHR system is the source for data of internal and external billing and compensation including follow up of quality indicators by reports and scorecards (e.g. for medication) in Business Objects. Data of lead-times in care support process from the EHR system is also followed up. Some of this data, such as availability of care, is reported to the national level.

Doctors, nurses and other healthcare professionals have access to all modules used by the respective HPO. However, the division of tasks between healthcare staff is reflected in the usage of different functionalities. Among the healthcare professionals, doctors make use of the broadest range of system functionalities. Nurses and secretaries are the main users of the patient administration module in the EHR system. They also execute most of the administrative tasks supported by the other clinical modules. These include for instance medication dosage administration for inpatients, following the care plan in the care documentation module or organising continuous care planning between a hospital department, primary care, and municipal home care. A common task for medical secretaries in different HPOs is to transcribe audio files with doctors' and other healthcare professionals' medical notes into the medical record. This mainly applies to long entries. Doctors enter short notes themselves. Doctors produce about 75,000 notes per month, 80% of which are dictated¹⁸.

The EHR system currently stores data on about 98% of the population in Kronoberg. The remaining 2% consists of citizens without previous care contacts. Central functions, such as referrals, test ordering and ePrescribing are heavily used across the county. The number of ePrescription has reached 48,000 per month, representing among the highest proportion of ePrescriptions out of all prescriptions in a Swedish county¹⁹. Referrals and orders amount to some 40,000 per month.

2.5.2 Supporting the patient's journey

The EHR system forms the foundation for a seamless patient journey through HPOs and also to and from different levels of care. Every time a patient seeks medical care, the county council must register information on the patient. Patients without an existing EHR can be registered

¹⁷ Kronoberg County (2008): Cambio Cosmic. Available at: http://www.ltkronoberg.se/templates/LTKPageWithPicture_35971.aspx (08-07-09)

¹⁸ Kronoberg County (2008): IT i vården. Available at: http://www.ltkronoberg.se/templates/LTKPresentation_8172.aspx (08-07-09)

¹⁹ Jerlvall, L, Pehrsson, T. (2009). IT-stöd i landstingen. Inventering på uppdrag av SLITgruppen. Available at: <http://www.skl.se/artikeldokument.asp?C=7925&A=50448&FileID=268231&NAME=Rapport+IT%2Dst%F6d+i+landstingen+SLIT+aug+2009.pdf> (10-09-09)

in the system by healthcare professionals at healthcare centres or hospital. The individual electronic health records are viewed and updated every time the patient receives medical care. This may be a visit to a primary healthcare centre, any activity in inpatient or outpatient care at a hospital, or a tele-consultation.

The following describes an exemplary patient journey through primary, secondary and nursing home care. This serves as an illustration of how the EHR system supports various healthcare processes.

Primary care

Taking primary care as a starting point, the patient has several possibilities. He can schedule an appointment or pay an unscheduled visit to a healthcare centre. If the patient has been at a healthcare centre before, he can send an inquiry to this particular healthcare centre over a patient web portal ("My care contact"). This service can be used with a certificate on the patient's computer and a password. This portal is not an integrated part of the EHR system but allows secure messaging to the system. On this web portal, the patient can enter administrative information in a booking form - information that can be accessed by the registering personnel in the healthcare centre and be reused in the care administration process. A patient can also make a phone call to the healthcare centre to schedule an appointment and/ or receive further advice.

The nurse represents the first point of contact to primary care. Before a patient visits a healthcare centre, he usually undergoes a telephone consultation with a nurse. At this stage, the nurse determines whether the patient has to come to the healthcare centre and see the nurse or the doctor in person. The nurse can also direct the patient to the hospital or emergency care, depending on the patient's medical condition. The nurse uses the patient's EHR for decision making and can give the patient further instructions.

For every patient visit to the healthcare centre, the medical secretary first accesses the patient administrative system (PAS) and creates a care contact note. Once registered, the patient is added to the contact list, giving the care provider an overview of the day's visit and planned care activities. Telephone and normal consultations alike appear on the schedule in the contact view and are highlighted accordingly.

At the healthcare centre, the patient can be treated by a nurse, a doctor or another healthcare professional, such as a physiotherapist. From the schedule in the patient administration system, the user can easily navigate to the patient's medical record or the medication list. Usually, the latest entries in the medical record are consulted first. The user can view for example previous and current examination and lab test results. The user can use the search functions in the care documentation module to extract relevant information through keywords. The medical record contains external medical notes from other HPOs. The user may actively open this view to learn what procedures were done and what results are available from other facilities. Some sensitive information such as psychiatric records is not accessible in this view. During the consultation, the care provider may also choose to show the patient certain parts of the EHR.

Further, the doctor, nurse, or another healthcare professional can view a list with current and active prescriptions. This list does not indicate the dispensed, or the consumed medication, but it nevertheless gives indications on what the patient should be taking. With the patient's consent, the care provider can also access the dispense record via a web portal. In order to keep the amount of information displayed in reasonable size and relevance, there are filters that can be adjusted by the user.

The doctor can enter the diagnosis into pre-defined templates or write reports according to pre-specified keywords. Templates and keywords are defined by a development committee and have to be used by all professionals. The alternative is to dictate notes that can be fed

into the patient record by a medical secretary. If a lab test is needed, he can use the order management module to send a request for a lab test. Referrals can be sent to other healthcare providers along with a specification of the reason. In many cases, a prescription is needed for the patient. The prescribing doctor has to choose the medication, enter an ordination, define the appropriate dosage form and select the correct package size. For decision support in the prescribing process, the doctor can access the basic pharmacological stock lists (FASS) to obtain information on drugs. Moreover, there are system alerts in case of contraindications, or issues arising from a combination between certain drugs and pregnancy or breastfeeding. The care provider also receives recommendations from a financial point of view. For example, inexpensive and effective drugs that are recommended by the authorities are highlighted with a green dot. FASS provides the information needed to find the appropriate medication brand in case the green dot mark does not appear.

After the visit in a primary healthcare centre, the patient can be referred to secondary care.

Secondary care

Patients can be referred to a hospital from a healthcare centre, enter the hospital through the emergency department, or visit an ambulatory department with or without previous referral. All incoming patients are initially considered outpatients. Only after a medical check-up, patients become inpatients or receive further treatment as outpatients.

In case of a referral, the hospital care provider receives a referral notice through the EHR system. The referrals contain a structured part defining the sender and the receiver, as well a box for free text to indicate the reason of the referral. Upon acceptance of the referral, the referring care provider receives an answer through the system. There is also the possibility to reject a referral through the system.

Patient registration resembles the procedures in primary care. It can be performed upon arrival or afterwards, using post-registration. These activities are supported by the patient administration module and form the basis for reimbursement and billing. Healthcare staff in the hospital then receives an overview of admitted patients, planned admissions and scheduled visits.

When a patient comes for an ambulatory check-up, the doctor or nurse first consults the electronic health record. The procedure is similar to the consultation procedure in primary care. When needed, the doctor or nurse looks up external notes on the patient, such as those from a GP, to facilitate the diagnosis and treatment decision making process. The prescribing and medication processes also correspond to the processes in primary care. Following an outpatient visit or discharge, the patient can receive his or her medication at the pharmacy of their choice. For inpatients, dispensing is processed by nurses and organised in their nursing plan. Inpatients can be referred to different units in the hospital with the referral functions in the EHR system. In hospitals, user access to patient information is not confined to data related to their own departments. Every healthcare professional can look into medical reports done in another department. An exception is psychiatry related information. Notes from the psychiatric departments are not open to healthcare professionals in other departments and in primary care.

Information entered into care plans automatically enters the EHR. There is a trend towards using more pre-defined care plans, in which nurses and doctors only change whatever is different, or just sign off tasks that are already completed.

Patients in need of long-term/nursing home care undergo a specific procedure. Upon arrival in hospital inpatient care, the hospital nurse sends an electronic registration message to the relevant primary care facility and the municipality, which is responsible for home care. When the patient's planned discharge is approaching, a notice is issued regarding coordinated care planning in order to hand over responsibility for the patient. After a joint care planning

meeting has taken place, the hospital nurse sends a discharge message to the other parties and can conclude the case.

Municipal care

Municipalities receive an electronic registration message from the hospital whenever a patient is deemed to enter or return to (nursing) home care after a hospitalisation. Through the "Link" module, municipal carers are always informed about their nursing home residents and home care patients. This registration message includes a mark for consent from the patient. With this consent, the municipality gains read-only access to parts of the patient's care documentation, such as medical epicrisis, final notes, nursing epicrisis, rehabilitation report, and the medication list. Through the "Link" module in the EHR system, a nursing home can also reject wrongly addressed registration messages and acknowledge a notice to attend care planning meetings. By receiving the discharge message, nursing homes are informed about the time of discharge and can prepare for the patient in advance. The patient is transferred to municipal care only after the responsible care personnel's confirmation via „Link“.

Patients that are residents in a nursing home do not need to visit healthcare centres for consultations. Usually doctors and nurses from healthcare centres pay weekly visits to the municipal nursing home. They can use the nursing home's workstations to access the patients' EHRs at the point of care.

ePrescription

The medications and ePrescribing module of the system consists of three major perspectives:

- Medication list, divided between acute and long-term ordinations including. Based on current, active prescriptions, the medication list consist of current ordinations. Ordinations are instances of a single medication prescribed. The list includes all drugs for inpatient & outpatients. No over-the counter drugs can be seen on the medication list yet.
- Information on dosage, timing, and intake details for inpatients, providing support to nurses.
- Prescription list, including repeat prescriptions of up to 12 months. Prescriptions can also be time-limited, for example expiring within a week. Expired prescriptions disappear from the national Apoteket ePrescription mailbox.

Doctors have to enter details on all three perspectives in order to complete a prescription. They are supported in this process by the option to consult the medication database FASS by following these steps:

- Chose a drug from the medication list screen
- Press the FASS button on the screen
- Read all FASS information on that specific drug, including recommended dosage details.

The current version of the decision support system only provides information and has no power to prevent action.

Paper prescriptions still exist, but are used only for the few patients who have opted out of the system, as well as tourists, asylum seekers, or other patients who do not have a Swedish national ID number.

With ePrescribing in Kronoberg County, patients can receive their medications for a predetermined period of time at any pharmacy in the country. The patient can receive an ePrescription after a physical or a telephone consultation. When patients arrive at a

pharmacy, they identify themselves with their personal, unique 10-digit identification number. Then the pharmacist accesses the web-service portal of Apoteket to download the patient's active prescriptions from the national mailbox for ePrescriptions. Repeat prescriptions can be saved at the pharmacy for a period of 15 months. The pharmacist is obliged to dispense the cheapest drug available and can thus dispense a generic drug even when the prescription is for a certain brand. An exception is when doctors explicitly note that the brand should not be changed. The pharmacist checks the ePrescription for potential mistakes. The pharmacists are also not allowed to return information on what has been actually dispensed in an electronic format to the doctors.

2.6 Technology

This section draws mainly from the technical overview of Cambio COSMIC²⁰, provided by the system vendor, Cambio Healthcare Systems AB²¹. Cambio COSMIC is the product behind the integrated EHR system in the county of Kronoberg.

2.6.1 Overview

The name COSMIC stands for "Compliant Open Solutions for Modern Integrated Care". Cambio COSMIC is developed in Java, which is the most modern and stable software development technology available today.

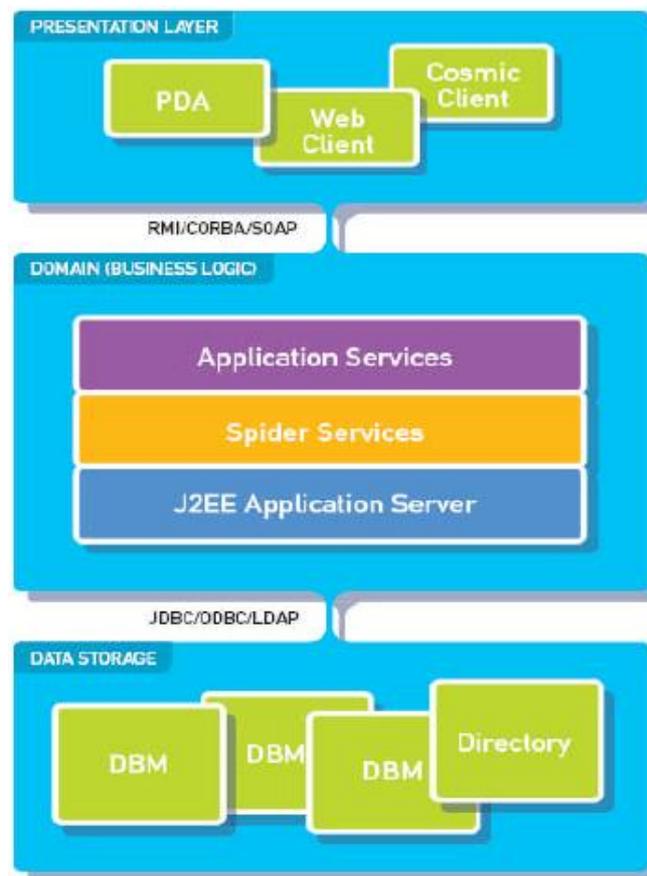
Cambio Spider, the business logic framework for COSMIC, is an open and flexible service platform. Cambio Spider is multi-layered, component-based technology with. Cambio Spider is a multi-layered, component-based, object-oriented middleware platform. It enables persistent storage, and offers an application programming interface (API) for implementing end-user applications and for system integration to various external systems such as lab systems and other healthcare facilities' IT systems. The integration APIs are today based on J2EE/Corba communication protocols. Integrations with external systems are usually done with the help of an integration engine, such as the SeeBeyond® ICAN™ Suite or similar products.

Figure 5 shows the three separated tiers of the system. These separate tiers communicate by using Transmission Control Protocol (TCP/IP) and different application program interface (API) languages and methods. Because of the separation of the tiers, the system is flexible in adding new application. A new application will only affect the layer where the application is located, not the whole system.

²⁰ Cambio Healthcare Systems AB: Cambio COSMIC Technical Overview. Available at: <http://www.cambio.se/document/sv-se/Technical%20Overview.pdf> (08-07-09)

²¹ Cambio Healthcare Systems AB: <http://www.cambio.se/>

Figure 5: Three layers of the Cambio COSMIC architecture



Source: Cambio Healthcare Systems AB

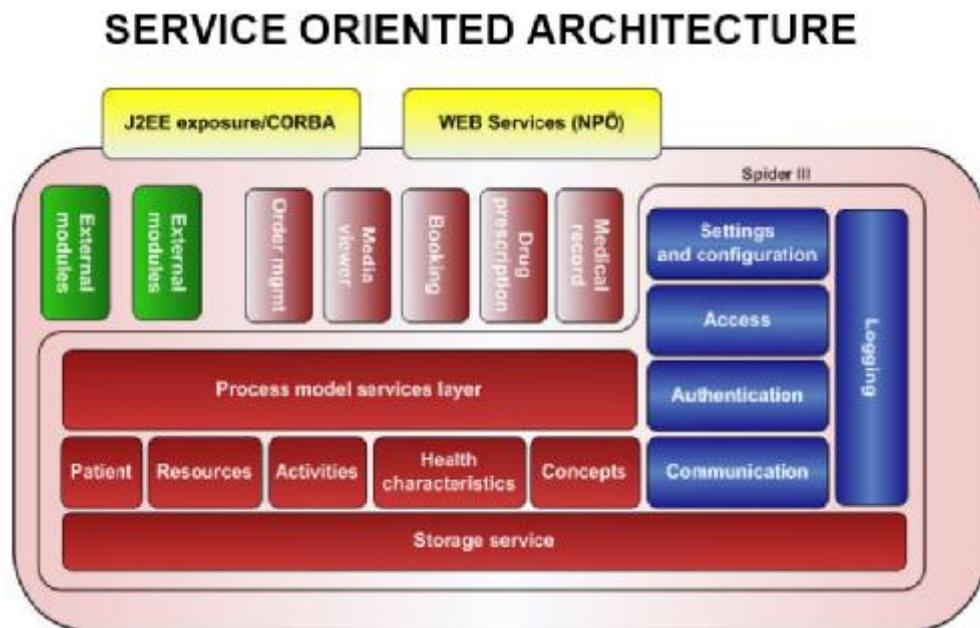
The **presentation layer** is usually a fat Java client which can be deployed in different ways. A complete thin client based only on a web browser is currently under development but has not yet reached the performance of the fat client solution.

The **business logic** is based on Java with a choice of J2EE-compliant application servers: JBoss, Sybase EA server, or Weblogic. The business logic is based on Java using JBoss as a J2EE-compliant application server. The business logic is organised into different common services and application modules.

For the **data storage**, various SQL-compliant database systems is used. The major providers are Oracle and Microsoft SQL server.

Based on the Spider engine, COSMIC is built on a Service-Oriented Architecture (SOA), depicted in figure 6.

Figure 6: Service oriented architecture



Source: Cambio Healthcare Systems AB

Due to the large amount of patient data the most recent and important information is stored in a primary database and older objects are compressed and archived in one or several secondary databases. Due to this design, the final system achieves a high degree of flexibility, performance and accessibility.

2.6.2 Security and confidentiality

Spider's underlying storage handling isolates the services from product-specific aspects like SQL syntax, communication protocols etc. The storage handling also enables distribution of services. The distribution may be based for example on the services' different performance requirements, which allows a particularly demanding service to run exclusively on a specified server.

All information is version-handled in Spider, and each user access is logged. For each update in the database, the change and/or access attempt is logged with user and time stamp. Thus, it is possible to re-create the exact information stored in the system back at a given time, or to log unauthorised attempts to access information.

User authorisation

Cambio Spider contains an all-embracing and well-integrated system for user authorisation control that meets the strict requirements of the healthcare sector. The user's identity is ascertained via password and/or PKI, depending on the client's infrastructure. The possibility of multidimensional control also allows a system where the user's information authorisation can be restricted to, for example, an organisational unit and a particular role. Cambio Spider also gives the option to decide which services and functions a particular user can access. The access rights system in COSMIC supports both negative permission ("access for all units except A and B") and functional permissions ("authorised to read and write", "read not write" etc.). COSMIC also supports auditing of events, for example, authorised and unauthorised attempts by users to access information.

Approach to security

- Integrated access system, can be integrated with existing solutions User authentication: Out-of-the-box password authentication, Biometric authentication available
- Authentication with electronic ID-card is planned to be implemented in January 2010 in Kronoberg.

Security model within the system

- Network: SSL-based encryption
- Data: Spider ensures integrity through total control of storage and integrity checking
- Users Access: controlled by Spider's access service
- Physical: access to application servers and database should be restricted. Data can be encrypted on storage level depending on choice of relational database.²²

An extra network not connected to, and physically separate from the standard redundant network, is run in order to ensure availability of services under all circumstances. There are two redundant data links between Växjö and Ljungby, with 1 Gbit/s and 45 Mbit/s. Between sites in the cities of Växjö and Ljungby there are redundant data links with 1 Gbit/s. Between healthcare centres in the country side and the cities, there are redundant data links with 10 Mbit/s or 2 Mbit/s. Doctors on duty at home use their private connection to the Internet with 2-8 Mbit/s.

2.6.3 Technology platform

The technology platform employed in Kronoberg includes the following components:

- Clustered Database Servers²³
 - 2 HP Integrity rx8620, 64-bit Itanium
 - 16 processors (max 16), 64 GB RAM (max 256)
 - SQL Server 2005 Enterprise Edition
 - Windows 2003 Datacenter Edition
- Load Balanced Application Servers
 - 16 HP DL360, 64-bit Intel Xeon
 - 2 processors, 4 GB RAM
 - JBoss Application Server
 - Windows 2003 Standard Edition
- Synchronised storage area networks (SANs)
 - 2 HP EVA 8000, 80 discs per SAN
- Redundant Sites
 - Full capacity in both sites
 - Real Time synchronised sites
- Redundant Networks
 - Duplicated vital components and connections in the networks
 - Duplicated ports for the national healthcare net.

²² Cambio Healthcare Systems AB: Cambio COSMIC Technical Overview. Available at: <http://www.cambio.se/document/sv-se/Technical%20Overview.pdf> (08-07-09)

²³ Source: Kronoberg County Council

2.6.4 Software development, installation and challenges

The biggest technical challenge to the implementation of the EHR system in Kronoberg has been reliability and speed of the applications. A technical upgrade has largely dealt with the problems. Availability was a problem before the upgrade from SQL Server 2000 to SQL Server 2005 in July 2006. Performance has then step by step been improved, so now there are no problems on database servers and application servers. There still is a challenge on the side of client computers due to old hardware and communications. A big improvement will be the roll-out of terminal servers for most of the clients with better response times for units with less advanced communication connection to the network. It will also result in better availability for users, as they will easily log into COSMIC on a computer in another room, keeping the same session.

As all healthcare information systems, COSMIC is sensitive to disruption and downtime. To ensure information security, prevent and mitigate the consequences of disruption/interruption, there are reserve procedures performed on all units in the county.

Besides redundant sites, there is also a read-only version of the production system, updated every 10 minutes, always available. Moreover, there is an extra, small, separate network, with a few separate critical workstations for the case that the redundant network, including computers, fails.

2.7 Level of interoperability

Compliance with standards

Cambio Spider is based on the European pre-standard HISA (Healthcare Information Systems Architecture), which involves a generic set of clinical processes applicable in all healthcare sectors and environments. Spider is a fully operational deployment of the original HISA architecture. It also includes a common underlying healthcare-process model used by all Cambio's applications. This is part of the new HISA standard EN 12967-1, Part 1: Healthcare middleware layer. Cambio has been leading the development of the second generation of EN 12967 parts 1 - 3 to become a full European standard.

This generation is based on the ISO 10746 Open Distributing Processing Architecture and uses the international and European most recent developments for information models for healthcare, based on the HL7 version 3 RIM and the derived General purpose components EN 14822-1, 2 and 3 published in 2005 as European and French standards.

Cambio also complies with many other standards which provide frameworks for clinical and administrative information systems, whether the standards are published, or subject to work in progress.

Two examples from the Security area are EN 13608 parts 1 - 3 Security for Healthcare communication (ENV 12388 Digital signature algorithm for healthcare), and the new ISO 17090 work on Health Informatics - Public Key Infrastructure (PKI). Among other recent work from ISO worth mentioning is the ISO/TR 22221, "Health informatics - Principles and practices for a clinical data warehouse".

Cambio has also been actively contributing to the development of the new CEN/ISO work prEN 13606 Health informatics - Electronic Health Record Communication series which we intend to implement in future releases and see as the major direction in a long-term perspective for the exchange of health records between independent systems from different manufacturers.

EHRI interoperability classification

The EHR system in Kronoberg is highly interoperable within the boundaries of the county, but also complies with standards that allow a national or even international exchange of clinical data. A specific feature is the trend towards standardisation of keyword, document templates, and clinical pathways, which fosters a wide-spread semantic interoperability to match the technological opportunities.

Of the three EHRI interoperability classifications of potential interoperability, limited connectivity and extended actual connectivity²⁴, the EHR system in Kronoberg reaches the third, extended and actual. The classification according to type of connectivity is summarised in table 1 below.

Table 1: Scope of interoperability of the integrated EHR system in Kronoberg²⁵

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

Source: EHR IMPACT study

²⁴ EHR IMPACT (2008): Methodology for evaluating the socio-economic impact of interoperable EHR and ePrescribing systems, Bonn. Available at: http://www.ehr-impact.eu/downloads/documents/EHRI_D1_3_Evaluation_Methodology_v1_0.pdf (08-07-09)

²⁵ EHR IMPACT (2008): Methodology for evaluating the socio-economic impact of interoperable EHR and ePrescribing systems, Bonn. Available at: http://www.ehr-impact.eu/downloads/documents/EHRI_D1_3_Evaluation_Methodology_v1_0.pdf (08-07-09)

3 Case analysis

3.1 Stakeholders

Stakeholders fall under the four groups defined by the EHR IMPACT methodology²⁶: Patients, informal carers and other people, health service teams, health provider organisations and third parties.

Patients, informal carers and other people

Out of the first category, mainly patients are affected by the county-wide EHR system. These include all citizens in Kronoberg with a unique identification number. Foreign nationals do not possess such a number. For these patients a local reserve number is created, so they can be registered in the system.

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 shared EHR system including ePrescribing 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 Kronoberg's hospitals, primary healthcare centres and mental health units, as well as pharmacists and nursing staff in municipal nursing homes and home care. The health professionals' teams at the hospitals include a total of about 280 doctors, some 900 nurses and nearly 800 other hospital staff. Over 200 doctors and more than 600 nurses and assistant nurses in primary healthcare centres use the EHR system. Using the broadest range of the EHR system, these healthcare professionals represent the primary users of the EHR system. The pharmacists in the country use the ePrescription services of the EHR system. Municipal nursing staff and therapists predominantly use a single feature of the EHR system, the „Link“ module. Other healthcare professionals using the EHR system are nurses working in the 1177 telephone service. However, they do not use the EHR system as their main application. They primarily work with a separate computer-based advice support system and access the patients EHR on a case-to-case basis. The non-clinical part is also used by staff for billing and accounting.

Further secondary users of the information system include county council managers. These use the non-clinical modules, and particularly Business Objects.

In this stakeholder group, we regard the healthcare team members as individuals, and not as employees of healthcare organisations. 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.

²⁶ EHR IMPACT (2008): Methodology for evaluating the socio-economic impact of interoperable EHR and ePrescribing systems, Bonn. Available at: http://www.ehr-impact.eu/downloads/documents/EHRI_D1_3_Evaluation_Methodology_v1_0.pdf (08-07-09)

Health service provider organisations (HPOs)

The stakeholders in this group are the Hospitals Växjö and Ljungby, the primary healthcare centres, mental health units, as well as the pharmacies and municipal care providers. In contrast to the health services teams, the focus is on the organisations and the effects of the shared EHR system on them. Here healthcare team members, being part of the HPO, are viewed as employees of the respective organisation rather than private persons. The hospitals, mental health units and most of the primary healthcare centres are publicly owned by the Regional Healthcare Authority of Kronoberg. Thus, the Regional Healthcare Authority of the county council can be regarded as a holding organisation of the single HPOs. A share of costs and benefits arising from the shared EHR system accrue to the county council as a HPO.

Third parties

The third party in this case is the Swedish Social Insurance Agency. The agency reimburses medications on a national level.

3.2 Process change

The main changes triggered by the introduction of a shared EHR system in Kronoberg concern the clinical aspects of healthcare services. Before the launch of the comprehensive EHR system, a patient administration system was already in place in most of Kronoberg's HPOs. The change from paper to digital storage and management of patient data required deeper changes towards standardisation of working processes. Even though the full potential of the ICT support is not being realised yet, a number of significant changes have already taken place. These fall under the following categories:

- Changed roles for healthcare professionals and support staff
- Shifts in responsibilities between health service team members
- New possibilities of cooperation between HPOs
- Availability of information and transparency between and within HPOs
- Changes in the health service delivery model.

3.2.1 Workflow

From a generalised perspective, workflow changes include different scope of responsibilities among care providers, the same tasks performed quicker or slower, and the same tasks performed in a different way. For example, while nurses are supported in taking some decisions about required treatment themselves instead of referring all patients to doctors, other tasks such as referrals and tele-consultations have been reported by interview partners to be quicker. Asynchronous communication and documentation allows better time management, yet does not change the tasks themselves or the total time needed for them. The changes in the workflow of healthcare professionals across different HPOs include the following themes:

- More efficient and streamlined patient flow between different levels of care
- Omitted steps in the workflow of healthcare professionals, such as looking for records
- Additional steps in the workflow, such as assignment of care responsibility in the context of referrals and care planning.

The shared EHR system has affected the patient flow both inside HPOs and between different organisations. The patient's journey to and from different points of care has already been described in 2.5.2. The EHR system enables caregivers to more precisely direct patients to the right level of care already at the first point of contact. This means that patients can avoid unnecessarily passing through points of care and get their treatment faster. This is a direct result of better and immediate access to medical information now stored in the electronic health records. For example, nurses in primary healthcare centres can, on the basis of information from the EHR available during the call, advise some patients to go directly to the hospital, without asking them to undergo a consultation with the GP first.

A core change in the workflow of healthcare professionals include the now redundant step of searching for patients' paper records. This applies to HPO-internal records previously stored in the same organisation and to external patient data stored with another HPO. In the past, the search for paper records was mainly performed by nurses, assistant nurses or medical secretaries. It involved looking in local archives scattered across different hospital departments or in quickly growing healthcare centre and nursing home archives. In case important patient data was documented and physically stored by a different HPO, the search involved further steps: Requesting data by phone and mailing or faxing the paper documents. Misplaced or missing data was a common challenge. The shared EHR system enables healthcare professionals to view the patient's record and retrieve medical data added by users in different HPOs.

Further examples for omitted steps in the workflow include calling the laboratory in the hospitals to get the status of results and numerous calls between hospital staff and municipal caregivers related to planning patient discharge.

By enabling ePrescribing, the county's EHR system has also changed the workflow of pharmacists, although only marginally. All pharmacies still use local pharmacy IT systems. The interconnection between the shared EHR system and those pharmacy systems exist through the nation-wide telecommunication network Sjunet. The main difference today concerns the entry of new prescriptions into the pharmacy system. In the past, paper prescriptions had to be manually typed into the system's input box. Today, pharmacists download electronic prescriptions that the EHR system sends to the national ePrescription mailbox into their pharmacy system. The workflow is thus shortened. This only applies to first time prescriptions. Paper-based repeat prescriptions were marked as such with a 2-D barcode containing the information on the respective medication. As prescriptions were stored in the pharmacy system for three month only, the patient would receive a paper slip with the barcode for the next dispensing encounter. The next time the patient comes in, the pharmacist would scan this barcode. Thus a repeated manual input of information was not necessary. Today prescriptions can remain in the pharmacy system for 15 months, which cover the time scope of any repeat prescription. Handing out paper slips became obsolete.

At the same time pharmacists have encountered a new role for their profession in checking for mistakes caused by the use of the ePrescribing module. Retyping information involved an automatic check for potential inconsistencies and mistakes. With ePrescribing, mistakes made at the very first step of medication treatment are passed directly through the whole system. Thus, pharmacists have to consciously verify each prescription.

The shared EHR system has also somewhat complicated the workflow of some healthcare professionals. The technical possibilities within the system allow for better compliance with rules for the medical profession and improved assignment of responsibility in the county's healthcare system. An example is the electronic signature of incoming and outgoing referrals and orders. With the shared EHR system, every referral has to be explicitly confirmed by the respective healthcare professional. The same applies to orders for examinations. The explicit confirmation gives an immediate notification to the referring professional that the responsibility for the patient is taken over. Another example can be found in the care

planning process of transferring hospital patient to municipal care. The system enforces GPs to use the care planning module in the EHR system twice a day and to explicitly accept their responsibility for the patients' care.

A change of workflow mainly affecting doctors across different levels of healthcare directly results from additional tasks that were assigned to nurses in the past. These include the search for patient information, some parts of care documentation. In a paper-based environment, doctors used to instruct nurses or secretaries to look for patient records. Now they have to look up the records up themselves. Previously, doctors used to speak notes on tape to let nurses and medical secretaries transcribe these. Today, they enter most of the shorter patient notes themselves, leaving only longer reports to nurses and secretaries. As a consequence, general workload of doctors has increased, while nurses and secretaries can focus on other tasks.

3.2.2 Clinical and medical practices

The shared EHR system provides healthcare professionals with a broader information basis and almost ubiquitous access to patient records. This, in combination with physicians' and nurses' professional knowledge and experience changes some of their clinical and medical practices. The changes are experienced in the following areas:

- Decision-support, particularly with prescribing
- Documentation
- Triage and decision-making, including expanded decision making by nurses
- Compliance with guidelines and protocols, such as nursing care paths
- Cross-consultation and second opinion, related to the shared use of records
- Cooperation between different levels of health and social care.

The shared EHR system provides decision-support at numerous levels by presenting the right information to the right person at the right time. The direct link to the medication database FASS allows doctors to quickly get information on drugs they are not familiar with. This support feature is particularly useful when guidelines refer to such medications. Conformance with guidelines is automatically displayed during the prescription process.

The medication module of the EHR system also supports features such as drug-drug and drug-patient interaction alerts, mainly for allergies. The system interface displays permanent warnings for patients with allergies, as well as for pregnant or breastfeeding women. In the paper environment, some of this important information would be noted on a coloured piece of paper in the patient record and come to the prescribing doctor's attention. In other cases, the information would have been hidden in vast amounts of paper scatter across different HPOs.

Hospital doctors point out that while the treatment decisions are usually not affected by the availability of more information, the investigations leading to these decisions are better prepared. Without the EHR system, clinical investigations would involve more tests and examinations on a regular basis.

More changes in clinical practice result from the way of preparing documentation. The EHR system enforces the rules that require carers to properly document care and clinical activities. Every contact with the patient is documented in the system. Every order and every referral has to be signed within the system. Information is entered into the system more promptly and can be accessed faster and more easily. For example, doctors' oral notes are stored in audio files in the EHR system and can be easily accessed in urgent cases, before their typed transcriptions are ready.

The improved access to information has a profound effect on nurses' scope of activity. With the shared EHR system, nurses have expanded their decision making spectrum. This is particularly the case when prioritising patients, based on the severity of their condition and now also on their past records. In primary care, nurses act as gatekeepers to the GP and other caregivers. The broad informational basis enables nurses to take more care decisions themselves. In the past, patients calling the healthcare centres would have been asked to come for a consultation with the GP or a nurse in case of doubt. Since nurses today can immediately look into the patient record including the medication list and other HPOs' notes, they are better prepared to make the best decision for the patient. In some cases, this includes advising patients directly on the phone, or identifying and dealing their problem without transferring to the GP. The same applies to nurses in primary care out of hours (OOH) services. Based on their judgement the nurse directs the patient to an attending doctor in OOH service. Similar changes are observed in the hospital environment, where doctors are called less often by ward nurses for validating decisions. Municipal caregivers also benefit from the EHR system, although their access is limited to the care planning module. The additional information and timelier advance notice on patient discharge help them to prioritise patients requiring immediate actions.

The clinical practice is further enhanced by the guidelines and templates in the EHR system. Examples are nursing care pathways directing nurses in their everyday work and templates for composing discharge letters. When writing discharge letters, doctors can fall back on keywords and structure the letter accordingly. The EHR enforces nurses to follow care pathways and document their activities more easily.

A further aspect of changed clinical practices is the cooperation between different care providers. The EHR system allows better timeliness of care, including transfers between wards, between primary and secondary care, and between health and social care. Sometimes, patients are even discharged earlier, because home care nurses can see the patient's journey through the hospital and can better assess their readiness to take over responsibility.

Patients brought into hospital by an ambulance also benefit from A&E doctors in the hospital being able to start treatment quicker.

3.2.3 Working practices

The themes for changed working practices include:

- Data entry into the patient record
- Access to information
 - Shared and location-independent use of records
 - Flexibility of working practices
- Daily work of home care and nursing home nurses
- New prescribing procedures.

The most notable changes in the working practices of healthcare professionals relates to the access to information. The physical search for paper records gradually became obsolete with the expansion of the EHR system across more and more hospital departments, healthcare centres and the mental health units. The scanning of paper records fills historical gaps and also applies to relocated patients from outside the county, who usually have paper records only. The EHR system allows the simultaneous access to the patient's record by different individuals and also the location-independent use of records. These possibilities allow a doctor to give a second opinion to the treating doctor while looking into the same record. Also, the system allows healthcare professionals to access the patient's file from any workstation or laptop via 3G or/and a VPN connection. This created an increasing flexibility in

the healthcare professionals' working practice. For example, doctor can be on call at home and check a patient record on the spot.

More flexibility is also observed in the process of data entry. The replacement of paper by electronic records makes it easier to prioritise tasks, to interrupt the care documentation process when needed and to finish data entry at a later stage, and from a different place. Also, as referrals and orders for examinations are entirely processed through the EHR system, repeated patient registration at different points of care can be avoided.

In terms of care documentation, a part of the data entered still consists of free text, but this is changing. The difference with the EHR system is the degree of standardisation of medical information and the use of templates. From the beginning, the EHR system was designed as a shared system. The system development was thus accompanied by enormous harmonisation efforts in terms of healthcare terminology. For example, hospital specialists had to agree on a uniform list of some 1,200 keywords describing common conditions and activities. In the data entry process, this means that healthcare professionals have to use these specific medical terms. Only then, the EHR system is able to search and filter the vast amount of information according to these keywords and display only relevant information.

The EHR system has also changed the working practice of municipal caregivers and pharmacists. As described above, the EHR system has mainly affected the care planning part of municipal caregivers' everyday work. This working practice has seen a shift from conventional ways of communication to electronic communications via the EHR system. Additionally, nursing care professionals have gained access to more information than previously available on paper. Before the care planning module („Link“) was introduced, municipal staff prepared the patient transfer from hospital to municipal care based on a brief notice on the patient's condition. Today, municipal caregivers receive access to selected parts of the patient's EHR and are more completely informed on the patient's needs. By checking the inbox in „Link“ twice a day municipal caregivers know if a patient is hospitalised, the reason for the hospitalisation, and the expected time of discharge. They also receive invitations and reply to joint care planning meetings at the hospital through „Link“.

Some of the changes in pharmacists working practices have already been described in terms of workflow in 3.2.1. Further changes relate to prescribing. By using the medication module in the EHRs system, doctors have to go through additional steps in the prescribing process: They need to select an ordination, define the appropriate dosage and form of intake, and select the correct package size. Going through these steps increases the risk of making a mistake. Doctors may accidentally choose the wrong dosage form. Another example is the prescription of drugs intended for short term use, such as antibiotics. Doctors may prescribe these for a longer time period than intended because they forget to remove a tick mark set on “from now on” by default. Pharmacists needed to adapt their working practice to this risk and systematically check for commonly made mistakes with ePrescribing.

ePrescribing reduces many risks, but also introduces new risks that have to be controlled, especially when a new way of working is introduced. This is handled by using more templates in prescribing.

3.2.4 Reaction and acceptance of users

The county council's decision to introduce a shared EHR system met with mixed reactions among healthcare professionals. Some of the future users feared that the change from paper to electronic procedures would impede their daily work rather than enhancing the clinical and work practices. Others were very eager to introduce the new system. As mentioned in section 2.2.1, opinion differed on the advantages of a shared EHR system versus those associated with

many local EHR systems. Primary healthcare centres already using a local EHR system were more resistant to switching to the shared EHR system.

The expectations and opinions varied across the single functions of the shared EHR system. The medication module with the medication list and ePrescribing functionalities was certainly one of the most welcomed changes. Especially pharmacists held high expectations on ePrescribing. They believed that ePrescribing would bring about significant changes in terms of data accuracy. Physicians also welcomed the prospect of a comprehensive medication list for every patient.

The initial period of testing the system proved an arduous experience for all users involved. For example, it was particularly difficult to use some of the modules in the system without having installed the patient administration module. In the beginning, the system was rather slow, experiencing downtimes, which was a challenge to acceptance and utilisation.

Further, the system required efforts of standardisation in order to make it acceptable to as many users as possible and to realise the highest possible potential. One factor facilitating the introduction of the EHR system in Kronoberg was the absence of a comprehensive predecessor IT system. Only a patient administration system was in place. Interestingly, this part of the system met most user resistance.

With the technical improvements and the functional expansion of the system, healthcare professionals more and more recognised the benefits of using the shared EHRs. Most healthcare professionals agreed that working without the EHR system is unimaginable. Also, municipal caregivers using the „Link“ module expressed their interest in extended data sharing with GPs and hospitals. Altogether, the healthcare professionals currently indicate a high level of acceptance. Various suggestions for improvements to optimise the system functionalities prove a high degree of engagement. For example, physicians suggested adapting the ePrescription module to prescribing according to active ingredients instead of brand name. Another physician expressed interest in more advanced decision support features in order to better react to critical symptoms and circumstances.

At the current stage, the system's response time is one of the most pressing concerns. At the same time, this is an aspect being improved by the IT department at the time of writing this report. Other concerns include the danger of information overload, new sources of mistakes created by the system and the concerns about data confidentiality, and potential misuse. These concerns provide a fertile ground for the IT staff and the vendor to further improve the EHR system.

When judging user acceptance and reactions to a county wide EHR system, it is worthwhile differentiating between different types of healthcare professionals. The interviews with various healthcare professionals indicate that nurses have reacted somewhat more positively to the changes than physicians. This certainly relates to the expanded scope of duties borne by physicians in all levels of healthcare. In certain areas of healthcare provision paper routines still prevail. In these cases, users consider it safer to rely on paper rather than using the designated functions in the EHR system. One prominent example is the triage process in the hospitals' A&E unit. The nurses in A&E prefer to use their customary paper sheet as a guidance and documentation form. Another paper routine was observed with nurses in the cardiology unit. Instead of following the care pathway on the screen of a work station, they prefer to handwrite a to-do-list on a piece of paper, which is easier to carry around the ward. They feel more secure and less prone to forget a task when they make their round on the ward with the paper in their hand.

Despite these minor instances that form a recommendation for future developments, the conclusion of the study team is that today the EHR system in Kronoberg has reached a high level of user acceptance.

3.3 Timeline and milestones

The core features of the shared EHR system were implemented between 2004 and 2007, following a test phase in 2004. The initial pilot projects started in two healthcare centres, the internal medicine and the emergency department at Växjö hospital. The first modules tested were ePrescribing, care documentation and order management, followed by resource planning and patient administration and billing. The medication module was the first to be rolled out across all healthcare centres, hospital departments and dental practices. The roll-out of all basic functions of the EHR system was completed in December 2006. The next steps involved implementing more and improved functions, such as decision support across all relevant healthcare provider organisations and new IT systems for A&E and operation theatre management. In 2007, the care planning module was rolled out in hospitals, healthcare centres and nursing homes. The following provides a detailed chronology of important milestones in the development of the EHR system in Kronoberg.

- 1993 Introduction of the first local patient administration system at GP office in Kronoberg. Started as a pilot project for a county wide EHR system, this solution remained an isolated application. It was used in two healthcare centres until 2004.
- 1999 Start of procurement for a shared EHR system. Start point of EHRI evaluation horizon.
- 2000 Introduction of the patient administration system Cambio 2000. This system was rolled out to most HPOs in the county until 2002.
Award of contract for an EHR system, later cancelled due to delivery problems.
- 09/2003 Contract for a shared EHR system with integrated patient administration system goes to software vendor Cambio Healthcare Systems.
Set up of project implementation groups with activities starting successively in 2003, 2004 and 2005.
- 2004 Start of decision process on keywords
- 03/2004 Start of pilot projects at Växjö hospital's department for internal medicine and a part of the A&E department. The first functions tested are the medication list within the ePrescribing module, care documentation and order management for biochemistry. Specification of medical list in the ePrescribing module.
Start of pilot projects at two healthcare centres (Teleborg and Birka), including order management for biochemistry, care documentation, and the medication list in the ePrescribing module.
Start of ePrescribing with electronic prescriptions sent to pre-selected pharmacies.
- 06/2004 Pharmacies in Kronoberg connected to the national ePrescription mailbox. Patients can pick up prescribed medication at any pharmacy.
- 09/2004 Start of roll-out across primary healthcare centres, including resource planning and patient administration module in addition to order management for biochemistry, care documentation and ePrescribing.
- 12/2004 Roll-out of ePrescribing completed in December across all HPOs.
- 06/2005 Roll-out of all basic functions finished across healthcare centres.
- 06/2006 Roll-out finished in hospitals.

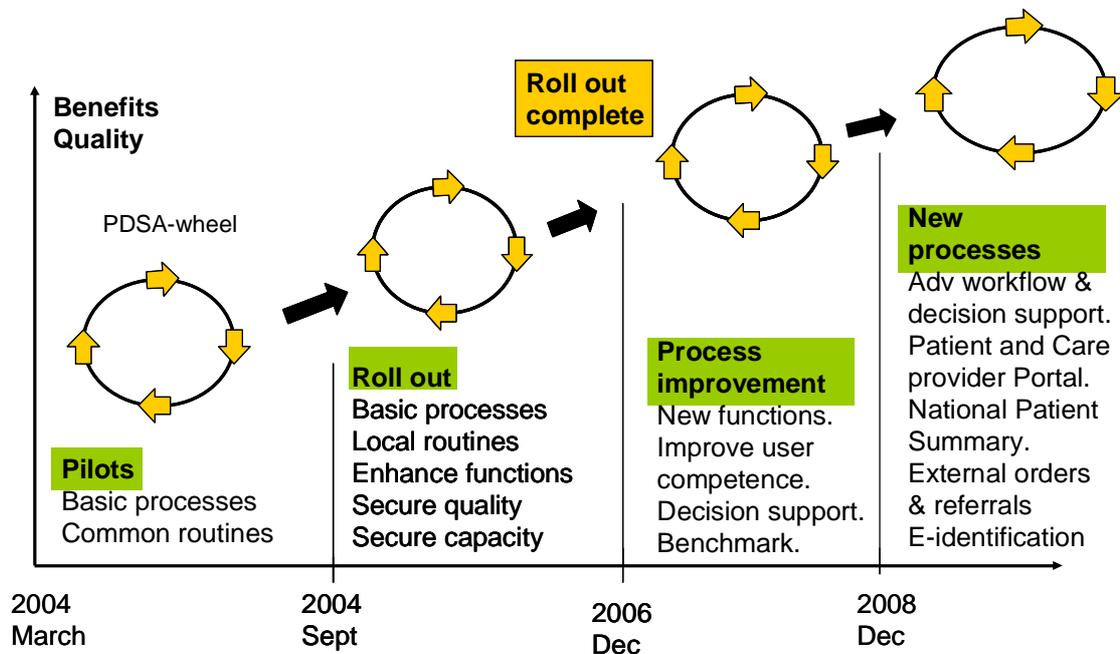
- 07/2006 A new technical platform with Windows 2003 Datacenter Edition and SQL Server 2005 Enterprise Edition. New databases servers and storage network (SAN).
- 12/2006 Roll-out finished in psychiatry.
Order management/Lab test integration completed, including biochemistry.
- 2006 EHR implementation in Kronoberg completed for all hospitals, primary healthcare centres and psychiatry.
Roll out of digital dictation completed.
- 2007 4,500 of the county's 5,700 healthcare professionals using the system.
Order management roll out completed for microbiology.
- 03/2007 Radiology - integration with PACS.
Integration of EHR system with data warehouse to exploit data for secondary uses.
- 06/2007 Physical lab tests integrated in order management.
Roll out of Business Objects as a management information tool.
- 07/2007 Rollout of referrals completed.
- 09/2007 Introduction of Ambulance ECG system in hospital emergency departments. ECG-system (common repository) rolled out across HPOs.
- 10/2007 Introduction of new module for joint care planning and sharing of case records and medication lists between the county council's healthcare and municipal nursing home care (rollout completed in November 2007).
- 11/2008 Shared EHR system enables automated nightly data transfer to national quality register (rolled out for all diabetes patients in the county).
- 2009 98% of the population in Kronoberg having an electronic health record.
- 03/2009 A customer choice system is introduced for healthcare centres and integrated with EHR system and data warehouse.
- 2009 Five new private healthcare centres, all using the shared EHR system
Planned new functions for the last quarter of 2009:
- § Extended information and decision support in medication module
 - § ePrescription to dose package
 - § Improved messaging system within the EHR system
 - § Maternity process tool
 - § Internet-booking.
- 2010 Planned new functions for the 1st and 2nd quarter:
- § Extension of referral functions to pathology (Q1)
 - § Extended support for A&E process with triage (Q1)
 - § Theatre management (Q1)
 - § Electronic identity card for authentication (Q1)
 - § Extended support for psychiatry process (Q2).
- 2010 Connection to the national patient summary and the national medication list.

3.4 Supporting take-up

County management and the council’s IT department knew from the start that the move towards a shared EHR system would represent a dramatic change to HPOs in Kronoberg. The risk of failure was high and thus carefully taken into consideration. In anticipation of potential user resistance, the management opted for a gradual and intricate implementation approach. At the same token, the management set the ambitious goal to implement all basis functions within 2.5 years. Throughout the change process, the users remained at the core of the attention.

Figure 7 illustrates the implementation process from pilot stage to roll out and to the continuous process of functional improvement and further development. The process followed a Plan-Study-Do-Act (PDSA) method. The PDSA-wheel stands for an iterative method. Following planning, small changes are induced in a controlled environment, the experimental results are then studied and later acted upon in order to standardise the change process.²⁷ Kronoberg’s healthcare system required “running the wheel” for numerous individual functionalities of the shared EHR system.

Figure 7: Implementation process and the Plan-Study-Do-Act wheels



Source: Kronoberg county council

The roll-out of all basic functions of the EHR system was completed in December 2006. The next steps involved implementing more and improved functions, such as decision support across all relevant healthcare provider organisations and new IT systems for A&E and operation theatre management. In 2007, the care planning module was rolled out in hospitals, healthcare centres and nursing homes.

Pilot phase and roll-out strategy

The initial pilot projects started in two healthcare centres, the internal medicine and the emergency department at Växjö hospital, representing the “Do” part of the PDSA wheel.

²⁷ Wikipedia PDCA (“Plan-Do-Check-Act”)/Plan-Do-Study-Act, accessed 21.09.2009 <http://en.wikipedia.org/wiki/PDCA>

Being by far the largest hospital department, the internal medicine department represented the litmus test for further roll-out. The management was sure that if the trial succeeded there, it would be feasible for other, smaller healthcare units follow. The healthcare centres participating in the pilot were headed by noted proponents of a shared EHR who were convinced of the benefits from the ICT applications. The first modules tested were ePrescribing, care documentation and order management, followed by resource planning and patient administration, and billing. The pilot testing played an important role in standardising processes.

The management chose ePrescribing as the first functionality to be rolled across different HPOs. Being one of the most welcomed features, ePrescribing was considered the “low hanging fruit” in the overall implementation process. The managements’ strategic goal was to realise tangible benefits in the beginning, minimise initial irritation and adaptation efforts and use the momentum to create a favourable attitude to system rollout.

The strategy relied on replacing paper with a digital equivalent in a first step, and only changes processes once the change from paper to digital has been completed and accepted. This is a good practice found in other successful implementations as well²⁸.

Extensive user engagement

In Kronoberg, the EHR software vendor played a supporting role in introducing their application. However, the implementation and the specification of the EHR system to the county’s healthcare system was mainly organised by the county council’s IT department and healthcare professionals.

Crucial to all past and ongoing planning processes are the so-called implementation, project and maintenance groups. These groups consist of healthcare professionals, IT professionals and other specialists on demand. Implementation groups start their work three to six months before a feature of the EHR system is first introduced. The pilot and the roll out phase required meetings of 460 healthcare and IT professionals in 51 implementation teams. The goal of implementation teams is to:

- Plan the introduction of the new EHR system features
- Identify the respective healthcare unit’s working routines and procedures
- Analyse how the EHR system can be used to support everyday work
- Create a conversion plan
- Provide training to healthcare team members.

Implementation group members act as lead users, assuming the role of ambassadors of the EHR system in their respective healthcare units. Usually, these are particularly influential members of the healthcare teams and thus in a good position to communicate the benefits to their colleagues. Implementation team members receive three or four days training by a central implementation team. Then, as trained trainers, they spend several hours per week training their peers. Continuous peer-to-peer training is an important part of the engagement policy across all HPOs and also in the municipality services. After the implementation phase, these groups resume their activities as working groups for improvements of routines. The groups maintain at least some of their members, so that they can benefit from the valuable knowledge gained during implementation. A favourable effect of implementation groups is some “cross-fertilisation” of knowledge and experience between the user sites. Formal and informal contacts between group members lead to exchange of experience on working and clinical practices, which gradually facilitate their standardisation.

²⁸ EHR IMPACT (2008): The socio-economic impact of the computerised patient record systems at the University Hospitals of Geneva. Available at: <http://www.ehr-impact.eu/cases/cases.html> (08-07-09)

The IT department support group facilitates implementation with system administration, education and support for information system functions. One of the staff is appointed to be responsible for the configuration plan for each HPO and contacts with the IT department. Local system support teams get help and advice from the system developing group in the IT department. They are responsible for developing, maintenance, problem management, project management, and process support within the whole information system, including COSMIC and related applications.

Project groups consist mainly of application managers and healthcare professionals that are assigned to the individual components of the EHR system. Ten teams supported the initial implementation with approximately 75 members. The work of the project groups is still ongoing and aiming at the technical and functional improvement of the EHR system. In contrast to the implementation groups, project groups were functionally organised and provided cross-organisational process support. After roll-out, these teams work on process improvement, change management, and new processes development.

The IT department support group also support the HPOs with:

- Telephone call support (7x24), including remote support
- On-site support
- Post go-live training
- Training for new employees
- Follow-up on-site per unit
- Instruction films
- Knowledge verification (started in 2009).

Calls by telephone or by web to the application support teams are registered at tool called "Servicedesk" as incidents, and if needed registered as a problem and assigned to application managers to be solved (ITIL processes). IT department use Servicedesk as a tool to support ITIL processes. The system is also used by the IT-support group. The calls to the application support teams are handled by staff with a background as healthcare professionals and calls to IT-support is handled by technicians.

3.5 Benefits

The benefits resulting from the EHR system in Kronoberg have been analysed against the background of the three main types of eHealth benefits, quality, access and efficiency²⁹. Improved quality of care and efficiency gains play the most important role. Unlike other case studies of the EHR IMPACT study, substantial efficiency gains can be assigned to both HPOs and patients. These include time savings and avoided waste, as well as some limited financial savings. Quality of care, including patient safety, continuity of care, better informed decisions, and effectiveness of health services account for the second largest group of positive impacts. With access levels already high, this benefit type plays a smaller, yet still important role. Healthcare professionals mostly profit from better employed time and better work satisfaction because of the improved availability of information in real time.

Positive impacts were identified through numerous interviews with users, as well as analysis of internal statistics and studies made available by the Kronoberg county council. The following analysis of the benefits for each stakeholder group provides a more thorough picture of the positive impact of the EHR system in Kronoberg. The methodology for

²⁹ EHR IMPACT (2008): Methodology for evaluating the socio-economic impact of interoperable EHR and ePrescribing systems, Bonn. Available at: http://www.ehr-impact.eu/downloads/documents/EHRI_D1_3_Evaluation_Methodology_v1_0.pdf (08-07-09)

quantification of the impacts is addressed in section 3.7 below. Appendix 2 of this report provides a comprehensive list of the benefit indicators and estimation techniques applied.

3.5.1 Patients, informal carers and other people

The main benefits for Kronoberg's population are in efficiency and quality of care. Better care comprises some 38% of the estimated benefits to citizens. Interviewed users, from both primary and secondary care, pointed out that patients are impressed by the information available to the carers, but also that many patients had expected this availability to have been reality for a longer time already. The availability of data from different care providers is particularly appreciated by chronic disease patients.

Quality indicators include well informed carers who are facilitated in providing continuity of care and increases patient safety. Improved patient safety in this specific case refers to a reduced risk of adverse events due to lack of information at the point and time of care. The information on medications plays a substantial role in patient safety. Because of the support provided to doctors in the prescribing process, patients are spared incidents of allergic reactions or contraindications. Of course, an IT system cannot completely eliminate such adverse events, but in the case of Kronoberg there are strong indications of avoided incidents³⁰.

The availability of information facilitates continuity of care in two respects. First, in cases of referrals professionals can access more detailed information and thus treat the patient on the basis of all information needed. This includes the transfer of patients from healthcare to social care. Before the module for exchange of information between healthcare providers and home care services, „Link“, was introduced, communication was based on faxes that included little information, like „patient has a leg fracture“. Because of „Link“, care planning is more precise. Sometimes care planning would have prepared for the worst case and patients is in much better condition or vice versa. For example, if a patient can walk without a walking frame, there is no need of an indoor frame, and the patient can be discharged and discuss the need of an outdoor frame in due course.

The second aspect of continuity relates to episodes of specialised care, such as within the paediatric or cardiology departments in hospitals. When patients seek assistance after a longer period of time, or by phone, the COSMIC system allows the care professionals to quickly identify the person who has been in charge of the patient on previous occasions and knows the patient. With paper, this process would take too long and has been omitted in the past.

A special quality benefit is realised for psychiatry patients. Some patients that would stay hospitalised in a traditional healthcare model are discharged in Kronoberg. This is because psychiatrists know that with COSMIC the patient's condition will be recognised correctly in case of a problem and the patient can be hospitalised in the right department straight away. This increases the quality of life of affected patients.

The availability of information at the point of care independent of its source also brings substantial efficiency gains for patients. These include mainly time saved from avoided visits to healthcare centres and hospitals. Apart from waiting time, travel time is a significant issue in a thinly populated region such as Kronoberg. Avoided co-payments for consultations and hospitalisations present a small, yet tangible financial benefit to patients. Altogether, efficiency gains account for more than half of the value of benefits to citizens.

Last but not least, certain improvements in access should also be mentioned. Some 4% of the benefits to patients are related to access to telephone consultations. Providers have time-

³⁰ An observation reported repeatedly throughout numerous interviews with doctors.

restricted windows for such activities. With time for searching for records saved, the number of patients that can receive this service has increased.

3.5.2 Health service teams

The shared EHR information directly affects health service teams, as individuals rather than employees. The themes that were repeatedly stressed include convenience and alleviation of work, flexibility, and comfort with regard to decision making and responsibility.

The value of these non-financial benefits has been estimated by using willingness to pay techniques in interviews. Understandably, some users whose work is mildly affected by the system have a lower willingness to pay than those users whose working practices have been fundamentally changed. Pharmacists and many home care nurses, for example see some parts of their workflow made easier, but the bulk of their activities are not directly related to the EHR system at the moment. This is because of more or less advanced purpose-bound local systems that impact the main activities. For those users, the value of the system is within the range of a certain share of their income.

Other users, whose working practices and role have changed significantly, persist that working without the county-wide EHR-based system will be unthinkable. Such users include secretaries responsible for documentation, but also doctors and nurses in healthcare centres and some hospital departments.

3.5.3 Healthcare Provider Organisations (HPOs)

Healthcare provision in the county of Kronoberg has gained from the introduction of a comprehensive EHR system in many respects, falling under the categories of efficiency and quality.

Quality gains comprise just below 20% of the value of positive impacts for health service provider organisations. They include the avoided consequences of adverse events due to fewer mistakes in primary and secondary care. As already noted, these avoided mistakes relate to such caused by lack of information at the right time and place in a traditional care model. Another quality gain is the reduced length of hospitalisation of mental health patients - a phenomenon already addressed above. The value of this benefit to HPOs is estimated by calculating the opportunity costs of hospitalisations. More effective management due to the information analysis from the EHR system helps the Kronoberg County to meet tough healthcare goals, which is the fourth significant quality indicator. The monetary value of this gain is estimated on the basis of the minimum share of a SEK 1 billion government award to counties for meeting the healthcare quality objectives.

Efficiency gains relate mainly to budget reductions, time savings, or to avoided contacts with the HPOs. Biggest time savings are achieved through not physically searching records. This applies mainly to primary and secondary care, but to some extent also to nursing homes. Pharmacists save time on from not having type in information from paper prescriptions into their local IT system, due to an interface between the ePrescribing module and the national ePrescribing portal of Apoteket AB.

In many cases, the instant availability of information from the EHR leads to problems being solved quicker and visits being avoided. This applies to patients seeking advice over phone as well as professionals seeking a second opinion during a consultation. Other instances of improved efficiency include patients not having to see a doctor because nurses have enough information through the EHR system in order to help.

Among the many other benefit indicators that comprise relatively small pockets of added value³¹, some financial gains deserve some attention. Sustainable budget reductions are observed in the accounting books of the council. The savings are mainly in staff reduction related to the health information system. Extra cash is being released from avoided travel, avoided duplicate laboratory and radiology examinations, and from saving expenditure of paper prescription forms, which costs SEK 0.50 each.

Further gains are expected to materialise in the near future, when scorecards enter the phase of routine operation in the prescribing process. The scorecards already allow doctors to better comply with guidelines on using cheaper medications, which may evolve to generic prescribing in the future. The quantitative value of these benefits is expected to be quite significant. They are, however, not included in the ex-post quantification of the socio-economic impact within the EHRI horizon, which ends in 2010.

One of the most important future benefits from the EHR system is the data warehouse with information about all healthcare units and all patients in the county, including care contacts, visits, diagnoses, activities, structured clinical data, medication, lab results, and more. The value of this data is exemplified in the following:

- Information about lead-times for healthcare processes make it possible to make healthcare much more effective and shorten waiting times
- Balance scorecard make it possible to benchmark units and doctors, for example on costs of medication prescriptions and different quality parameters
- With information of all activities, it is possible to calculate the cost of delivering healthcare services
- The information from the data warehouse is necessary for enabling citizens to make informed choices about their healthcare centre and other providers, by making compensation and quality transparent
- Results of patients pathways can be followed up
- New methods in medicine and providing health services in general can be evaluated on the basis of the aggregated data
- Information could be used to focus on prevention of diseases.

3.5.4 Third parties

The third party beneficiary in this case in the Swedish Social Insurance Agency, which reimburses medications on a national level. The reduction in prescribed medications has a direct effect on the overall bill for drugs. General occasions at which money is saved are instances where a doctor would prescribe a medication again, but sees that another doctor has already prescribed it. A more specific example is sleeping pills, for which patients used to consciously search for double and triple prescriptions.

3.6 Costs

There are two major types of costs associated with eHealth activities. One is the investment-related extra expenditure, effort, and opportunity costs, and the other is any negative impact from the utilisation of eHealth systems. In the specific case, the first type is mainly borne by the county council, whereas the second type is spread among all stakeholder groups. Details on the individual cost indicators are presented in Appendix 2 of this document.

³¹ Cf. Appendix 2

3.6.1 Patients, informal carers and other people

The largest negative impact for patients is an often underestimated phenomenon of new risks associated with the use of eHealth applications, including EHR and ePrescribing systems. In the specific case of Kronoberg, such risks were specifically related to the period of transition from the old routines to the new, ICT-supported working practices. An example is when short-lived confusions occurred with doctors from different organisations having the same name. Another risk factor concerns the communication between professionals. While Kronoberg's EHR system fosters continuity of care through providing all relevant information at the point of care, it also leads to professionals often relying on that information only. Fewer phone contacts between doctors, for instance, can lead to some subtle aspects of the health record, which is not explicitly written into reports, being left out from the decision-making process at later treatment stages.

The second-largest negative factor for citizens is the initial inconvenience caused during the roll-out of the system. This usually comprised about two weeks of restricted access to certain healthcare facilities. This negative effect has ceased in 2007.

Providing consent for patient data to be exchanged electronically is a necessity associated with a certain amount of time and effort on behalf of citizens. This factor has also been taken into account.

Last, the fact that patients used to look for ways to get access to more medications than recommended, especially sleeping pills, points towards some irritation by patients who cannot get certain drugs prescribed two or three times simultaneously.

3.6.2 Health service teams

More than two thirds of the estimated value of costs to health service teams is associated with initial inconveniences. This is a common occurrence in environments that change from paper to digital data storage and management.

The second largest factor is informal training and exchange about functionalities and use of the system, taking place during breaks and users' private time. Pharmacists have encountered a new role in checking for mistakes caused by the use of the ePrescribing module, as already described in section 3.2 above. Other, smaller impacts include a slightly increased workload for doctors in primary and secondary care, and some continuous inconvenience to those home care nurses who do not use the system frequently.

An unusual impact was identified by psychiatrists. Doctors reported having more stress due to more information being available at once. The paper environment has been giving them time to think about decisions while the patient file is under way. Now, the decision has to be quick, which causes feelings of uncertainty and pressure.

3.6.3 Healthcare Provider Organisations (HPOs)

Healthcare provider organisations face two main types of costs - ICT costs and organisational investments and impacts.

ICT costs

The ICT costs associated with the EHR system in Kronoberg account for some 42% of all cost and 48% of the costs to HPOs. They include the contracts with the vendor, Cambio Healthcare

Systems AB, as well as all hardware infrastructure, licences, and relevant ICT staff of the Kronoberg county council.

Organisational issues

Organisational impacts fall, broadly speaking, into two categories - investment related issues and negative impacts on process, working and clinical practices. The organisational investment includes training and adaptation-related temporary productivity reductions, as well as engagement of users in the development and implementation phases of the initiative. These have been estimated to account for about a third of all organisational costs.

The value of time needed for new tasks, especially by hospital doctors who need to record more themselves, and by secretaries in primary healthcare centres who now have a new role of ICT support, amount to more than half the estimated organisational costs to HPOs.

Lacking interoperability between COSMIC and some local nursing home systems is a small, yet important cost indicator. It leads to the need for manual transfer of data from „Link“ to the local system, which is time better spent on other tasks.

Income shifts between HPOs, in particular between healthcare centres and hospitals on the one hand and the county council on the other hand, are also reflected in the estimated costs. These shifts result from healthcare activities such as consultations and hospitalisations being avoided, or replaced by cheaper forms of treatment, such as telephone consultations. These shifts present some 11% of the costs to HPOs, with respective benefits also being absorbed by the HPOs.

3.6.4 Third parties

The costs to third parties are nil.

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)³². The UK Treasury's Green Book³³ and Germany's WiBe³⁴ 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 1999 to 2010 for the EHRI evaluation. Three datasets are: statistics, costs and benefits.

Statistics include data about the population affected by the EHR or ePrescribing solution, the number of users, eHealth transactions, and changes in healthcare activity. Indicators can be available from healthcare provider organisations (HPO), but not always for the whole

³² EHR IMPACT (2008): Methodology for evaluating the socio-economic impact of interoperable EHR and ePrescribing systems, Bonn. Available at: http://www.ehr-impact.eu/downloads/documents/EHRI_D1_3_Evaluation_Methodology_v1_0.pdf (08-07-09)

³³ 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 (08-07-09)

³⁴ WiBe-TEAM PR. Wirtschaftlichkeitsberechnungen mit dem WiBe-Konzept, Wirtschaftslichkeitsuntersuchungen. Available at: http://www.wibe.de/konzept/wibe_ueberblick/wibe_ueberblick.html (08-07-09)

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 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.

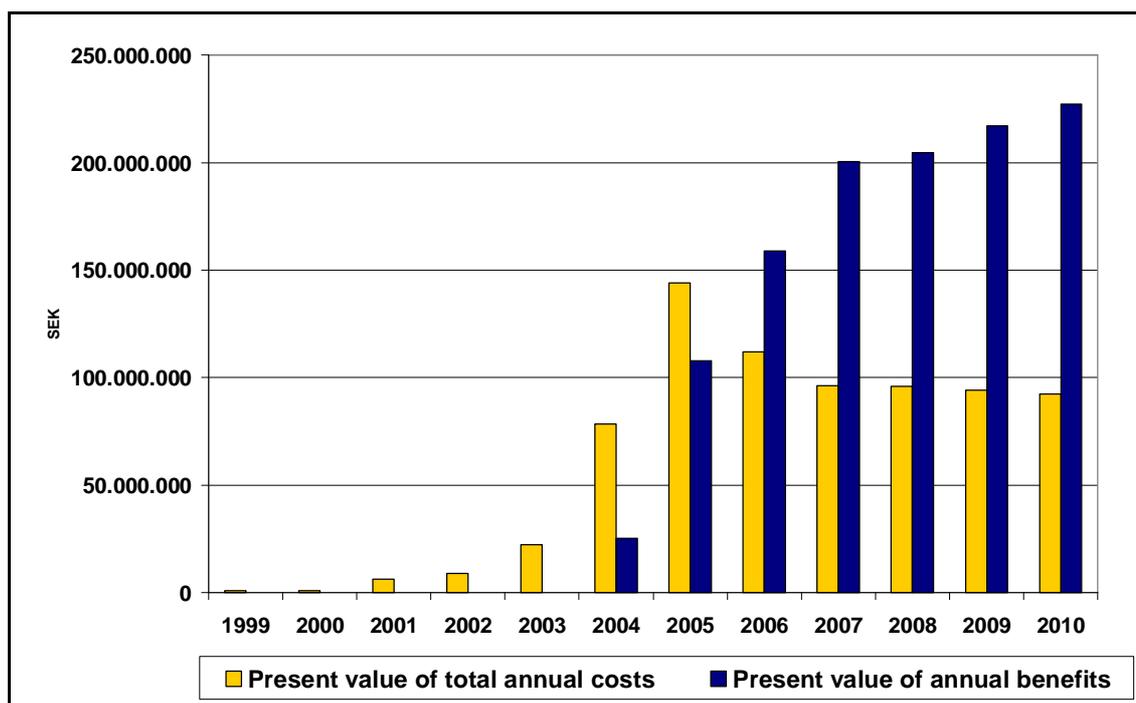
3.7.2 Net benefits

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 presented³⁵.

3.7.2.1 First year of annual net benefits

Chart 1 below shows the present values of estimated costs and benefits for each individual year over the EHRI horizon of 1999 to 2010. Estimated annual net benefits were first realised in 2006, year 8 after the very beginning of the integrated EHR initiative and the 3rd year of implementation. This timescale is in line with other initiatives of comparable scope and complexity³⁶.

Chart 1: Estimated annual cost and benefits



Source: EHR IMPACT study

The benefits only start in the year of implementation, but their value reaches a stable high level within a fairly short period of about three years. Further increases could be expected from current developments, yet their impact is outside the scope of this EHRI evaluation. The

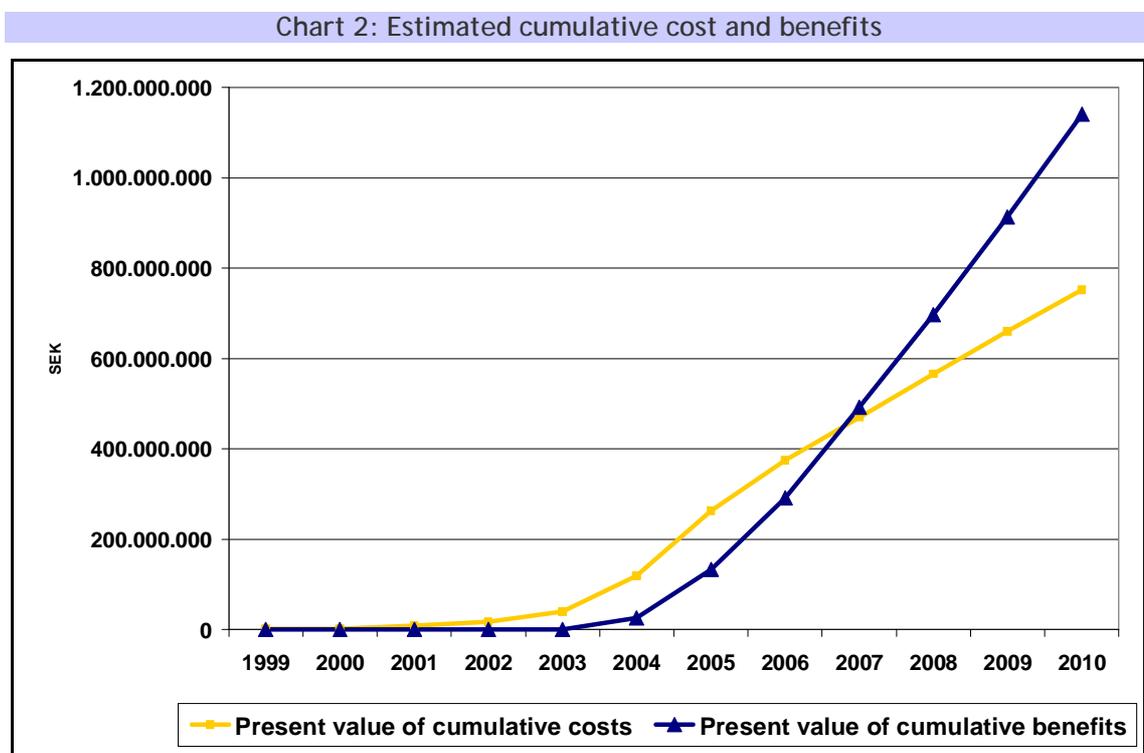
³⁵ see also Section 3.7.4 on sensitivity of results

³⁶ Stroetmann, Karl A.; Jones, Tom; Dobrev, Alex; Stroetmann, Veli N. (2006): eHealth is Worth it - The economic benefits of implemented eHealth solutions at ten European sites. Luxembourg: Office for Official Publications of the European Communities, p. 56. Available at: <http://www.ehealth-impact.org/download/documents/ehealthimpactsept2006.pdf> (08-07-09); other EHR IMPACT reports on www.ehr-impact.eu

long period of continuous costs without benefits to match them reflects the time of careful planning and searching for an IT solution that matches the requirements of Kronoberg's health system. The long preparation phase also allowed the county council's IT department to organise the implementation process in a way minimising risks. The success is reflected in the quick realisation of net benefits after implementation. The net benefit margin from 2007 onwards is substantial, suggesting a sustainable positive impact over the long run.

3.7.2.2 First year of cumulative net benefits

The cumulative position of estimated costs and benefits from the integrated EHR system in Kronoberg is presented on chart 2. The first year of cumulative net benefits is 2007, year 9 of the whole life-cycle, 4 years after implementation and only one year after the estimated value of annual benefits exceed annual costs for the first time. This position is also in line with experience from other initiatives - although it takes time for technically and organisationally complex eHealth activities, such as networks for exchanging patient data, to be set up, once utilisation begins, benefits tend to increase fast.



Source: EHR IMPACT study

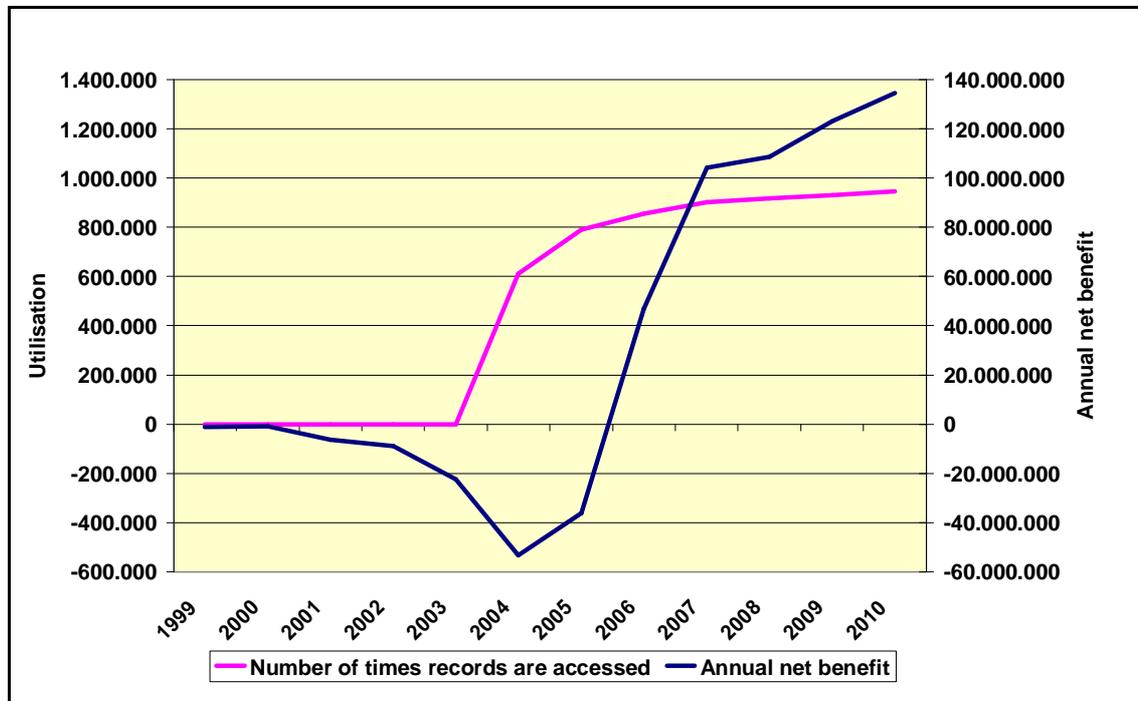
The pivotal point in the chart is year 2005, after which the value of benefits start increasing much faster than the value of costs. The fact that growth rates of cumulative costs are significantly lower than growth rates of cumulative benefits in the late years of the EHRI horizon, presenting a stable state of development, indicates that the investment on behalf of the county council has been worthwhile.

3.7.2.3 Net benefits and utilisation

Generally, annual benefits and utilisation can be seen as broadly correlated. The relationship between annual benefit and utilisation is shown in chart 3 below. During the first 5 years,

utilisation is at zero and no benefits are realised. With utilisation beginning in 2004, implementation costs still keep net outcomes negative, but the net benefit curve switches direction towards zero as soon as the bulk of implementation costs are overcome. After 2007, stable utilisation rates correspond to stable, positive net benefit levels.

Chart 3: Link between net benefit and utilisation



Source: EHR IMPACT study

The correlation of utilisation to benefits is about +0.91, which is a very high correlation. It indicates that the positive economic impact of the EHR system is substantially driven by its increasing utilisation. It is important to note, that the quantification of impact indicators relies on data other than utilisation³⁷, which means that this result is not a methodological artefact.

The correlation between utilisation and net benefits is about +0.66, which is positive, but not as strong as experienced elsewhere. The difference between the two correlations indicates that the costs more independent of utilisation. Thus, with levels of use already reaching the full spectrum of healthcare services in Kronoberg, the cumulative value of gains can be expected to rise without a matching increase in the value of costs.

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.

At year 8, the annual net benefit ratio to costs turns positive and rises continuously to +1.46 at year 12, which is 2010. The cumulative ratio increases steadily after 2004 and turns

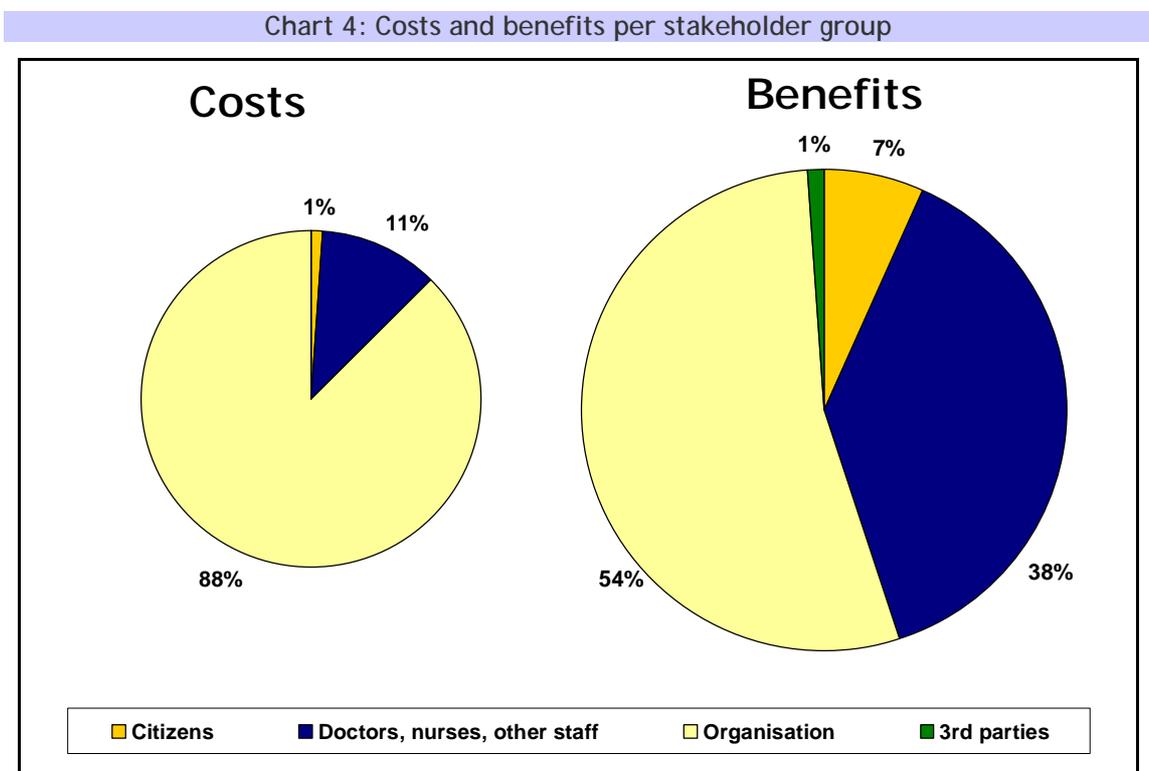
³⁷ Cf. Appendix 2

positive in 2007, reaching at +0.52 by 2010. This means that for every SEK100 worth of negative impact, there are SEK152 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 county-wide EHR system in Kronoberg of about 52% over a lifecycle of 12 years. This result is impressive, given the long build-up period before development and implementation was able to start. The long preparation period is a recognised good practice for initiatives of this scope³⁸, which need careful planning and string support from a number of political bodies. Failing to secure this support and prepare appropriately carries the risk of being faster, but failing the whole initiative. The steady increase in estimated annual socio-economic returns in the late years of the EHRI horizon, reaching 146% in 2010, point towards a sustainable performance. The cumulative returns are thus expected to stay on a rising path.

3.7.3 Distribution of costs and benefits to stakeholders

Chart 4 below shows the distribution of costs and benefits between the main stakeholder groups. Health service provider organisations in this case are all healthcare and social care facilities, including hospitals and healthcare centres, as well as the Regional Healthcare Authority of Kronoberg’s county council. The category “doctors, nurses, and other staff” refers to professionals as individuals, not as employees. Thus, only impacts such as private time invested or saved, and inconvenience or feeling of comfort, are attributed to this group. As already addressed, “citizens” in this case refers mainly to patients. Third party is the Swedish Social Insurance Agency.



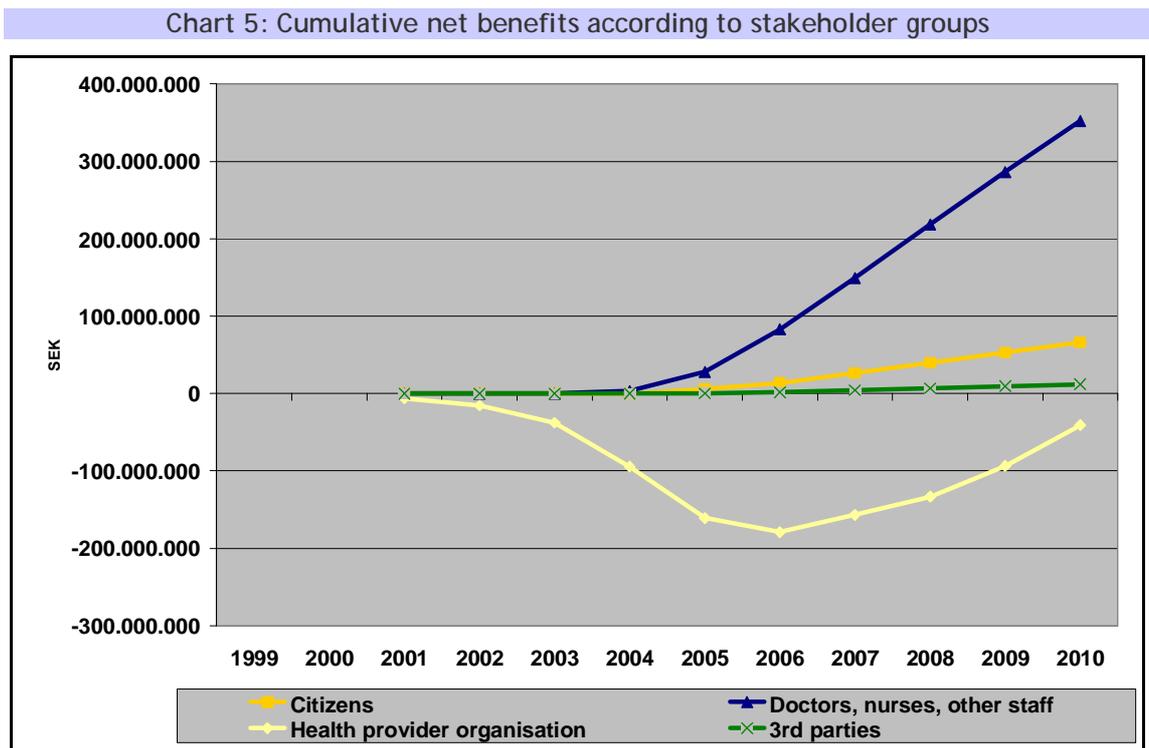
Source: EHR IMPACT study

³⁸ Stroetmann, Karl A.; Jones, Tom; Dobrev, Alex; Stroetmann, Veli N. (2006): eHealth is Worth it - The economic benefits of implemented eHealth solutions at ten European sites. Luxembourg: Office for Official Publications of the European Communities, p. 56. Available at: <http://www.ehealth-impact.org/download/documents/ehealthimpactsept2006.pdf> (08-07-09)

Estimated costs are distributed between all groups, but third parties. New risks associated with using EHRs drives the costs for citizens. Inconveniences and initial adaptation efforts for users comprise some 11% of the total value of costs. The fact that the county council bears the bulk of cost is neither surprising, nor concerning. In a centralised health system, such as in Sweden, investments of such kind are the responsibility of the public sector.

The county council and the HPOs that belong to it also reap the largest share of benefits - about 54% of the total. Professionals are major beneficiaries from the integrated EHR system. Their non-financial investment is modest compared to their equally non-financial benefits of 38% of total. The benefits to citizens are exceeding their proportion of costs.

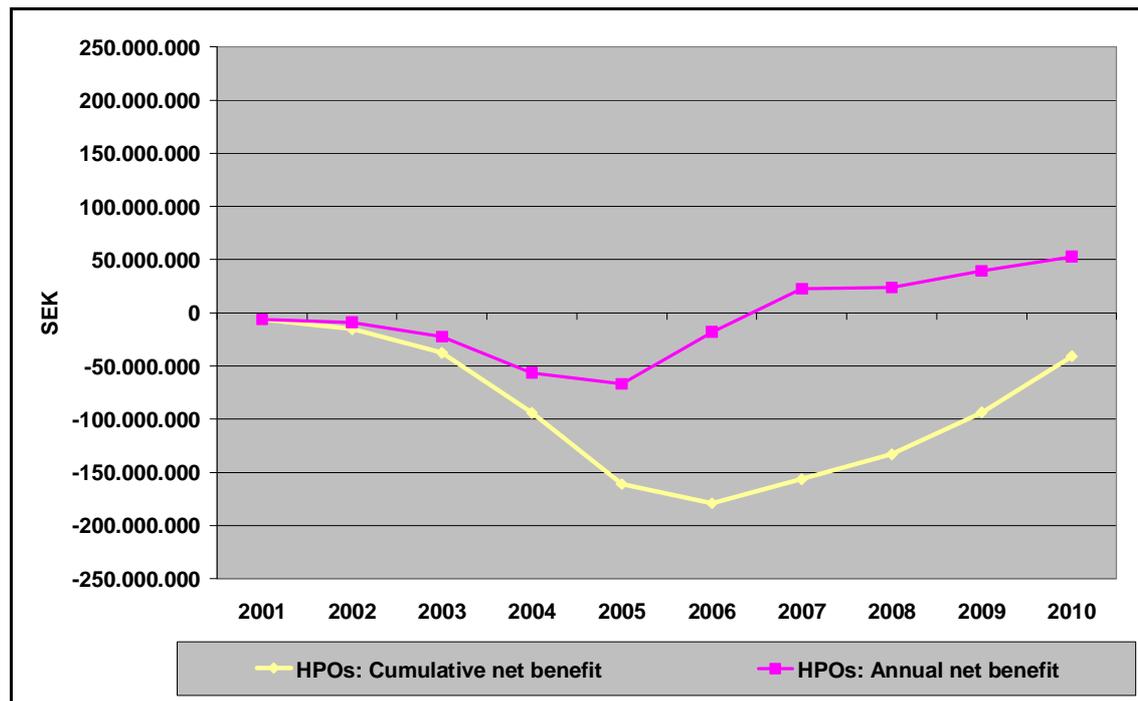
The cumulative net benefits for each stakeholder group are shown in chart 5 below.



Source: EHR IMPACT study

HPOs reap some 54% of benefits, bearing 88% of the costs. Being the prime investor, they will take longer to recover the financial and non-financial investments, yet on an annual level they already achieve net benefits since 2007. Chart 6 below shows the annual and cumulative position of HPOs. The investment includes all expenditure by the county council, which is an investment in longer term health policy goals. Part of these goals includes meeting future demand challenges in healthcare with a stable resource base.

Chart 6: Estimated annual and cumulative net benefits to health providers



Source: EHR IMPACT study

The impact on healthcare team members strongly suggests that the EHR system is a right step in the direction of meeting the challenges. The real impact, however, is expected to become visible only well into the next decade, which is beyond the EHRI horizon. Nevertheless, the position shown in chart 6 already indicates a potential trend towards a net return in the future. The string overall performance supports this observation.

3.7.4 Sensitivity analysis

The sensitivity analysis consisted of 37 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 literature³⁹, 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 EHR system 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. A total of 196 variables were tested. Values were lowered or increased by between 50% and 500%, depending on the variable in question, and in a direction potentially reducing the net benefit over time. The discount rate has been tested for sensitivity at plus 100% and minus 50% of the EHRI rate of 3.5%.

The overall results of the socio-economic analysis are not sensitive to any individual block of estimations. The impact of manipulating assumptions is minimal, with highest impact involving a deferral of annual or cumulative net benefits by one year; in two occasions by two years. The overall socio-economic impact for the EHRI evaluation timeline, measured by the

³⁹ Cf. Reference list

cumulative net benefit to cost ratio in 2010, worsens within a range of up to 0.43, still leaving a comfortable positive result of 9%.

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

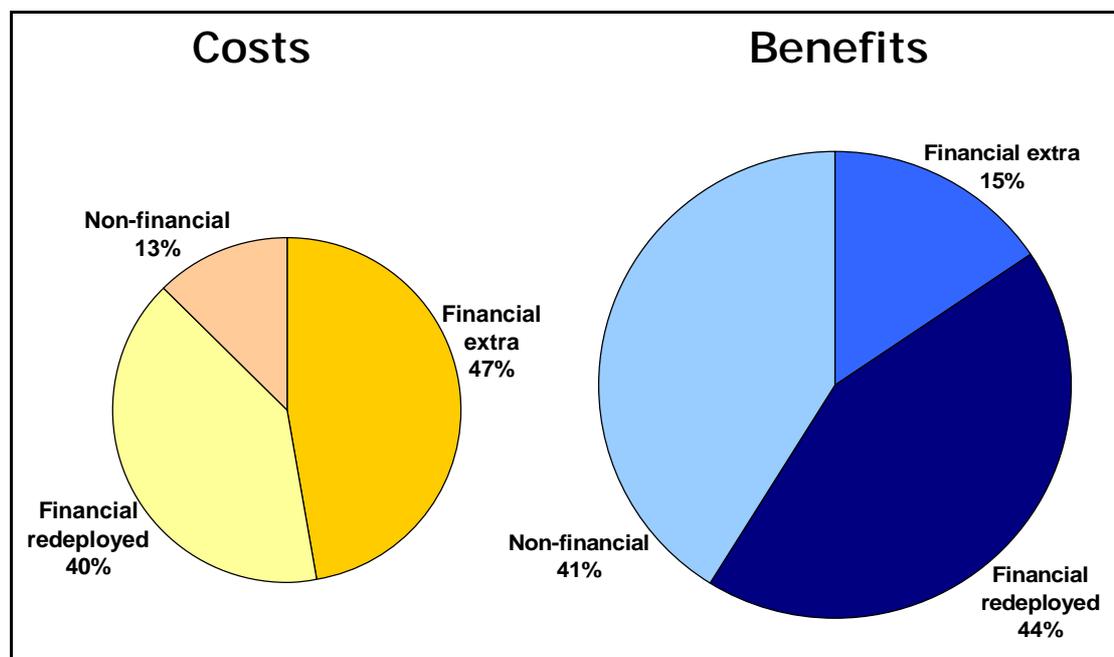
3.8 Financing and financial impact

3.8.1 Financial impact

The financial impact of the EHR system shows a very different picture to the cost benefit performance. Each costs and benefits have been assigned to a category of extra finance, non-financial, or redeployed finance to show the financial implications of the investment. Results are depicted in Chart 7 below. The financial classification of benefits shows that only 15% of the benefits are released extra finance. This is compared to 47%, or SEK354 million, of extra financial costs related to the investment over the period of 12 years. Some 40% of the costs are redeployed resources from other activities, and the remaining 13% of the costs can be classified as non-financial.

Benefits are primarily non-financial and redeployable resources. Non-financial benefits, including better quality of care, have a considerable value, but cannot be really converted into cash. About 44% of the benefits can potentially be redeployed into productive resources. The benefits in the redeployed category are found in many small pockets and cannot easily be redeployed as a set of corporate decisions. Releasing the potential financial benefit from redeploying resources is a difficult managerial challenge.

Chart 7: Financial and non-financial impact



Source: EHR IMPACT study

An interesting observation is that the budgetary savings lead to a positive annual net financial impact for the county council in 2010, which indicates at a potential a financial return in the longer term. This, however, is outside the EHRI horizon and is not captured by the results of the quantitative analysis.

Taken together, the analysis shows a financial position where extra cash of some SEK354 million is invested over twelve years with a corresponding cash return of only SEK176 million. However, the investment has already been worthwhile from the socio-economic perspective, which justifies not only the investment as a whole, but also the financial contributions.

3.8.2 Financing arrangements

The shared EHR system in Kronoberg County was financed locally by the county council. The Regional Health Authority of the council provides the EHR software to all HPOs without additional charges. The same applies to municipalities' nursing care. Up to date, hardware, such as computers and laptops to run the EHR software was entirely funded by the Regional Health Authority as well. A share of the resources allocated to system implementation and maintenance come from the individual HPO budget.

Starting in summer 2009, the county council changes this arrangement and levies a rent for all hardware used at the HPOs. This is part of a strategy for healthcare centres to become more independent and have a better cost control. Healthcare facilities can decide on the number of computers and other hardware they want to use. The software will continue to be provided free of charge to hospitals, healthcare centres, and other facilities.

3.9 Legal aspects

3.9.1 Data protection

The most relevant data protection law with respect to EHR systems in Sweden is the Patient Data Act of 2008, replacing the previous Health Records Act and the Care Registers Act. The previous laws were revised to adapt to and to foster the increasing use of ICT in the Swedish health system. Under the Patient Data Act, healthcare and social care professionals can digitally access a person's full history from care providers at different levels of the health care system. At the same time, the Act strengthens the framework for citizen influence and involvement, since individuals themselves decide, in a consent process, who is to be given access to their overall record. Citizens will also be able to directly access their own digital information and see a log of healthcare staff who have had access to their record⁴⁰.

Besides the Patient Data Act, citizens can fall back on the Swedish Secrecy Act. According to the Swedish Secrecy Act, access to any healthcare related data is restricted to healthcare staff who need this data to fulfil their duties, and it should be directly related to the purpose for which the data have been collected⁴¹.

⁴⁰ Ministry of Health and Social Affairs, Swedish Association of Local Authorities and Regions and National Board of Health and Welfare (2008): Swedish Strategy for eHealth 2008 Status Report. Available at: <http://www.sweden.gov.se/content/1/c6/11/48/75/39097860.pdf> (08-07-09)

⁴¹ Rolfhamre P, Janson A, Arneborn M, Ekdahl K. SmiNet-2 (2006): Description of an internet-based surveillance system for communicable diseases in Sweden. Euro Surveill, 11(5):pii=626. Available online: <http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=626>

Every time a patient seeks medical or dental care, the county council must register information on the patient in accordance with the Patient Record Act. This is usually information on:

- Visits to health centres, hospitals, dental clinics, medical-aid centres and rehabilitation units
- Registration for hospital care
- Examinations and treatment
- Diagnoses
- Travel in connection with care
- Paid and unpaid patient charges.

Patients without an existing EHR can be registered in the system by healthcare professionals at healthcare centres or hospitals.

The individual electronic health records are viewed and updated every time the patient receives medical care. This may be a visit to a primary healthcare centre, any activity in inpatient or outpatient care at a hospital, or a tele-consultation.

The county council Executive Committee is responsible for handling of personal data within Kronoberg county council. There is also a personal data representative whose remit is to ensure that personal data is dealt with in legitimately and correctly⁴². Access to records follows the principle of an established care relationship. Only professionals with an established care relationship with a specific patient are allowed to access the records if this patient.

3.9.2 Information governance

Information governance is particularly challenging in a shared EHR system that connects such a multitude of HPOs as in Kronoberg. In order to comply with legislation described above, Kronoberg county council employs an intricate information governance structure based mainly on a role-based access management system.

Patient consent

While the patient is not a direct user of the EHR system, he has to give his explicit and informed consent to the access to health related information in an organisation different from the one in which the data is created. In Kronoberg, a patient has to give his explicit consent before an EHR is created. This patient consent is stored in the EHR and the basis for any data sharing. Once a year, patients have the right to access information on their personal data registered by the county council free of charge.

A healthcare or social care professional can only view an EHR if there is an established care relation and the information is needed for the patient's care. An established care relation also means that nurses and medical secretaries affiliated with the treating doctor are entitled to access the patients' medical record. In some cases, caregivers can ask a patient for his explicit consent.

Access rights and functional permissions

The access rights of individual users are controlled and managed by the EHR systems' engine. Every user needs to have an active profile in the system. Access to EHRs requires log-in with

⁴² Kronoberg County (2009): Identity. Prove your identity - for your own sake. Available at: http://www.ltkronoberg.se/upload/Dokument/Languages/07%20-%20identite%20o%20pu-lag_en.pdf (08-07-09)

user name and a password. The amount of information visible to the user, as well as the tasks enabled, is defined in the system's administrators in the system engine. The access rights system supports both negative permission ("access for all units except A and B") and functional permissions ("authorised to read and write", "read not write", etc.).⁴³

Access and functional permissions are given according to the respective staff category. Usually, physicians can access all patient information in the EHR and are authorised to both read and write with some exceptions. They are also authorised to send prescriptions, sign referrals and orders. When a physician receives a referral, he is automatically granted access to the patient's EHR. Nurses and assistant nurses can view the entire patient record, while medical secretaries can access selected parts of patient records only. In the hospital setting, users are not restricted to information in their own department. However, medical notes from certain specialties such as psychiatry are not visible to users outside the department team. Only the medication list is shared between all departments and facilities. Similar restrictions apply to data sharing between mental health units and other HPOs. While a psychiatrist in a mental health unit can access all external notes from other HPOs, hospital doctors have no access to the psychiatrists' notes.

All accesses to any clinical data in the EHR system are logged. For each update in the database, the change and/or access attempt is logged with a user and time stamp⁴⁴. In the hospital setting, every department has a responsible manager to monitor the department's log files for any irregularities. The EHR system does not yet support automatic matching of care relationship and unauthorised accesses.

Access rights for municipal nursing care staff include selected parts of patient records from their municipality. Caregivers are usually authorised to access the records of patients they are assigned to.

Out of hour and emergency services count as an established care relationship, so that professionals on duty have access to any record they need during their shift.

Pharmacists are only allowed to see the record of all drugs dispensed with explicit patient consent for each access. Doctors also need the patient's consent in order to look into the dispense record. The latter belongs to the patient and can be seen from anywhere via a web-portal. Identification is solved by using the barcode on a driving licence, or other ID card, which contains the national 10 digit identification number.

⁴³ Cambio Healthcare Systems AB: Cambio COSMIC Technical Overview. Available at: <http://www.cambio.se/document/sv-se/Technical%20Overview.pdf> (08-07-09)

⁴⁴ Cambio Healthcare Systems AB: Cambio COSMIC Technical Overview. Available at: <http://www.cambio.se/document/sv-se/Technical%20Overview.pdf> (08-07-09)

4 Conclusions

The overall conclusion from the qualitative and quantitative analysis of the regional integrated EHR and ePrescribing system in Kronoberg is that it presents a benchmark from which many other European regions can learn a great deal. Although still being developed, the system already achieves impressive results in a number of areas. The socio-economic performance is robust, with a net return rate of 52% over 12 years, at a current annual rate of over 145%. The EHR system already spreads across all levels of healthcare in routine operation, and even reaches out to home care. The high value to users, made clear in numerous interviews, proves sustainable acceptance levels and a positive impact on healthcare services. The ongoing work on standardisation of templates for notes and reports, as well as keywords and care plans, indicates a successful engagement policy. It also shows a serious commitment to developing semantic interoperability.

4.1 Future potential

As any successful eHealth initiative, the shared EHR system in Kronoberg will never be finished. Further developments are driven by constantly increasing demands from users and the health system as a whole, as well as technology and innovation developments. Specific potential has already been identified in the following themes:

- Secondary use of health data
- Elimination of parallel routines
- Intelligent decision support
- Technical improvements reducing response times and time spent by users on the technical as opposed to the content part of the system.

The first theme relates to the vast amount of data available in the database, which is already used for some basic statistic purposes supporting management. However, the potential of this data is much higher. Running clinical analyses is a visionary goal that could become reality in Kronoberg. An example is the possibility to compare data on public health level, such as blood pressure or cholesterol levels. More knowledge from the anonymised statistical analyses of EHRs can help monitor outcomes and steer clinical guidelines accordingly. The trend towards standardisation of documentation practices facilitates the process, as it will improve the quality of data. The increased utilisation of the data warehouse and Business Objects is expected to help improve monitoring and management, facilitate more choice and involvement of citizens in the health system, aid a shift towards more prevention, and thus generally improve the quality of health services in Kronoberg.

Some paper processes have not yet been fully replaced yet, or have only been replaced by a digital version of the paper-based practices. This is by no means a negative feature at this stage of development, as it is a recognised good practice in risk mitigation.

Decision support is currently based on providing professionals with all possible information they need for making the right decision. Next generations of decision support tools will account for personal circumstances related to the specific patient.

Technical advancements include the implementation of terminal servers and single sign-on, which will allow users to virtually take their session between different workstations. Terminal

servers will improve the speed of the system, as response times will depend less on the characteristics of the local processors.

4.2 Transferability

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

Usually, technological transferability refers to the possibility to install the ICT in another setting. As a commercial product, the EHR system applied in HPOs across Kronoberg has already been introduced in several other Swedish counties and various sites outside Sweden. Unlike non-commercial, proprietary products, the EHR system was not developed for a specific HPO. This facilitates the technical transferability to different healthcare provider organisations. The flexibility of configuration helps to adapt the technology to different organisational settings. The component based architecture allows such adaptations to be made with relatively low effort.

However, when it comes to the concept of “one patient-one record” as seen in Kronoberg, organisational transferability can be a major challenge. The organisational transferability depends as much on the system to be transferred, as on the setting in which it is to be transferred. With the variety of healthcare systems, this specific solution in Kronoberg is not necessarily transferable to other contexts.

On a positive note, the lessons from implementing the EHR system across Kronoberg are transferable to other settings. The challenge is only to interpret the lessons in a way that fits the specific context.

4.3 The role of interoperability in realising the benefits

By its design, the system ensures interoperability as one of its primary purposes. The strategy to implement one system across all healthcare facilities was driven by the realisation that interoperability is a critical factor to providing value added through EHRs and thus for the success of the initiative.

These strategic thoughts have been proven accurate by experience. The benefits identified in the analysis rely to a large extent on information being available regardless of the place of creation and the place of access. Local IT systems lacking interoperability would miss these substantial gains. An exception proves the point - lacking interoperability between some nursing home systems and COSMIC lead to time being spent on manual re-entry of data. Absent interoperability on a larger scale may have an impact on costs, which can threaten the overall performance of the initiative.

4.4 What it means for decision makers

Success is by no means an automatic consequence of investments in eHealth. A number of aspects from Kronoberg's experience can be useful for decision makers in planning and managing investments in interoperable EHR and ePrescribing systems.

Management

One fundamental success factor in large scale initiatives, such as implementations across whole regions, is the commitment of management at all levels. The shift from paper to digital storage and management of data carries with it fundamental changes to the processes and practices on the affected organisations. These changes need careful handling and often even more attention than the IT component of the investment.

Engagement

A parallel theme to management commitment to changes on organisations is the engagement of healthcare teams and all other users of the IT system. Engagement is different from consultation, which is often mistakenly seen as sufficient involvement of users. Kronoberg provides a benchmark example in how to engage health professionals. The details of the approach are described in section 3.4 above.

The hybrid of bottom-up and top-down system development and implementation approach involved groups of people from "near the floor", who want to use an IT system and are trusted by their colleagues, working closely together with the IT department. With these mixed development and implementation groups starting work way before implementation, the EHR system in Kronoberg has become an indispensable tool for health service teams, rather than a technology gadget. Taking those lead users over from implementation teams into maintenance teams ensured continuity and meaningful continuous development of all modules of the system.

Change

Even though involving lead users in the planning and development stages improves the usability and perceived usefulness of IT, changes in the field need to be carefully managed in order to succeed in realising the benefits from EHR and ePrescribing systems. In Kronoberg, the EHRI recognised an approach proven helpful elsewhere as well⁴⁵ - quick implementation of the least distorting parts of the eHealth application, aiming at fast returns for users, with a subsequent long-term commitment to changing processes and standardising clinical and working practices. These changes are needed to release the full potential not just of eHealth, but of health services as a whole. The technology then becomes an enabler, rather than a trigger for a deep re-structuring of care provision.

Technology

Healthcare is a sector where time is one of the most important and simultaneously scarce assets. Short response times and high levels of accessibility and reliability are essential. Furthermore, these have to be achieved quickly, so that working practices can switch without prolonged duplication of work. The experience from Kronoberg's IT department team is that

⁴⁵ EHR IMPACT (2008): The socio-economic impact of the computerised patient record systems at the University Hospitals of Geneva. Available at: <http://www.ehr-impact.eu/cases/cases.html> (08-07-09)

it is complicated and dangerous to work with parallel routines over long periods. This puts a substantial amount of pressure on technology.

Risk

Last, but by no means least, identifying, mitigating, and managing risks is absolutely critical to success. eHealth projects in general, but because of their scope and complexity EHR and ePrescribing systems in particular, are high risk initiatives. Project leaders thus need to be aware of the risks and also be prepared to deal with them quickly at any stage of the investment life-cycle. Identify risks requires the close work with users already addressed. Dealing with the problems needs the link and commitment of top management, also stressed already.

The experience from Kronoberg is that technology risks are easier to identify in advance. The second request for proposals regarding the clinical part of the comprehensive system now implemented, after the technology failure after the first procurement cycle, illustrates the point. Organisational risks, often stemming from hidden processes and the automatic increase in transparency brought about by the implementation of a comprehensive EHR system, are the bigger challenge, as they are less predictable.

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Appendix 1: Summary of evaluation data

Generic data summary	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Cosmic - Kronoberg												
Estimated COSTS												
Citizens	0	0	0	0	0	964.192	1.559.560	1.432.276	1.332.374	1.032.479	1.212.299	1.111.074
HPOs												
Doctors, nurses, other staff	0	0	0	0	0	14.345.338	35.367.871	15.234.603	6.220.700	5.304.196	4.606.456	4.546.908
Organisation	1.023.559	988.946	6.285.668	9.077.896	22.361.900	63.153.784	107.162.943	95.251.642	88.610.633	89.727.500	88.200.621	86.618.299
Third parties	0	0	0	0	0	0	0	0	0	0	0	0
Present value of total annual costs	1.023.559	988.946	6.285.668	9.077.896	22.361.900	78.463.314	144.090.374	111.918.521	96.163.707	96.064.175	94.019.376	92.276.281
Present value of cumulative costs	1.023.559	2.012.505	8.298.173	17.376.069	39.737.969	118.201.282	262.291.656	374.210.177	470.373.884	566.438.059	660.457.435	752.733.716
Estimated BENEFITS												
Citizens	0	0	0	0	0	828.950	7.401.637	9.660.712	14.058.415	14.245.038	14.321.195	14.212.971
HPOs												
Doctors, nurses, other staff	0	0	0	0	0	17.663.054	59.869.989	70.449.688	72.607.249	74.294.230	72.461.129	70.691.116
Organisation	0	0	0	0	0	6.713.609	40.283.562	77.137.601	111.097.220	113.424.567	127.635.509	139.419.767
Third parties	0	0	0	0	0	0	253.059	1.530.924	2.572.664	2.593.962	2.615.437	2.637.089
Present value of annual benefits	0	0	0	0	0	25.205.613	107.808.247	158.778.925	200.335.547	204.557.797	217.033.270	226.960.943
Present value of cumulative benefits	0	0	0	0	0	25.205.613	133.013.861	291.792.786	492.128.333	696.686.131	913.719.400	1.140.680.344
Net benefits												
Present value of annual net benefits	-1.023.559	-988.946	-6.285.668	-9.077.896	-22.361.900	-53.257.701	-36.282.126	46.860.404	104.171.841	108.493.622	123.013.894	134.684.662
Present value of cumulative net benefits	-1.023.559	-2.012.505	-8.298.173	-17.376.069	-39.737.969	-92.995.669	-129.277.795	-82.417.391	21.754.449	130.248.072	253.261.966	387.946.628
Net benefits over cost ratio - annual	-1,00	-1,00	-1,00	-1,00	-1,00	-0,68	-0,25	0,42	1,08	1,13	1,31	1,46
Net benefits over cost ration - cumulative	-1,00	-1,00	-1,00	-1,00	-1,00	-0,79	-0,49	-0,22	0,05	0,23	0,38	0,52
Number of records	0	0	0	0	0	106.291	135.417	140.717	145.023	147.065	179.999	182.355
Number of times records are accessed	0	0	0	0	0	610.218	791.001	856.103	902.348	916.431	930.734	945.260
Distributions			Costs		Benefits				Type of costs		Type of benefits	
Citizens			1,15%		6,55%				financial extra	47,09%		15,48%
HPOs									financial redeployed	40,38%		43,36%
Doctors, nurses, other staff			11,38%		38,40%				non-financial	12,52%		41,16%
Health provider organisation			87,48%		53,98%							
Third parties			0,00%		1,07%							
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	
Patients, carers & other individual people	Subjective irritation from limited access to double-prescriptions of sleeping pills	Doctors can avoid duplicate prescription with the information from the common medication list	Frequency of patients asking for already prescribed sleeping pills; negative WTP for not getting sleeping pills	
	Effort for providing consent	Time used as a proxy for all effort	Relevant population; estimated average time required for providing consent; average wage in Kronoberg	
	Inconvenience during system rollout	Reduced access to care for about two weeks during initial implementation	Relevant number of patients; length of inconvenience period; negative WTP for inconvenience during EHR system rollout	
	Risk from unclear identity of physician	Common names are more likely to occur more than once in a system covering the whole county, leading to risks during referrals	Relevant number of referrals; negative WTP for increased risk	
	Risk from reduced communication	Less direct communication between psychiatrists and other doctors can lead to information being overseen or not identified as important	Relevant number of outpatients; risk that psychiatrist misinterprets/misses out information; negative WTP for increased risk	
HPOs - Staff	Primary healthcare centres	Informal peer to peer training	Including all staff members	Number of employees in primary care: doctors, nurses, assistant nurses, secretaries, other; time spent on informal training; hourly average pay for each staff category
		Increased workload with additional working procedures for doctors	A shift of responsibilities from (assistant) nurses to doctors is observed	Relevant number of doctors; negative WTP for additional work
		Initial inconveniences: irritation and information overload	Including all staff members	Number of employees in primary care; negative WTP for initial inconvenience for each staff category; length of adaptation period

Stakeholder group		Cost indicator	Clarification	Variables	
	Hospitals	Increased workload with additional working procedures for doctors	A shift of responsibilities from (assistant) nurses to doctors is observed	Relevant number of doctors; negative WTP for additional work	
		Initial inconveniences: irritation and information overload	Including all staff members	Relevant number of employees; negative WTP for initial inconvenience for each staff category; length of adaptation period	
	Mental health units	More pressure on psychiatry doctors	Feeling more pressured in decision-making when having all patient information without waiting times	Relevant number of psychiatrists; negative WTP for increase of pressure due to EHR system	
		Initial inconveniences: irritation and information overload	Including all staff members	Relevant number of employees; negative WTP for initial inconvenience for each staff category; length of adaptation period	
	Municipalities	Initial inconveniences to frequent users	Nurses and therapists	Relevant number of employees; negative WTP for initial inconvenience for each staff category; length of adaptation period	
		Continuous inconvenience to infrequent users	Nurses and therapists	Relevant number of employees; negative WTP for initial inconvenience for each staff category; length of adaptation period	
	Pharmacies	Initial inconveniences	Pharmacists	Relevant number of employees; negative WTP for initial inconvenience for each staff category; length of adaptation period	
		Continuous inconvenience	New, EHR system related mistakes causing inconvenience	Relevant number of ePrescriptions; negative WTP for inconvenience due to EHR system related mistakes	
	HPOs - ICT	Kronoberg county/regional health authority	Vendor contracts	Including support by system vendor	External ICT-costs for healthcare information system
			Server & network infrastructure		Costs of licenses
Server & network infrastructure			New database servers & storage network (SAN)	Investment for SAN for COSMIC	
COSMIC licences				Cost of COSMIC licence	
Back up				Investment in backup system	
Obsolescence & new hardware			Old model till 2009	Total costs controlled by county council	

Stakeholder group		Cost indicator	Clarification	Variables
		obsolescence & new hardware	New model since 2009 - HPOs pay rent to the authority and define their demand	Total costs driven by demand from HPOs
		Data traffic	For exchange of health related data	Data traffic fees
		ICT staff		IT staff cost; share dealing with clinical solutions
		Rent for hardware	From HPOs to county authority	Annual rent
HPOs - organisational issues	Kronoberg county- IT department staff	Pre-COSMIC procurement		Cost of procurement of unsuccessful system
		Strategic planning & procurement		Strategic planning and procurement cost as share of vendor contract
		IT staff providing training to implementation teams	Time of implementation team members	Number of implementation team members; distribution of professions in implementation teams; Time for training; share of FTEs per staff category
		IT staff providing training maintenance teams on new system features	Time of maintenance team members	Number of maintenance team members; distribution of professions in maintenance teams; Post go life training time; share of FTEs per staff category
		Engagement in development	By implementation teams	Number of implementation team members; duration of implementation team activity before system rollout; frequency & duration of team meetings; distribution of professions in implementation teams; pre-implementation engagement teams activity; share of FTEs per staff category
		Engagement in development	Travel of implementation teams	Estimated travel costs for attending meetings
		Engagement in continuous development	By maintenance teams	Number of maintenance team members; duration of maintenance team activity before system rollout; frequency & duration of team meetings; distribution of professions in maintenance teams; post-implementation engagement teams activity; share of FTEs per staff category
		Engagement in continuous development	Travel of maintenance teams	Estimated travel costs for attending meetings
	Primary healthcare	Adaptation to the system	Productivity reduction during implementation	Economic performance of healthcare centres (revenue); duration of adaptation; productivity reduction

Stakeholder group		Cost indicator	Clarification	Variables
		Forgone income due to avoided visits	After phone consultation with nurse and when nurses treat unplanned patients instead of doctors making the consultations	Relevant number of telephone contacts with primary care; relevant number of patients coming without appointment; average costs of GP and nurse consultations
		Initial training	Including implementation team members in their training function; all staff categories; including training of new employees	Relevant number of primary care staff; training time; share of FTEs per staff category
		Continuous training	Continuous training for new system features; all staff categories	Relevant number of primary care staff; post go live training time; share of FTEs per staff category
		Time spent on coordinated care planning	GPs have to check „Link“ twice a day and sign coordinated care planning agreements	Relevant number of doctors in primary care; estimated time spent on „Link“, including signing care plans; share of FTE doctors
		Secretaries taking IT support responsibilities	Shift on the responsibilities of secretaries	Relevant number of medical secretaries; share of time spent by secretaries on internal IT support; share of FTE medical secretary
		Forgone income form avoided doctor consultations	Because of the system, nurses can effectively treat some patients	Relevant number of consultations; average costs of GP and nurse consultations
	Hospitals	Initial training	Excluding implementation team members, Initial training includes all basic features in EHR system; all staff categories; including training of new employees	Relevant number of staff; training time; share of FTEs per staff category
		Continuous training	Continuous training for new system features; all staff categories	Relevant number of staff; post go live training time; share of FTEs per staff category
		Adaptation to the system	During pilot and rollout, extra effort put by internal medicine department staff	Temporary staff increase (incl. overtime); adaptation time; share of FTEs per staff category
		Increase in time spent on EHR system	Doctors need longer for new tasks, incl. typing, searching the EHR, etc.	Estimated additional time to do extra work, share of FTE doctors
		Increase in time spent on inpatient ordination	Doctors in paediatrics have to enter a lot of information, e.g. when infusions are needed	Relevant number of inpatients in paediatrics; additional time needed; share of FTE doctors
		Increase in time spent on reading scanned documents	Looking through a paper file is quicker	Relevant number of patients; time for scanned documents - normal amount; Time for scanned documents - large amount; share of FTE doctors

Stakeholder group	Cost indicator	Clarification	Variables	
	Increase in time spent on extra log-in	When doctors move between departments and work stations	Estimated time to log into system, frequency of hospital users logging at different work stations; share of FTE doctors	
	Nurses' waiting time to use a work station	Some bottlenecks still exist in the availability of work stations	Estimated average waiting time for free laptop per time period; share of FTE nurses	
	Manual entry of A&E patient data into EHR system	For patients staying at home after an emergency call, ambulance staff has to update records manually	Relevant number of patients; time for registration of incident details into the EHR system; share of FTE nurses	
	Mental Health Units	Initial training	Excluding implementation team members, Initial training includes all basic features in EHR system; all staff categories; including training of new employees	Relevant number of staff; training time; share of FTEs per staff category
		Continuous training	Continuous training for new system features; all staff categories	Relevant number of staff; post go live training time; share of FTEs per staff category
		Increase in time spent on EHR system - psychiatrists	additional time doctors spent on patient consultations	Relevant number of patients; estimated additional time; share of FTE doctors
	Municipalities	Training	Training with county council IT staff for „Link“ module in EHR system	Number of „Link“ users in municipalities; training time; share of FTE
		Adaptation to the „Link“ - frequent users	Short time, e.g. for home care staff	Number of frequent „Link“ users in municipalities; frequent users' adaptation time; temporary productivity loss; share of FTE
		Adaptation to the „Link“ - infrequent users	Up to 1 year, e.g. for nurses in nursing homes	Number of infrequent „Link“ users in municipalities; infrequent users' adaptation time; temporary productivity loss; share of FTE
		Time spent on „Link“	Twice a day for each home care nurse	Relevant number of „Link“ users in municipalities; time spent on „Link“ per check; frequency of access; share of FTE
		Cost of lacking interoperability	Re-entering data from „Link“ to local system	Relevant number of „Link“ patients; time to copy data into local system; share of FTE
	Pharmacies	Adaptation to ePrescribing	Additional time for processing prescriptions during adaptation period	Total number of prescribed items; adaptation time; additional time; share of FTE pharmacists

Stakeholder group	Cost indicator	Clarification	Variables
	Increase in time spent on EHR system	Increase in time spent on double checking ePrescriptions for mistakes, e.g. wrong package size	Relevant number of ordinations, estimated average extra time per drug prescribed (ordination), share of FTE pharmacist

Table 3: Benefit indicators and variables

Stakeholder group	Benefit indicator	Clarification	Variables
Patients, carers & other individual people Primary healthcare centres	Quality: effectiveness	Better care by better informed caregivers having access to all HPO internal and external medical information on patients	Relevant number of patients; WTP for better care by better informed caregivers
	Quality: better informed patients	During the consultation, caregivers show patients their medical records, test results, images etc. on the screen	Relevant number of patients; WTP for being better informed
	Quality: better informed patients	Chronic disease patients	Relevant number of patients; WTP Chronic disease patients
	Patient safety	Reduced risk with decision support helping to avoid contraindications and allergic reactions	Relevant number of patients for whom a clinical decision has changed; WTP for avoided adverse event
	Efficiency: productivity	Avoided visits to healthcare centre because of information allowing phone consultation to suffice - travel time and waiting time	Relevant number of telephone contacts primary care; average waiting and travelling time for consultation at healthcare centres (HCC); estimated hourly average pay in Kronoberg
	Efficiency: financial saving	Avoided co-payments for hospitalisation because of results and other hospital information available at HCC	Avoided hospitalisations; co-payment rate for hospitalisation
	Efficiency: productivity	Avoided visits to hospital A&E because of GPs receiving informed second opinion in real time - waiting time and consultation	Relevant number of calls; length of A&E process, incl. waiting and consultation; estimated hourly average pay

Stakeholder group		Benefit indicator	Clarification	Variables
		Efficiency: productivity	Avoided visits to hospital A&E because of GPs receiving informed second opinion in real time - travel time	Relevant number of calls; average travel time to A&E; estimated hourly average pay
		Quality: fewer tests	Avoided tests because GP has access to test results from another HPO	Estimated number of avoided tests; WTP for test avoided
		Quality: convenience	Avoided return visits to hospital for taking tests when these can be ordered for execution in a healthcare centre	Relevant number of tests at HCCs; WTP for not having to return to hospital to take tests
		Efficiency: Cost saving	Patient fees can be avoided when patient can stay at home after phone consultation with nurse	Relevant number of patients and calls; co-payment price of consultation with a doctor at a HCC
		Efficiency: Cost saving	Patients seeing a nurse instead of a doctor in primary care	Relevant number of patients and calls; co-payment prices of consultations with a doctor and with nurses at a HCC
	Hospitals	Patient safety	Reduced risk with decision support helping to avoid contraindications and allergic reactions	Relevant number of prescriptions (guided by available information); WTP for avoided adverse event
		Better access for patients with a record	Facilitated phone access to care - faster access to records allow professionals taking calls to answer more calls in the given time	Share of telephone contacts to hospitals that would be unsuccessful ; WTP for easier phone access to hospital care
		Efficiency: Productivity	Avoided consultation/visits when referrals can be dealt without seeing the patient	Relevant number of patients; time saved on avoided referral; estimated hourly average pay
	Mental health units	Patient Safety	Psychiatry patients can be discharged earlier. Doctors feel more comfortable that other HPOs can see when a patient has to be admitted immediately if something happens	Relevant number of inpatients; WTP for early discharge - psychiatry
		Patient Safety	Reduced risk of adverse events due to shared medication lists. Especially relevant for dementia patients	Relevant number of inpatients; estimated cost to patient of adverse event
	Municipalities	Better Care	Coordinated transfer from hospital to nursing home	Number of „Link“ relevant patients; WTP for coordinated care planning with „Link“
		Patient safety	Avoided extension of hospitalisation due to better	Number of „Link“ relevant patients; WTP

Stakeholder group		Benefit indicator	Clarification	Variables
			and faster care planning	for earlier discharge because of „Link“
		Efficiency: Cost saving	Avoided co-payment for hospitalisation due to better and faster care planning	Number of „Link“ relevant patients; average co-payment rate for one day of hospital care
	1177	Patient Safety	Avoided risk of adverse events because 1177 nurses have additional information. Saving a visit to another HPO	Relevant number of calls and changed decisions; 1177-WTP for patients
	Pharmacies	Timeliness	Faster dispensing of drugs avoids patient waiting time - no manual typing	Total number of ePrescriptions; time for typing in one paper prescription; estimated hourly average pay
HPO - healthcare staff	Primary healthcare centres	Alleviation of work & comfort in decision-making	Increased work satisfaction for doctors, nurses, assistant nurses, secretaries and other team members	Number of team members; WTP for each healthcare centre staff category
	Hospitals	Alleviation of work & comfort in decision-making	All team members. Comfort from certainty about availability of patient data. Convenience by following a structured nursing care plan in the EHR system. Less time consuming care coordination when working with „Link“ module. Less interruptions of work due to communication via „Link“	Number of team members; WTP for each hospital staff category
	Mental health units	Alleviation of work & comfort in decision-making	Psychiatry patients can be discharged earlier as doctors feel more comfortable; comfort from certainty about availability of patient data	Number of team members; WTP for each psychiatry staff category
	Municipalities	Alleviation of work	„Link“ allows carers to prioritise tasks decreasing pressure and stress	Number of frequent „Link“ users in municipalities; average WTP for „Link“
	1177	Alleviation of work	Nurses feel safer - very small WTP	Number of nurses; WTP for using Cosmic
	Pharmacies	Alleviation of work	New prescriptions do not have to be manually entered into the pharmacy IT system	Number of pharmacists; WTP for ePrescribing

Stakeholder group		Benefit indicator	Clarification	Variables
	Kronoberg county/regional health authority	County council managers alleviation of work & comfort in decision-making	Better information and the availability of key indicators in Business Objects enhances decision making	Number of county council managers; WTP for better information
HPO - organisation	Primary healthcare centres	Efficiency: Productivity	Time saving for nurses/medical secretaries/assistant nurses on searching paper records	Reported time saving; share of average cost of relevant Full Time Equivalent (FTE)
		Quality: fewer mistakes	Avoiding adverse events because of decision support	Relevant number of patients and visits; reduced probability of adverse event; average cost of a GP consultation
		Efficiency	Cost implications from avoided visits because of more efficient telephone consultations	Relevant number of patients and calls; average cost of a GP consultation
		Efficiency	Avoided doctor consultation, nurse as nurse encounter is sufficient	Relevant number of consultations; average costs of GP and nurse consultations
		Increased productivity in OOH service	EHR system enables OOH doctors to provide more efficient care	Time on duty in OOH avoided; share of FTE doctors
		Increased productivity in OOH service	Fewer nurses in OOH shifts	Avoided nurse shift in OOH; FTE nurses
		Efficiency	Saving from not taking duplicate tests	Estimated number of avoided tests per year; average cost of a test
		Cost saving	Budget reduction due to EHRs	Saving reported by county council
	Hospitals	Efficiency: Productivity	Time saving for nurses on searching paper records	Reported time saving, share of FTE nurses
		Time saving	Time saving for nurses on care coordination when working with „Link“	Relevant number of patients, reported time saving share of FTE nurse
		Efficiency	Avoided blood & other lab tests	Number of avoided tests; average costs of chemical, microbiology, and radiology tests
		Time saving	Doctors saving time on documentation	Relevant number of doctors; reported time saving; share of FTE doctors
		Efficiency of phone consultations	Time to search for records used as proxy for increased productivity	Relevant number of consultations; average time to search for a paper record; share of FTE nurses

Stakeholder group		Benefit indicator	Clarification	Variables
		Patient safety: avoiding ADEs	Fewer mistakes with ePrescribing because of medication list from other HPOs available	Relevant number of patients and prescriptions; reduced probability of ADE; estimated average consequence of an ADE; average cost of hospitalisation day; average cost of outpatient visit
		Efficiency: prescribing	Time saving for doctors on prescribing	Number of prescribed items (all patients) in hospital; time saved on prescribing for doctors; share of FTE doctors
		Less waste: No clarifying of handwriting	Time saved by doctors on clarifying illegible paper prescriptions when pharmacists call	Relevant number of prescriptions; time for a doctor clarifying illegible paper prescription; share of FTE doctors
		Time saving for doctors on giving a second opinion	Second opinion from A&E to GP if more effective because of available information in real time	Relevant number of second opinion calls; time to search for a paper record; share of FTE doctors
		Time saving for doctors on giving a second opinion	Real time second opinions in paediatrics	Relevant number of second opinion calls; time to search for a paper record; share of FTE doctors
		Time saved by doctors from avoided referrals	Tele-referrals substitute physical referrals	Relevant number of patients and referrals; time saved per incident; share of FTE doctors
		Time saved by nurses from avoided referrals	Tele-referrals substitute physical referrals	Relevant number of patients and referrals; time saved per incident; share of FTE nurses
		Efficiency: avoided hospitalisations	More efficient care due to EHR assisted second opinions - avoided hospitalisation referrals	Relevant number of patients and referrals; average cost short of hospitalisation
		Efficiency: reduced length of hospitalisation	Reduced length of hospitalisation due to faster transfer to home care leads to resources being available for other patients	Relevant number of „Link“ patients; cost of a day of hospitalisation
		Quality: avoided hospitalisations	Avoided hospitalisations as patients treated effectively in primary care	Estimated number of hospitalisations avoided; cost of hospitalisation day
		Cost saving	Budget reduction due to EHRs	Saving reported by county council
	Mental health units	Productivity	Proxy: time avoidance for doctors	Relevant number of patients; average time avoided per patient; share of FTE doctors

Stakeholder group		Benefit indicator	Clarification	Variables
		Efficiency: time saving	Time saving for nurses on searching paper records	Estimated time saved for nurses, FTE nurses
		Quality: patient safety	Avoided prolonged hospitalisation due to reduced risk of adverse drug events	Relevant number of inpatients; estimated probability of adverse events; estimated probability of avoiding adverse events; average cost of hospitalisation
		Reduced length of hospitalisation	Psychiatrists feel safer to release patients when leaving a note to other physicians that the patient has to be readmitted if anything happens	Relevant number of inpatients; length of stay in case doctors cannot discharge early; cost hospitalisation day
		Cost saving	Budget reduction due to EHRs	Saving reported by county council
	Municipalities	Avoided phone calls	Time saving for nurses on care coordination with hospitals	Relevant number of „Link“ patients; number of calls to hospitals before „Link“; estimated number of calls avoided; average duration of phone call; share of FTE municipality nurses
		Avoiding waste	Time saved on visiting a patient at home not knowing that he is hospitalised	Relevant number of „Link“ users in municipalities; average travel time for a home visit; relevant number of patients; share of FTE municipality nurses
		Productivity	Proxy: time avoided to provide all information that is available today via „Link“	Estimated time for organising without „Link“ the same amount of information available today; relevant number of „Link“ users in municipalities; share of FTE municipality nurses
	Pharmacies	Time saving on typing in prescriptions	New paper prescriptions had to be manually entered into the pharmacy system	Relevant number of ordinations, estimated average time saved per drug prescribed (ordination), share of FTE pharmacist
		Fewer disruptions and streamlined care	Proxy: time saving on clarifying hand-written prescriptions through avoided exchange with prescribing doctor	Frequency of phone calls; average length of phone call, share of FTE pharmacist
		Cost saving	On paper prescription forms	Relevant number of ePrescriptions; price per paper form

Stakeholder group		Benefit indicator	Clarification	Variables
	Kronoberg county/regional health authority	Extra income	Better information for management improves the management of healthcare. A proxy for the value is extra income from the national government for meeting quality targets	Expected share of national target budget going to Kronoberg
		Extra income	As of 2009, primary healthcare centres pay rent for hardware	Estimated annual rent income
		Cost savings on travel reimbursement to patients	Patients are granted travel reimbursement for healthcare. This does not have to be paid when consultations can be avoided due to the EHR system, including from more effective teleconsultations at HCC and hospitals, tele-referrals, avoided A&E visits, and avoided visits for tests	Relevant number of avoided primary care visits; relevant number of avoided secondary care visits; average travel cost for a primary care visit; average travel cost for trip to hospital
		Efficiency in primary care	From nurses being able to complete all care during phone calls, without the need for an intervention by doctors	Relevant number of patients and calls; average cost of nurse consultation; average cost of doctor consultation
3rd parties	Swedish social insurance agency	Cost saving	Avoided double prescriptions	Frequency of patients asking for already prescribed drugs; average price of most common double-prescription drugs