EHR IMPACT
European Commission, DG INFSO & Media
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Qualitative report on

The socio-economic impact of the EHR system at NorthShore University HealthSystem, Evanston, IL (Chicago), USA

September 2009

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About EHR IMAPCT

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

Full project title

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

Number and title of deliverable

This report is deliverable D2.3k of the EHR IMPACT study. It addresses the socio-economic impact of the electronic health records system at NorthShore University HealthSystem, Evanston, IL (Chicago), USA from a qualitative perspective.

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The EHR system at NorthShore University HealthSystem, Evanston, IL (Chicago)

Socio-economic impact and lessons learnt

Qualitative report

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Disclaimer

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The study team

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Abbreviations

ADT	Admissions, Discharge, Transfer
AP	(Wireless) Access Point
CEO	Chief Executive Officer
CPOE	Computerised Physician Order Entry
CPR	Clinical Patient Record
ED	Emergency Department
ED	Emergency Department
EHR	Electronic Health Record
EHRI	EHR IMPACT study
EMR	Electronic Medical Record
ENH	Evanston Northwestern Healthcare
GP	General Practitioner
HIN	Health Information Network
HIS	Hospital Information System
HL7	Health Level Seven
ICT	Information and Communication Technology
ICU	Intensive Care Unit
LAN	Local Area Network
MAR	Medication Administration Record
MRSA	Methicillin-Resistant Staphylococcus Aureus
OECD	Organisation for Economic Co-operation and Development
PACS	Picture Archiving and Communication System

EXECUTIVE SUMMARY

Among the roughly 6.000 USA hospitals, *NorthShore* University HealthSystem in Evanston, IL (North of Chicago), formerly known as Evanston Northwestern Healthcare (ENH), is one of the few North American healthcare provider organisations using a completely electronic, fully integrated health record and hospital information system that is built around the patient rather than the provider. The key feature of the system is its ability to function as a comprehensive, state-of-the-art suite of software products that work together in a unified fashion. Its tightly integrated functionality distinguishes the system from many other electronic health record systems. With this *NorthShore* has three of 15 USA hospitals reaching Stage 7 at the top of the HIMSS Analytics "EMR [Electronic Medical Record] Adoption Model" scale in 2008.

With respect to GP systems' diffusion across the USA, the OECD in a recent special "Statement to [USA] Senate Special Committee on Aging" observed, that "up to now, use of ICT in the US health sector has been little short of woeful in comparison with the best performing countries. Australia, the Netherlands, New Zealand, the UK and the [European] Nordic countries have near-universal use of electronic health records (EHR) by GPs which, along with the potential benefits for quality of care, also reduces administrative costs."[1]

It is against this general background, that this case study is set. It illustrates a probably world-wide leading example of good practice in planning, implementing and running a comprehensive, integrated information system allowing four hospitals and about 80 regional GP offices and primary care facilities to cooperate closely, with access to the same information on all their patients. The experience, lessons learned and identified success factors at *NorthShore* are of more or less universal relevance.

By the early 80s, far ahead of most other hospitals or regional systems, adoption of information technology solutions began. Initial clinical ICT applications were for laboratory results reporting, unit clerk ordering and billing. The initiative to implement a comprehensive, interoperable EHR and hospital information system at *NorthShore* derived from the 1996-2001 strategic plan, which stated as its primary goal to become the "best integrated healthcare delivery system in its region."[2] The overall objective was to facilitate a seamless movement of patients between physician offices, hospital inpatient services and ambulatory services by providing physicians, nurses and other staff with access to complete, accurate and current patient data.

After many years of experience with various stand-alone health IT systems, *NorthShore* decided to purchase an *Epic Systems* EMR in 2001, and it started going live in early 2003, a phase mostly completed that year for their then three hospitals in Evanston, Glenbrook and Highland Park. A key aspect to note is that his was not designed as a technology project, but rather as "a clinical project, and ENH launched the project with a full-scale analysis and redesign of all clinical processes. … Early on, the steering committee knew that to succeed, most if not all workflow processes would need to be examined and redesigned. Existing processes were too inconsistent and convoluted to have an electronic system dropped on top of them."[3] It is this clear focus, which dominated strategic planning for three years with no other objectives acknowledged, which is a rather unique feature of this case.

The information system at NorthShore is operational throughout the whole organisation and consequently is used in a wide variety of different healthcare settings. Each of the following services is supported by a modified module of the core system, which was adapted to and extended by additional functionalities to fit the special needs of each service:

[1] OECD (2009): Disparities in health expenditure across OECD countries: Why does the United States spend so much more than other countries? Written Statement to Senate Special Committee on Aging. Paris: OECD, 30th September 2009
[2] Tom Smith et al. (2004): Transforming Healthcare with a Patient-Centric Health Record System. Submission to the Nicholas E. Davies Award of Excellence. Evanston, IL, Dec. 2004, p.4
[3] Ibidem, p.8

- EpicCare inpatient medical record
- Ambulatory Care
- Intensive Care Unit (ICU)
- Care Plans and Critical Pathways
- Nursing Flowsheet Documentation
- Decision Support
- Emergency Department (ED)
- Computerised Physician Order Entry (CPOE)
- Pharmacy
- Medication Administration Record (MAR)
- Patient Education and Support for Care Decisions

The Prelude Registration, Cadence Scheduling and Resolute Billing modules complement EpicCare's clinical and healthcare modules. Together with a NorthShore connect module, they provide a fully integrated, interoperable ICT infrastructure across all the organisation's services, healthcare facilities and locations.

NorthShore's capital and operational ICT costs from 2001 through 2004 were about $35m. In addition, operational expenses for training were 7.5 million during the first three years, involving staff time of about 150,000 hours. When other costs like reduced productivity during change-over are factored in, the overall cost is likely to have exceeded $50m.

Most obvious benefits from the new system are quality and safety improvements for patients, while providing ease of use and greater efficiency among physicians, nurses, administrators and managers. On the financial side, realised cost reductions and financial benefits were estimated at about $12.5m overall per year. *NorthShore* estimates that it realises ongoing incremental savings of $10m per year over incremental IT expenses. *And* it believes that after factoring in the cost of capital, the system has proven its worth. They see a small but positive financial return from the HIS.

But even being at the leading edge of eHealth developments still implies that many documents received from outside the *NorthShore* system need to be scanned so that they can be viewed electronically, but scans are nothing more than images, not computable data. The same applies to dictations or typed notes by its professionals. To fully realise the eHealth vision, it is still needed to transfer this and other unstructured information into discrete data, i.e. in a structured format rather than as free text. And that comes back to better structured workflows. "The art of medicine has to change. It's wasteful if it doesn't," commented *W. Ed Hammond*, MD, professor emeritus at Duke University. "Healthcare in the future is not about physicians. It's about me, the patient." In his opinion, it doesn't matter if it takes the doctor an extra minute to get a piece of information if the information is pertinent to the case at hand. "The whole purpose of this is improving health and healthcare. If we're not doing that, we're doing things wrong."[4] And *NorthShore* has the potential to fully realise these visions in the medium term.

As *NorthShore* is using a commercial system, technological transferability of this case should be possible. Of course, as each hospital and each context will differ somewhat, an adaptation to local contexts will be mandatory. But the component-based architecture should allow such adaptations to be made with relatively low effort. The *organisational* transferability depends as much on the system to be transferred, as on the setting in which it is to be transferred. Here, quite independent from technical details, the planning and implementation approach characterised by strong leadership and commitment by management, by facilitating full involvement of professionals, securing their acceptance and charging them with changing working practices is surely transferable.

[4] Versel, Neil: Rethinking EMRs - Clinical Leaders on the Features Next-Generation Systems Need. CMIO Magazine (http://www.cmio.net/magazine) April 2009:, p. 17.

These enabling conditions point to a relatively high level of transferability of this case to other contexts, not only in the USA but in a wide variety of contexts. The risks associated with an actual transfer seem to be associated more with the receiving side rather than with the flexibility of the overall change approach and system observed at *NorthShore*. It took a combination of high-level, visionary people at the clinical, the technical and the operational level, supported by people who excel in health informatics, to succeed. This combination of people and circumstances is difficult to achieve on purpose.

In summary, the following factors and change management aspects were identified as key contributors to the overall success of this case:

- Strong executive and professional staff leadership right from the beginning of the planning process through to full implementation
- Well-designed, communicated and implemented overall project governance and clearly defined core objectives
- Clearly articulated expectations of behaviour with respect to both training involvement and usage of the new system by physicians
- Physicians, who had the trust of the operations staff, as champions and team leaders of clinical pathway redesign and standardisation
- Comprehensive training programme of 55 different courses for all staff with full support by super-users; only physicians that passed the competency test allowed to access the system. For two weeks from the start of each go-live phase in each hospital, a command centre was staffed 24/7
- Open, organisation-wide and intensive communication processes to engage and commit all leaders, managers and users
- Recognition and rewards to motivate people
- Strong support from technology and IS staff, highly reliable and fail-save system.

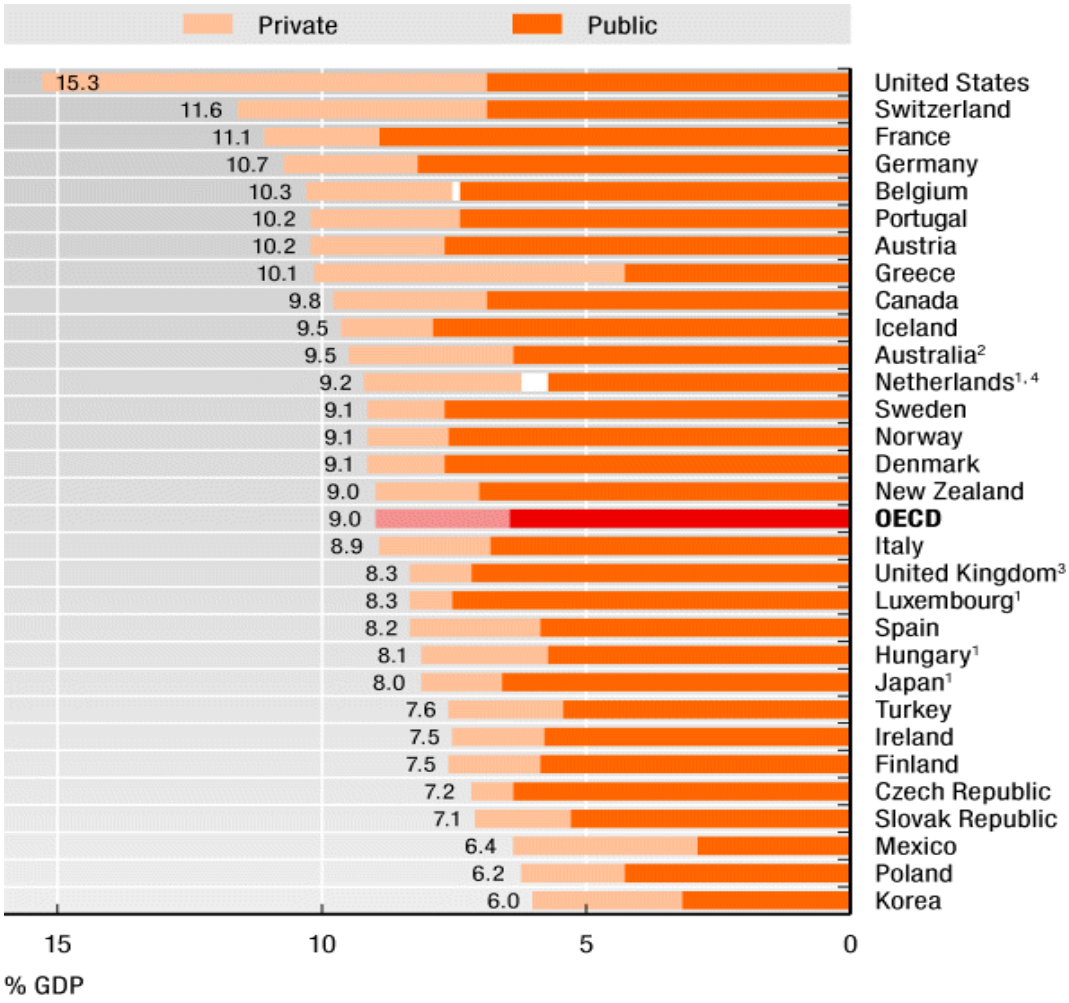
1 Background

1.1 USA health system setting

The healthcare system in the USA is subject to much debate. On the one hand, it delivers some of the most state of the art medical technologies and facilities globally. On the other hand, the USA spends more than any other country on per capita healthcare but still suffers from relatively high levels of uninsured persons, uneven quality of care and outcomes, and administrative inefficiencies.[5]

In 2005, total health spending accounted for 15.3% of GDP in the US, which is the highest share among OECD countries: For comparison, Germany expended 10.7 % of its GDP to health, Canada 9.8 % and France about 11,1%.[6]

Chart 1: Health expenditure in relation to GDP (Source: OECD[7])



Despite the relatively high level of health expenditure in the United States, there are fewer physicians per capita than in most other OECD countries. In 2002, the United States had 2.3 practising physicians per 1000 population, below the OECD average of 2.9. The number of

[5] Kao-Ping Chua: Overview of the U.S. Health Care System, American Medical Student Association, 2006.
[6] OECD Health Data 2005, available from www.oecd.org/health/healthdata
[7] OECD, Health at a Glance 2007: OECD Indicators, available from http://www.oecdilibrary.org/content/book/health_glance-2009-en

acute care hospital beds in the United States in 2003 was 2.8 per 1 000 population, which is also lower than the OECD average of 4.1 beds per 1 000 population. [8]

The U.S. healthcare system is unique in the world because of the dominance of private over public insurance. In 2003, 68 % of non-elderly Americans had private insurance, 15% had public insurance and 18 % were uninsured. Almost all of the Individuals aged over 65 are publicly insured. [9]

Private health insurance is mostly employer sponsored, as employers provide health insurance as part of the benefits package for employees. The majority of the premiums is usually paid by the company with the remainder paid by the employee. They are normally enrolled into private health plans. Some, often very big companies such as General Motors, also self-insure their employees, which means they cover all healthcare costs of their employees directly. The benefits of the privately insured may vary considerably depending on the premium paid, earlier or prevailing diseases, age, etc.

Public Health insurance is based on two pillars: Medicare and Medicaid.

Medicare is a federal programme which covers needy individuals aged over 65. It is administered by government agencies. It is financed by federal taxes and individual premiums. It covers hospital services, physician services and drug prescriptions. There are gaps in Medicare coverage, including coverage for nursing facilities and preventive care, and no coverage for dental, hearing and vision care. Therefore many of the elderly insured by Medicare purchase supplemental insurance.

Medicaid is a programme for low-income and disabled individuals below the age of 65, which includes very poor pregnant women, children, elderly, disabled and parents. Childless adults are not covered, and the eligibility for the programme is such that many quite poor individuals still have too high an income for inclusion into the programme. It is administered by individual states, so there are effectively fifty-one different Medicaid programmes. They are financed jointly by the states and the federal government through taxes. Medicaid offers a fairly comprehensive set of benefits, but due to its low reimbursement rate many individuals with Medicaid coverage have difficulties finding healthcare providers that accept Medicaid reimbursement.

1.2 EHR and hospital-wide information systems in the USA context

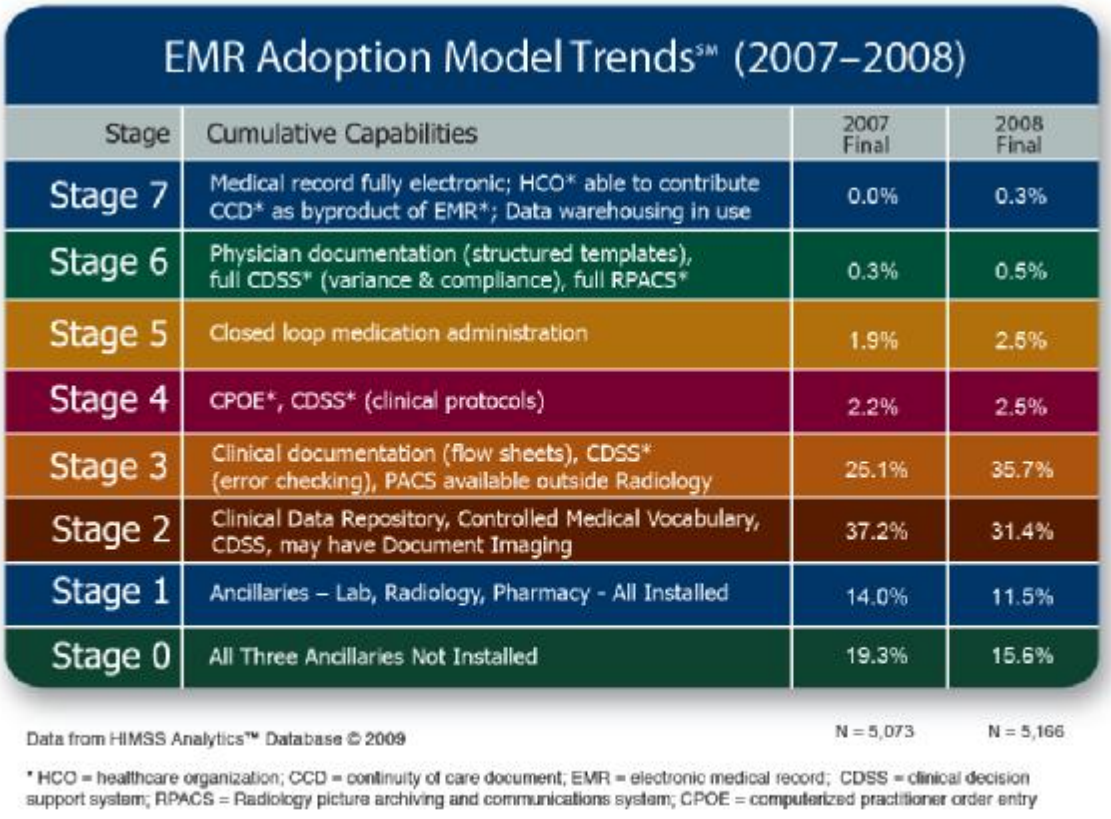
In spite of all the publicity about electronic health record (EHR) and advanced hospital-wide information systems (HIS), their diffusion across the about 6,000 hospitals in the USA is very limited. In a recent acute care hospital survey, based on all members of the American Hospital Association, it was estimated that only about 1.5% of USA hospitals have a comprehensive electronic-record system (i.e., present in all clinical units), and an additional 7.6% have a basic system (i.e., present in at least one clinical unit). Computerised provider-order entry (CPOE) for medications has been implemented in 17% of hospitals. Larger hospitals, those located in urban areas, and teaching hospitals were more likely to have electronic record systems.[10]

The case to be reported about in the following concerns the *NorthShore* University HealthSystem in Evanston, Ill., USA, formerly known as Evanston Northwestern Healthcare (ENH). It has three of the 15 hospitals which reached Stage 7 at the top of the *HIMSS*

[8] OECD Health Data 2005, "How Does the United States Compare", available from http://www.oecd.org/dataoecd/15/23/34970246.pdf
[9] Kaiser Commission of Medicaid and the uninsured: The uninsured and their access to Health Care, available from http://www.kff.org/uninsured/loader.cfm?url=/commonspot/security/getfile.cfm&PageID=49531 (accessed 14-1-2010)
[10] Ashish K. Jha et al. Use of Electronic Health Records in U.S. Hospitals. N Engl J Med 2009 (April 16, 2009);360:1628-38

Analytics scale for 2008 - see Chart 2 below; the other 12 are all Kaiser Permanente facilities in California.

Chart 2: Electronic medical record (EMR) systems adoption trends in the USA (2007-2008)



EMR Adoption Model Trends℠ (2007–2008)

Stage	Cumulative Capabilities	2007 Final	2008 Final
Stage 7	Medical record fully electronic; HCO* able to contribute CCD* as byproduct of EMR*; Data warehousing in use	0.0%	0.3%
Stage 6	Physician documentation (structured templates), full CDSS* (variance & compliance), full RPACS*	0.3%	0.5%
Stage 5	Closed loop medication administration	1.9%	2.6%
Stage 4	CPOE*, CDSS* (clinical protocols)	2.2%	2.5%
Stage 3	Clinical documentation (flow sheets), CDSS* (error checking), PACS available outside Radiology	26.1%	35.7%
Stage 2	Clinical Data Repository, Controlled Medical Vocabulary, CDSS, may have Document Imaging	37.2%	31.4%
Stage 1	Ancillaries – Lab, Radiology, Pharmacy - All Installed	14.0%	11.5%
Stage 0	All Three Ancillaries Not Installed	19.3%	15.6%

Data from HIMSS Analytics™ Database © 2009 N = 5,073 N = 5,166

* HCO = healthcare organization; CCD = continuity of care document; EMR = electronic medical record; CDSS = clinical decision support system; RPACS = Radiology picture archiving and communications system; CPOE = computerized practitioner order entry

HIMSS Analytics™ Database © 2009 HIMSS Analytics

The data in Chart 2 equally underline the very low level of implementation of electronic health record and related systems in USA hospitals.

With respect to GP systems diffusion, the situation is similar. In a recent special "Statement to [USA] Senate Special Committee on Aging" the OECD observed that "up to now, use of ICT in the US health sector has been little short of woeful in comparison with the best performing countries. Australia, the Netherlands, New Zealand, the UK and the [European] Nordic countries have near-universal use of electronic health records (EHR) by GPs which, along with the potential benefits for quality of care, also reduces administrative costs."[11]

It is against this general background, that the following case study is set. It illustrates a probably world-wide leading example of good practice in planning, implementing and running a comprehensive, integrated patient record and hospital information system allowing 4 hospitals and about 80 regional GP offices and primary care facilities to closely cooperate and access to the same information on all their patients. And the authors believe that the experience, lessons learned and identified success factors are of universal relevance.

[11] OECD (2009): Disparities in health expenditure across OECD countries: Why does the United States spend so much more than other countries? Written Statement to Senate Special Committee on Aging. Paris: OECD, 30th September 2009

2 The EHR system at NorthShore

2.1 Organisation involved

NorthShore University HealthSystem (NorthShore) in Evanston, Michigan, is a fully integrated healthcare delivery organisation that offers a very broad spectrum of services to patients throughout the greater Chicago metropolitan area. The organisation consists of four hospitals with around 750 beds and more than 2000 affiliated physicians, including a multi-speciality group practise, with over 80 office locations. It has annual revenues of US$1.5 billion and a total staff of around 8,000, of which more than 200 IT employees.

NorthShore (respectively Evanston Northwestern Healthcare - ENH, its former name) has been mentioned among the 100 top hospitals and 15 top teaching hospitals in the USA 9 out of 10 times in the last 10 years by Solucient, a leading provider of strategic healthcare information.

Its clinical capabilities lie in a wide spectrum of specialties, such as oncology, cardiology, orthopaedics, high-risk maternities and paediatrics. It is a national leader in the implementation of innovative medical technologies. NorthShore is also active as a teaching institution, affiliated with the University of Chicago's Pritzker School of Medicine. It focuses on clinical and translational research, including leadership in outcomes research and clinical trials.

Four affiliated hospitals

Evanston Hospital

The 420- bed hospital in Evanston forms the nucleus of NorthShore. It is a leader in cancer and cardiac care, with strong cooperation between physicians and leading researchers. The hospital serves as a regional centre for high risk obstetrics, offering a comfortable birthing environment for high risk pregnant women with access to latest technology and highly trained staff. Evanston Hospital is also a licensed Level I Trauma Centre.

Glenbrook Hospital

The Glenbrook 143-bed hospital facility offers high-tech medical care in a community setting. It delivers such diverse services as cardiac care, total hip and knee replacement, an eye and vision centre, neurological services, a cognitive and memory disorder programem and a Parkinson's disease clinic.

Highland Park Hospital

Highland Park Hospital is a 239-bed hospital that offers comprehensive subspecialty care for oncology patients and has recently opened a new stroke centre. Additionally, a new wound care centre gives patients access to the most comprehensive wound treatment programme within the Lake Michigan North Shore area.

Skokie Hospital

This hospital was added in January of 2009. It is an acute care, 175-bed hospital with nationally recognized expertise in cancer care, cardiac care and orthopaedics. It also serves as a Level II Trauma Centre which is staffed by experienced trauma team members specially trained in paediatric life support.

Primary and specialty care services

Medical Group

NorthShore Medical Group is comprised of more than 550 employed primary and specialty care physicians throughout Chicago and the north and northwest suburbs of the city, including

a multispecialty group practice, with about 70 office locations. A single unified medical staff is in place for the system. Physicians can admit patients to any of the four *NorthShore* Hospitals.

In addition, about 15 independent physician offices are affiliated to *Northshore HealthSystem*.

Other services

Home & Hospice Services

NorthShore Home and Hospice Services is an integral part of the NorthShore organisation, providing complete continuity of care to patients in their own homes. It is a non-profit agency working with patients, families and physicians to offer personalised care based on individual needs. They follow the same protocols and standards of practice used in their "award-winning hospitals", and clinical staff are available to home-bound patients 24 hours a day, seven days a week.

NorthShore Home and Hospice Services is Medicare certified and CHAP accredited (Community Health Accreditation Program). As part of NorthShore, they have full access to electronic medical records of patients so clinical staff are immediately up-to-speed with patients' medical conditions and history.

Research Institute

Established in 1996, the Research Institute serves as a focal point for more than 1,000 active research projects and over 150 externally funded research faculty. Priority areas for research are medical genetics, cancer, neurosciences, advanced imaging research, cardiovascular, peri-neonatal and outcomes research. Emphasis is on translational and clinical research allowing discoveries from the basic sciences and engineering to be brought promptly to the bedside. Funding from the National Institutes of Health (NIH) places the Hospitals of NorthShore University HealthSystem ninth among the top 10 multispecialty independent research hospitals nationwide.

NorthShore University HealthSystem Foundation

Created in 2003, the NorthShore University HealthSystem Foundation strives to enhance philanthropic support and develop strategies to build advocacy for NorthShore University HealthSystem and the world-class care it provides.

2.2 Origin of the EHR initiative, eHealth dynamic and planned eHealth impact

The initiative to implement a comprehensive, interoperable EHR system at *NorthShore* (then: Evanston Northwestern Healthcare - ENH) derived from the 1996-2001 strategic plan, which stated as its primary goal for *NorthShore* to become the "best integrated healthcare delivery system in its region." The overall objective was to facilitate a seamless movement of patients between physician offices, in-hospital services and also ambulatory services by providing physicians with access to complete, accurate and up-to-date patient data.

Already in the early 80s, far ahead of most other hospitals or regional systems, adoption of information technology solutions began. Initial clinical information technology applications concerned laboratory results reporting, unit clerk ordering and billing. One of the first clinical system for doctors was a system for placing medication orders. However, it was dropped after one year due to low levels of acceptance, because everything else had still to be ordered by using paper form.

In spite of this experience, the Information System Group of the hospital and the Medical Informatics Committee, in cooperation with existing software vendors, started to work towards a fully integrated communications and information system already as of 1996.

By 2000 the information system at ENH included electronic nursing notes, patient vital data, a consolidated results repository and an electronic patient chart after discharge, as well as a complete picture archiving and communications (PACS) system as well as a teleradiology system.

In 2001, the implementation of a comprehensive, interoperable electronic health record (EHR) system including a complete computerised physician order entry (CPOE) solution in all hospitals and 68 own office locations was decided upon. It was not seen as the #1 information system project, but rather as the *#1 and only* corporate goal. And this not only for a single year, but for three years, from 2002 to 2004.

The decision was based on the premise that this implementation would have a huge impact on all of the five strategic objectives of the organisation, which consist of offering the best possible care and clinical outcomes for patients with high levels of patient safety and patient satisfaction, the retention of talented staff coupled with sound financial performance. It was decided to aim for a system with an adoption rate of 100 %, i.e. that every physician and every clinician would use the system - and only the system, i.e. no paper anymore.

The following goals were set:

- Eliminate problems associated with illegible orders and medication errors
- Ensure that everybody has the right patient data at the right time
- Guarantee the accuracy of the information in each record
- Simplify health service processes and make them consistent across the organisation

The financial case for the system was based on projected savings in four areas:

- Billing – lower receivables and higher staffing efficiencies
- Diagnoses - greater coding accuracy
- Medication — fewer medication errors
- Scheduling — centralized scheduling

In the meantime, the system was also deployed to medical practises which are affiliated with NorthShore but not directly owned by it.

2.3 Health services supported

The EHR system at NorthShore has been implemented throughout the whole organisation and consequently is applied in a wide variety of health service situations. Each of the following services is supported by a modified module of the core system, which was adapted to and extended by additional functionalities to fit the special needs of each service.

Inpatient Care

The EpicCare inpatient medical record offers a wide range of functionalities, including patient summary reports with lists of medication and allergies, help for initial assessment, predefined sets for ordering standard procedures and medications, and automated listing of consults and tasks.

Ambulatory Care

Through EpicCare Ambulatory Medical Record ambulatory services are supported with functionalities such as summary of episodes of care, problem list management and support,

computerized physician order entry, results management and communication and medication management.

Intensive Care Unit (ICU)

The functionalities of the core system are extended with fine-tuned, configurable workflows for treatment decisions and a high-density information review.

Emergency Department

The EpicCare Inpatient Emergency department module offers a "mini" patient registration that quickly captures essential demographic and medication information of patients such that the decision on appropriate measures is made faster and treatment is induced immediately. Real-time patient tracking allows for easy status checking of every patient.

A useful reporting tool tracks patient wait times or total ED stay time in relation to acuity, diagnosis, provider, and other parameters.

Pharmacy

The pharmacy module automates hospital pharmacy communication and workflow by coordinating ordering, dispensing, administration, billing and patient management activities. It is integrated within the EHR system and an embedded decision support engine. It delivers timely alerts, guidance and financial support suggestions throughout the whole treatment process.

2.4 Further components and functionalities

The Prelude Registration, Cadence Scheduling and Resolute Billing modules complement the above IT service modules, and together with a NorthShore connect module provide for a fully integrated, interoperable information and communications technology infrastructure across all organisations and locations.

Registration

The electronic tools for hospital ADT (Admissions, Discharge, Transfer), registration and billing already in place before the introduction of the EHR system are continued to be used, but where integrated with the overall HIS and EHR system. This allowed to use a single patient registration number for all care settings as well as shared patient demographics and administrative data.

Scheduling

The scheduling module makes it possible to schedule appointments and procedures from anywhere in the organisation. It provides context specific instructions, validation of a patient's entitlements, extensive date conflict checking and solutions to complicated appointment searches. It offers comprehensive rules based scheduling, which accommodates the needs and availability of each clinician, room, and piece of equipment.

Billing

The billing module tracks physician, anaesthesia and dental billing by entities, divisions, or market, and supports at the same time multiple coverage classes for each patient and includes a library of medical necessity checks.

Computerised Physician Order Entry (CPOE)

The ***C****omputerised Physician Order Entry* (CPOE) module is an electronic tool for the entry of medical instructions and medication orders. It helps to standardise workflows, but at the

same time is flexible enough to accommodate a variety of physicians' requirements. It facilitates entry of orders by offering a variety of tools, such as:

- Preference lists for common medications and procedures
- Predefined order sets for simultaneous selection of multiple orders
- Quick cancel, reorder, and review of existing orders
- Task management that automatically routes orders to work lists,
- Duplicate order checking

Nursing Flowsheet Documentation

The flowsheet module streamlines common tasks such as charting vital data, intake/output, and daily assessment. It offers an efficient structure that makes it easier to document care completely and comply with regulatory demands. The use of documentation navigators ensures that all the relevant data is captured in synchronisation with workflows.

Medication Administration Record (MAR)

The Medication Administration Record is a summary of all medication-related patient information. It is integrated with the CPOE and pharmacy system to produce a dynamic and complete picture of a patient's medication status. New orders and changes of medication are instantly reflected within the MAR. It also provides decision support by providing information on drug interactions, warning of high risk drugs, and alerting nurses when a medication is overdue.

Interdisciplinary Notes

This tool maintains a complete history of a patient's documents in a single location in order to foster communication among caregivers. It provides physicians with specialised documentation templates for any discipline, and intelligent documentation tools for facilitating text formatting and rapid data entry. Extensive sorting, filtering, and searching options help to prioritise notes.

Care Plans & Critical Pathways

The Care Plans module consists of templates that serve as a framework for multidisciplinary care, and together with order sets this module provides support for physicians in order to comply with *NorthShore's* critical pathway guide. The critical pathway guide serves as a best practice guide for predefined encounters. It defines timing and sequencing of care and services, provides decision points in care, identifies expected outcomes, and allows variances from the plan of care to be captured.

Decision Support

The system also offers decision support capabilities for physicians and other caregivers on a wide variety of care aspects like allergies or patienbt-specific aspects like fall risk or potential pregancny.

Patient Education and Support for Care Decisions

This module tracks all patient education activities throughout a patient's stay. It contains specific templates to inform and educate about a problem, diagnosis or procedure. This provides clinicians with an understanding of a patient's knowledge and skill level. A set of 2000 discharge instructions is provided, and nurses can pull relevant discharge medication information for patients to take home.

This module also allows patients to check details of their patient record online or to pay bills, communicate with their physicians, and schedule their own appointments online.

2.5 The system in practice

Although this EHR and HIS system offers a wide range of functionalities to physicians and nurses, its most unique feature is the advanced way in which it integrates all these functions across the whole *NorthShore* organisation. The need for paper-based patient documentation, charting, and handwritten prescriptions was completely eliminated. Each encounter (office visit, phone call, emergency department visit, outpatient visit and inpatient stay) is associated with an individual patient and is documented within his/her EHR. All modules share a common database. Complex patient care scenarios and a wide variety of patient care models across all of *NorthShores* units, departments and locations are easily recorded.

The EHR is accessible from a physician's office, the exams rooms, at more than 6,000 devices throughout the four hospitals, and at remote locations, such as from the physician's home, through the internet. This makes relevant patient information such as problem lists, allergies or medications available for every patient encounter. In this way, clinicians can base their decisions directly at the point o f-care on real-time information.

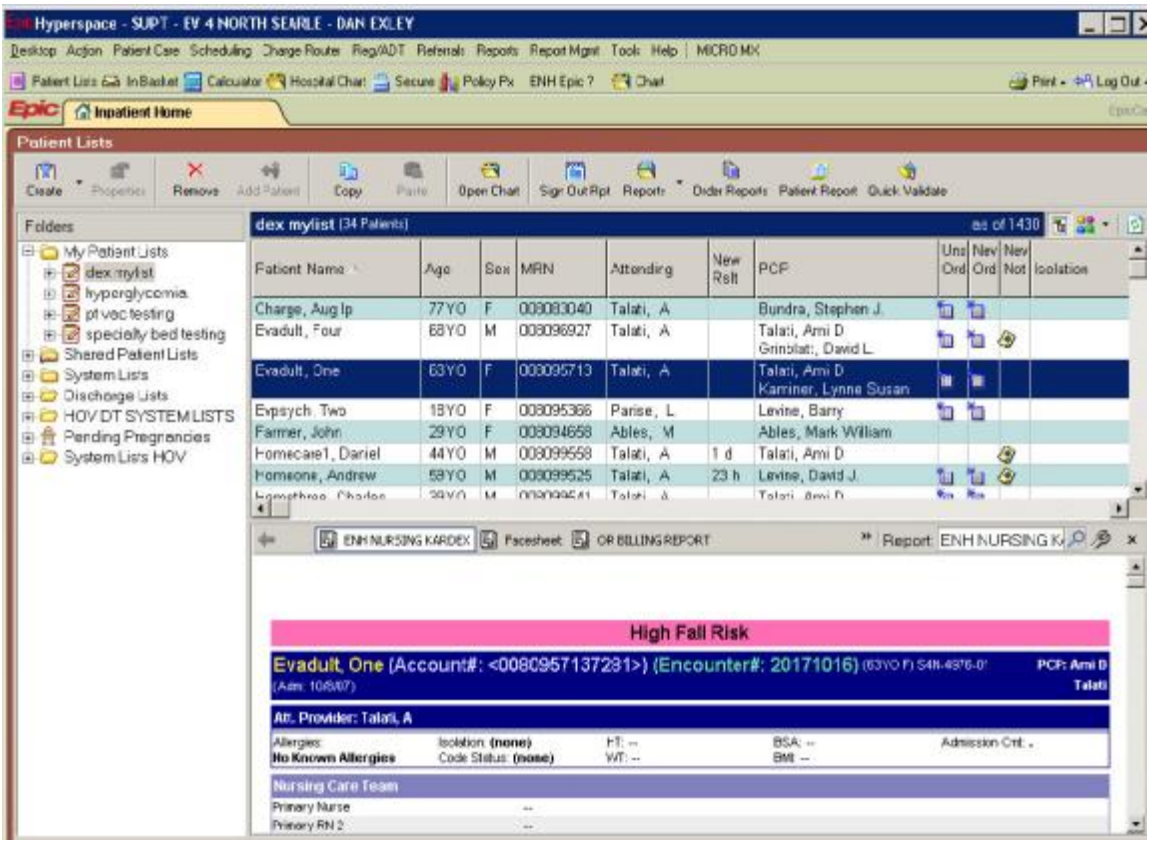
But the system offers much more than a record keeping function. It is used to order tests, view and interpret results, communicate with other physicians and to conduct best-practise care planning.

For example, in 2007, *NortShore* had 100,000 Emergency Department patients, of which 55 % already had a complete record in the EHR system prior to their arrival. This percentage has grown steadily form 45 % in 2004 to 55 % in 2007. This growth is due to annually over 600,000 office visits recorded within the system.

The following Figure 2 shows a doctor using a wireless workstation, and in Figure 3 a screenshot of a patient record view is shown.

Figure 1: A doctor using a wireless workstation

Figure 2: Screenshot of a patient record



2.6 Technology

2.6.1 Overview - architecture

Patient Identification and Data Search

Patient identification is conducted through a master person index, which keeps the database clean by finding duplicate records and actively preventing users from creating them. The system compares a broad sample of identifying information to evaluate patient records. A fast and efficient database management system functions as a high-performance data engine for every application, which optimises individual record searches and record updates.

Data Centre Hardware

The Data Centre runs on selected IBM servers. The system is designed to function 24 hours a day and 7 days a week, with unplanned downtime reduced to an absolute minimum. A system failover model has been installed with redundant servers, storage area network equipment and high availability software. The goal was to build a system that can take a hit to a critical component and recover in an acceptable period of time. For example, a server failure can be alleviated by switching over to a backup system within 15 minutes. In recent years, the data centre had about 99.9% of scheduled uptime.

Network

The Network components consist of:

- 110 Network closets
- 9300 Active LAN nodes

- Data line connections to 26 remote offices
- SONET ring connecting 7 major sites
- Wireless– over 450 Access Point (AP) units

The Wireless network provides the physicians and nurses with point-of-care access to the EHR system. The wireless network is installed in all hospitals and has a coverage of 100 percent.

Access-Points

The system is designed such that the database and applications are run on the same backend servers. Users connect to an application via a web- interface. The actual application is run on a server and not on the devices that are used to access a pateint's EHR. This so-called "thin-client" architecture, where the connecting devices only need minimal computing power is significantly cheaper than a "fat client" architecture based on standard PCs.

Mobile carts bring the chart to the point of care, like the bedside. The carts contain a terminal device connected wirelessly to the LAN.

Remote access from outside of the organisation is available through the Internet. Physicians can remotely perform the same functions as on the nursing floor. In the meantime, more than 1000 physicians uses remote access. They regularly check the status of their patients from their office or from home.

2.6.2 Standards and technical interoperability

Common User Interface and Data Exchange Standards

The EHR system is standardised across the organisation i.e. access to the system and hardware configurations are largely the same. Data Exchange Standards and admission, discharge and transfer (ADT) interfaces are written in accordance with HL7 interface standards.

Data Content and Vocabulary Standards

A data dictionary is used, that acts as an open-access data source. It lists all data fields available in the system with their respective definitions. The user can find out for himself if the data he needs is available for retrieval. This reduces the demand on centralised report writing and accelerates raw data retrieval, because the information needed for this is in the data dictionary.

Communication and Networking Standards

NorthShore has chosen to spent a great deal of time to standardise all networking and server equipment. This limits the number of vendors that the organisation purchases from. Examples are Nortel for networking equipment, IBM for application and database servers, and HP for Citrix servers. This approach reduces incompatibility issues, reduces costs, supports vendor liaison, and testing of new technologies. Purchase of equipment is centralised and coordinated through the IS and purchasing department.

2.6.3 Security and confidentiality

Each user must log on with a user specific ID and password. A specific role and class is assigned to each user, depending on his job function. The specific role and class of the user determines to which part of the system he has access. Additionally, a user can only gain access to that part of the system he has demonstrated his competency through a training programme.

To protect internet access to patient records, a Citrix Secure Gateway and a two factor authentication system was established, supported by a secure SSL 128 bit encryption connection. Each remote user uses a SecurID "key fob" which generates new pass codes with every user login. This enhances the already strong authentication security.

2.7 Level of interoperability

Using a fully integrated system consisting of a multitude of modules as outlined above, the scope of interoperability of the overall system is commensurate with its geographic reach, extending form single sites to the overall regional system as indicated in Table 1:

Table 1: Scope of interoperability at ***NorthShore***

Type of connectivity	Characteristics	***NortShore***
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

Case analysis

A high level analysis based both on a visit to *NorthShore* and on secondary sources is provided in the following. It is concerned with key changes in work processes, the timeline of the endeavour, crucial support in securing wholesale take-up of the changes involved, as well as benefits and costs experienced and recent developments.

2.8 Process change and work flow redesign

2.8.1 EHR implementation as a *clinical* priority

A key reason for the overall success of implementing such a complex system in a relatively short time period was that *NorthShore* regarded introducing the electronic health record and ancillary systems as a *clinical* endeavour involving basic changes in how clinical and other work processes were performed, whereby the various IT systems were considered merely "IT tools" supporting a *clinical* initiative. "This project was a clinical project, and ENH launched the project with a full-scale analysis and redesign of all clinical processes. ... Early on, the steering committee knew that to succeed, most if not all workflow processes would need to be examined and redesigned. Existing processes were too inconsistent and convoluted to have an electronic system dropped on top of them."[12] To each of the seven operational areas involved, a team leader was assigned, as well as a team led by Information Services and a training team. It is important to note that individuals were selected who had *clinical* experience, who had process redesign and performance improvement experience, and - most

[12] Smith et al. (2004). Transforming Healthcare with a Patient-Centric Health Record Systems. Submission to the Nicholas E. Davies Award of Excellence. Evanston, IL, Dec. 2004, p.8

of all - who had the *trust* of the operations staff. This team of team leaders was then charged with overall responsibility for the detailed planning and preparation of the implementation.

2.8.2 End-user involvement

Remarkable is also the overall change management approach: To prepare for its tasks, team leaders and key physician leaders participated in a training class on the capabilities of the new software. With this understanding, team leaders began to redesign workflows throughout the then three hospitals. For three months, they led more than 150 end-users through a complete analysis of the patients and information flow throughout their areas and the organisation. This analysis touched every workflow, and revealed redundancies, workarounds, and hand-offs that significantly slowed the flow of patients and information, and which created numerable opportunities for error. With this insight into current processes, the team leaders worked intensively with end-users to redesign the flow of information and create *integrated* workflows. The result were 500 integrated high level workflows which provided for consistency in managing clinical information across the whole organisation. By now, these 500 high-level workflows have been developed into more than 2,000 detailed workflows. [13]

The high level workflows laid the foundation for the simultaneous development of:

- Deeper, more detailed department and unit workflows
- Policies and procedures to support the new workflows
- Training materials
- System planning and build-up
- Training and support for change management.[14]

2.8.3 Redesigning working practices

Implementing new, IT-facilitated health service chains was based on redesigning all clinical and many administrative processes first, and only then designing and building the new hospital information system (HIS) to support these workflows. It was to reduce hand-offs among entities, care teams and care professionals. Or, in other words, it was to support integrated, seamless services by providing for continuous access to all relevant patient information across all personnel participating in the care delivery process.

Furthermore, physician teams standardised medical documentation and order sets. They built templates to enable electronic documentation by physicians and established standards for order entry. An indication of the success of these templates is that many physicians have discontinued the practice of dictating notes and results, and now enter them directly into the electronic health record. [15]

Various physician groups practicing the same specialty developed more than 1,000 order sets, which are widely used across the organisation, thus also supporting the provision of a consistent quality of care.

Concerning ambulatory care, the ambulatory team developed a basic set of workflows to serve as a model for the by now more than 80 primary care sites. These standardised workflows assure that each office performs critical workflows in the same efficient manner, while allowing for the respective set of physicians, specialties, personnel mix, and physical characteristics at each practice. Organisation-wide registration conventions ensure that equivalent information is collected and entered into the system in the same way. This helps

[13] Ibidem, p. 9
[14] Smith et al. (2004)., p.9
[15] Ibid. p.10.

to establish basic routines from co-pay collection and payment posting to scheduling patients or taking phone messages from patients.

2.8.4 Motivating and safeguarding acceptance by users

A key motivational aspect of both medical professionals and other staff was their full involvement, from the start, in designing, selecting and implementing the EHR system, supported by a very comprehensive, one and a half year training period, complemented by detailed planning, refresher training and instant IT support during the go-live phase. As clinicians were already extensively involved in the redesign of clinical and other work processes, most were eager to transition to the new system. Additionally, all users were well prepared through the extensive and mandatory training sessions finished off by an individual certification process.

Another important contributing factor was that *NorthShore's* management made it clear that they were firm on the decision to implement the system and set ambitious goals for success. This made it much easier to build enthusiasm for the project, as everyone was certain it would come to pass . This would have been different for a project that may or may not move forward.

To gain acceptance from physicians, it also helped that most of them had previous experience with a successful switch to electronic X-rays and medical imaging (PACS) systems. This established a foundation of trust in the decision to implement an EHR system. This prior, positive experience also gave confidence that the system would be reliable, once installed.

2.9 Project history and schedule

Development and implementation of this EHR system project must be seen against the longer-term history of introducing IT systems to support delivery of health services at *NorthShore* (cf. *section 2.1.2* above):

History:

late 70s:	First adoption of information technology solutions
1996-2001	Strategic plan - *NorthShore* to become the "best integrated healthcare delivery system in its region"
1996-2000:	Information System Group and Medical Informatics Committee, in cooperation with software vendors, worked towards designing a fully integrated communications and information system

Project schedule:

2001:	03 - Decision to implement an EHR system; consideration of possible vendors
	08 - Signing of contract with vendor
2002:	04 - Finish of workflow redesign
	06 - Training begins
	10 - Development of interfaces completed
	12 - First use of module for scheduling
2003:	01 - First physician office goes live
	03 - Pharmacy and first hospital inpatient application go live
	07 - Second hospital inpatient application goes live

2003:	12 - Third hospital inpatient applicaiton goes live
2004:	05 - Last "Employed Offices" goes live
	06 - First independent office goes live

Continuing upgrades:

2007	06 - Move to new production data centre
2008	01 - Launch of data warehouse containing EHR, financial, payroll, cost and marketing data
2008	08 - Patient portal can accept patient entered data
2009	03 - Implementation of new hospital billing, health information management (HIM) and admissions, discharge and transfer system

This short review indicates that the EHR implementation project at *NorthShore* had a long "history" -- both in terms of concrete experience with IT systems and as a tool to realise strategic goals of the organisation. With around five years, strategic decision making, planning and high level designing took more time than actual implementation with slightly more than 3 years altogether. And, as at all other sites, implementation is continuing, also here we can observe a continuing, dynamic development of the overall system over time.

2.10 Supporting take-up

Introduction and implementation of the overall IT system went rather smoothly at *NorthShore*. Evidence suggests that this feast was accomplished not the least due to clear and strong executive and professional leadership, an enormous, well-planned training and education effort as well as the dedicated implementation approach supported by a high ratio of support staff to clinical users at this highly critical stage.

Project leadership, governance and user involvement

Whereas *NorthShore* used to set itself for each year several strategic goals to be accomplished, it decided to have for not only one, but for the three years from 2002 to 2004 only one single corporate goal - the successful implementation of the *Epic* system. To provide adequate leadership and governance for such a huge endeavour, it established not only a Steering Committee which included all of *NorthShore's* top leadership, and which met every two weeks to provide overall guidance and oversight, but also a Physician Advisory Committee and a medical informatics department. The duties of the latter were day-to-day management and accountability for the project. The project was run by all as a clinical project rather than an IT project. To this day, the medical informatics department is dedicated to supporting the new system, overseeing upgrades, leveraging new functionalities, and working with operations to adjust and enhance workflow processes as needed.

The Physician Advisory Group has continued to meet after the system was implemented, in order to address new issues arising and recommend enhancements to the EHR system.

Training and Education

A particular characteristic of this case is the a massive, extended training programme undertaken, which not only involved teaching the functionalities of the system, but also introduced everyone to the new workflows.

For around one and a half year, a specific training facility was rented, which provided 13 class rooms. Over 30 full-time and supplemental trainers were recruited and certified. In

addition, on-site training facilities were established at three hospitals and one ambulatory office. Where deemed necessary, custom training courses were offered.

Everybody that was expected to use the system had to complete the training programme and had to demonstrate its ability to use it. Initially, from among overall staff, around 400 so-called super users were trained. It followed detailed scheduling of training for thousands of more users. All physicians had to pass a proficiency test at completion of their training; all other future users were tested by the super users. The typical time it took physicians to complete the program was between 16 to 24 hours. Only physicians that passed the competency test were allowed to admit or to treat patients within *NorthShore's* hospitals. Any staff member is only allowed to access those parts of the system that s/he has been trained on. This extensive first-time user training was later complemented by go-live refresher training and upgrade training.

To motivate personnel, so-called Care Awards were granted for completed *Epic* certification. Furthermore, professional staff dues were waived for one year (2003), and physicians received CME points after successful training. These efforts were supplemented by recognition gifts, testimonials by staff members and others.

Overall, 8 general subjects have been taught, split into 55 different courses. So far, more than 18,000 training encounters by about 11,000 staff, including over 1,300 physicians, have been accounted for. Overall, more than 150,000 hours of training have been offered.

In a new development, in-patient trainers were recently added to the training programme, which provide more than 1500 individual coaching sessions per month to patients to access their data.

Implementation and support

Early into the implementation process, *NorthShore* decided to aim for very rapid and full implementation of the overall integrated system, as it was believed that this offered the greatest assurance to reduce the number of care errors and improve the quality of care. As a consequence, a no-pilot, all-at-once approach was selected to introduce the *Epic* system as quickly as possible. Clearly, earlier experience with IT systems also played a role in this approach.

Hospitals

The goal was to get to only one set of data for each patient as quickly as possible and to reduce the risks inherent with dual systems.[16] For each hospital *Go.Live*, a command centre with 20 to 30 workstations was set up to provide support to end-users. For two weeks from the start of each go-live phase in each hospital, the command centre was staffed 24/7. Additional support staff covered every clinical location in the hospital that was open for business.

Ambulatory offices

For each ambulatory office location, the implementation schedule included a step-wise project plan that began four months before a site's go-live and which allowed for three to five practices per month to become connected. In the first eight months, NorthShore rolled out all primary care sites, including Internal Medicine, Paediatrics, Obstetrics/Gynaecology and Family Medicine. Implementation for the remaining 30 specialties began in the ninth month and continued at the same pace.

Preparation meetings involved office management and clinical staff along with team members for registration, scheduling, billing and the clinical system. Information Systems staff managed the respective security, hardware and connectivity strategy. The training team incorporated plans for training, competency testing, and allocating time to spend in the practice environment. As the go-live dates approached, appointment conversion from the older scheduling systems to the new one was completed. The team conducted dress

[16] Smith et al, p.8

rehearsals to test the planned workflows and hardware from patient check-in through typical office visit scenarios to patient check out. [17]

Critical for the smooth introduction process was the high ratio of support staff to clinical users of one to three for a full month. Weekly sessions with the staff covered any workflow issue that came up, allowed time for expressing frustrations and helped identifying new training topics as needed.

2.11 Benefits

The decision to indeed implement the full Epic system and supporting modules was based on projected benefits and savings expected in four areas:

- Billing — lower receivables and staffing efficiencies
- Diagnoses — greater coding accuracy
- Medication — fewer medication errors
- Scheduling — centralized scheduling [18]

And indeed experience has shown that the system drastically reduced rework and irregularities in everything from a telephone encounter in the office to inpatient medication ordering. The system eliminates the need for the paper-based patient chart, handwritten prescriptions, and much of the copying and rewriting of the same information that occurs with paper-based manual charting systems. Physicians, nurses and all caregivers document all the care they provide directly into the EHR using wireless mobile devices. This greatly reduces miscommunication, redundant tests, human error and handoffs between various members of the clinical team. It also ensures that clinicians make decisions with real-time point-of-care information.[19]

A comprehensive list of all the benefits measured in detail can be found in the report by Tom Smith et al. on *Transforming Healthcare with a Patient-Centric Electronic Health Record System* - Submission to the Nicholas E. Davies Award of Excellence. Here we only summarise some major outcomes.[20]

Patient safety and medication management

As already noted, a key strategic factor for introducing the EHR system was to improve medication management and therewith patient safety. As it turned out, the new system helped to eliminate entire categories of errors and near-misses, including transcription errors, errors due to misunderstood abbreviations and mix-ups due to look-alike drug names. E.g., errors and near-misses caused by transcription errors, which represented 42 percent of total errors before system implementation, were eliminated altogether. Now all physicians directly enter their orders into the system and each medication order is passed directly, without re-entry, to the pharmacy and posted on the electronic medication administration records (eMAR). As another safeguard, the system does not allow physicians to abbreviate medication names.

The system has also reduced delays and omissions in the administration of medications. With the system's eMAR and alerts to nurses, delayed administration of patient medications decreased 70 percent and omission errors were reduced by 22 percent. Transcription errors were reduced to zero. And omitted administrations of medications decreased 22 percent from 18 per month to 14 per month. Verification screens assure the "time out" for right patient, right procedure and right site.

The system also helped to improve the safety of using high-alert medications. E.g., two care providers must independently verify and document the right drug, right dose, right person

[17] Ibid., p.11
[18] bid., p.7
[19] Smith et al, p. 20
[20] Ibid., pp. 45 ff.

and the right programming of an infusion pump. Now new drugs can be added to the mandatory high alert field within minutes by the pharmacist. Alerts were also built in for look-alike and sound-alike drugs, drug interactions and drug reactions.

In order to reduce the risk of nosocomial infections, surgical pathways and order sets were implemented to facilitate the use of evidence-based prophylactic antibiotics in a timely, effective manner; the ICU admission order set has VRE and MRSA screening orders defaulted in. The new system also helped to improve turn-around times for critical drugs: Time from order to administration of first dose antibiotics was reduced from 160 to 80 minutes.

Allergies and intolerances encountered within the past year must be entered before medication orders can be placed for a patient. Drug interactions, duplicate therapy, dose alerts, and allergy alerts are presented to the physician at the time of order entry. If physicians place an order for a non-formulary medication, they receive a list for recommended alternatives. They can select the recommendation or continue with the original non-formulary order. If they do continue with the non-formulary they must enter a reason. For appropriate medications, the dose can be expressed as a weight-based dose. The weight that is used in the calculation of the dose is set up in the system to use actual weight or ideal weight as appropriate for the drug. Furthermore, the system assures that a pharmacist will review all medication orders before a nurse can administer the medication except in true emergency situations.

The Epic-based system and the Pyxis automated dispensing cabinet system are directly connected. If a medication is pulled on override or pulled from a Pyxis Medstation an electronic message populates the MAR for the nurse to chart against. Patient-specific medication orders are electronically transmitted to Pyxis so that the correct product is removed for administration to the patient.

In summary, with the EHR system in place, NorthShore saw rapid gains in several areas. Through a combination of electronic ordering and bar coding for medication administration, medication errors dropped by 80 percent. MRSA infections were reduced by 70 percent, as the EHR red- flagged at-risk patients and recommended them for a genetic test. For patients who needed antibiotics, the time from their first encounter to drug administration was reduced by 50 percent.

INPATIENT AND OUTPATIENT VISITS

Direct benefits to patients and the hospital alike accrue form the fact that the system has shortened inpatient diagnostic and treatment cycles as indicated by shortened length of stay for several diagnostic groupings common to acute care settings. NorthShore estimated that it realized nearly $1m in direct cost savings related to shorter length of stay just between October 2003 and March 2004, i.e. immediately after fully implementing the system.

The number of lost or mislaid patient charts, a chronic health organisation problem, was reduced to zero. In the ambulatory sector, at NorthShore Medical Group practices, the number of paper charts missing when pulling charts often ran as high as 10 percent. Reductions in the turnaround time for ambulatory test results were equally significant. Also here the process redesigns supported by the system's tools produced remarkable results.

An astounding 60 percent of patients visiting the emergency departments at three NorthShore University HealthSystem hospitals in the northern suburbs of Chicago already have medical records in the electronic database, according to CIO Thomas W. Smith. Think about that. For the majority of emergency cases at Evanston Hospital, Glenbrook Hospital and Highland Park Hospital, clinicians don't have to guess when treating someone who's unconscious or count on patients to remember their medication history while sick or in pain. That remarkable figure is the direct result of an Epic Systems EMR that records 600,000 physician office visits a year, in wide use not just with NorthShore's own

Record Accuracy and financial performance

Billing denials and returned mail are both indicators of record accuracy and completeness. With the new system, NorthShore reports that the overall billing denial rate dropped from 23% to 10%. The returned mail rate dropped from five percent to zero percent.

Improvements were also seen in several financial metrics. E.g., the co-pay collection rate increased from 21 percent to 50 percent. Physician office practices used the system's potential to enhance revenue through better charge capture and greater billing accuracy.

Proactive risk management

Another critical benefit aspect is that the system can easily be reconfigured for the near-instant implementation of new safety procedures and performance improvements. E.g., following the result of an unanticipated outcome among patients receiving the pain medication Dilaudid, NorthShore was able to respond immediately with a change in recommended dosages for patients. NorthShore changed all its 32 order sets and 22 preference lists in just three hours. Through the system, it notified every clinician of the change.

Patient satisfaction

Also patients receive benefits from the EHR system. It supports their involvement and concern about the care they receive. If they want, e.g., to know what drug is administered, how many milligrams, who actually ordered it, etc., nurses can double check on their computers, and this clearly makes patients feel more comfortable. In the meantime, the MyChart function, which was installed late in 2004, gave patients online access to portions of their charts and real-time connectivity with NorthShore and their physicians. A further development was the recent implementation of a patient portal which can accept patient-entered data

Retention and recruitment of talented staff

NorthShore also believes that for good reason more and more nurses prefer to work with the support of information technology. The EHR system has eliminated much of the work that nurses enjoy least and that take them away from their clinical duties: photocopying, faxing, rewriting documents, and other time-consuming tasks associated with manual processes. During a drive to recruit 100 nurses, NorthShore advertised and demonstrated the Epic-based system to potential hires. The drive successfully recruited 142 nurses in 100 days.

2.12 Financing, costs and savings

Capital and operational IT costs from 2001 through 2004 were around $35 million. To this have to be added $7.5m in operational expenses for training, and staff time of about 150,000 hours (see section 3.3 above).[21] Considering that these figures do not include other change costs like reduced productivity during change-over, overall costs likely exceeded $50m altogether.

Initially, in July 2001, the then ENH Board of Directors accepted the proposal from senior management to introduce the EHR system and approved a $25 million capital spend for the hardware, software and other resources needed to complete the project. For the 2003-2004 operational budget, they approved additional IT positions to continue the installation and to support the system in the future, as well as funding for ongoing software and hardware maintenance costs.

Whereas the above listed benefits and gains, and others like them, have led to quality and safety improvements for patients, while providing ease of use and greater efficiency among physicians, nurses, administrators and managers may already be regarded as been enough to justify the investment, (additional) financial factors proved - from the view of NorthShore management - the case conclusively.

[21] Using an estimated value of $50 per hour, this would add another 7.5m to implementation and running costs.

In its "Davies Award of Excellence" submission NorthShore provides a very detailed schedule of realised cost reductions and financial benefits associated with the EHR system implementation. Staff-related reductions like those resulting from improved emergency department efficiencies (including dictation expense saved), scanning of documents avoided, greater volume of billable activities with same staff or physician billing office savings amounted to about $8m. Increased hospital charge capture due to being linked to order entry and improved coding edits led to additional revenues of around $2.7m. Service-related savings resulted from reduced dictation costs, other computer systems eliminated or reductions in usage of forms added up to almost $2m, or altogether to overall direct financial benefits of about $12.5m.[22]

"After factoring in the cost of capital, the system has proven its worth. 'We've seen a small but positive financial return from the EMR,' Neaman [Mark R. Neaman, *NorthShore's* president and CEO] says. Those returns mainly come from two sources. ' We've eliminated all of the things such as medication errors that complicate care and cost you money in the long run,' Neaman says. 'And we've also seen improvement in payment cycles because of the improved quality of documentation.'

A third factor, harder to quantify at this point but just as real, is growth. Neaman and Smith noted that about 2 percent of independent physicians initially stopped referring patients to ENH after electronic records were implemented, but referrals from new physicians who wanted to work with EMRs more than made up the difference."[23]

NorthShore estimates that it realises ongoing incremental savings of $10m per year over incremental IT expenses.

For 2009, the operational budget was around $57 million, which amounted to almost 3.6% of annual corporate expenses of 1.6 billion dollars. Both these figures include depreciation dollars from past capital spent

IT capital budget in 2009 was about $14m, or 9% of $160m total capital spent for the corporation. Taken together, almost 4.5% of overall budget was spent on IT, an unusually high figure far above usual averages.

In May 2008 Moody's Investors Service upgraded NorthShore's bond rating to Aa2 with a stable outlook; this concerned $597m of outstanding bonds. Among the arguments were these: "The medical group has grown 10% since 2006. Importantly, Evanston has aligned more closely with the physicians through its advanced information technology strategy, which has enabled electronic medical records and centralized scheduling, among other benefits" … "Evanston has had several years of improving operations, reversing prior operating losses, as a result of growth in the medical group, increasing outpatient revenue and benefits from the system's advanced information technology strategy."[24] This suggests that the new EHR system and investments in IT also contributed to improved standing with investors and thereby to reduced cost of capital when borrowing in the financial market.

2.13 Recent developments

Having successfully implemented the system all across *NorthShore* service locations with full support for clinical and other workflows, the strategic focus shifted in recent years more towards further improving quality and outcomes and less on transactions as such. To assist in such tasks, a data warehouse of all clinical and administrative data is being implemented to assist in these outcomes measurements and their analysis.

[22] Smith et al, pp. 49-50.
[23] Chris Serb: On the Fast Track at Evanston Northwestern - Known for its rapid EMR rollout, the suburban Chicago system looks forward to a future of comparative data. In HHN's Most Wired Magazine, Winter 2008, p. 14
[24] Moody's Investors Service, Global Credit Research, Rating update 23 May 2008, p. 2.

Due to unfortunate experience from smoke setting off an alarm, which impacted severely on the availability of the overall system (in spite of no hardware damage), more focus has also been put on disaster recovery issues.

Another priority has been the improvement and further development of patient empowerment and participation through the patient portal.

On the clinical side, the system is being further developed to move from generic application to more specialized modules for oncology and other clinical specialities.

3 Conclusions

NorthShore's own assessment of the success of implementing the new EHR system was very enthusiastic in 2004: "Overall, the system is a tremendous success. It has been up and running at all three hospitals as of April 2004 and has changed patient care forever at ENH. ENH leadership believes that its approach to management — setting goals from the top and then giving flexibility in their planning to achieve those goals — creates the right environment for total involvement, creative problem solving and reliable results. "[25] When visiting the hospital in 2008 and talking to various staff members, this full engagement, enthusiasm and pride of the results achieved continued be felt. *NorthShore* still has a great potential to improve health services further, and it surely is a very good example of how to successfully plan, introduce and run a complex, dynamically developing EHR and overall hospital information system.

3.1 Future potential

Although NorthShore University HealthSystem in Evanston, Ill., has three of the 15 USA hospitals reaching Stage 7 at the top of the HIMSS Analytics scale for 2008 (the other 12 are all Kaiser Permanente facilities in California),[26] there exists still lots of room for further expansion by applying ICT-facilitated solutions to further streamline and improve healthcare services.

Considering the above mentioned benefits and financial results - which we could not verify - the achievements and improvements of NorthShore from a socio-economic point of view are impressive. It will be essential to continue investment in supporting the changes and developments in order to exploit, e.g., further the new knowledge which can be generated from such a vast data and information resource for planning, organisation, and delivery of services.

A common feature of this, and other success stories, is that the drive for improvement is continuous. The annual net socio-economic benefit from the system at this point in time seems to have reached a stable size and will continue to improve the cumulative position. The real future potential, however, lies in the immediate and planned further developments of the system.

In 2009, they have added a module for operating suites as part of ongoing quality-improvement efforts. Also, much time has been invested to automate Skokie Hospital, which NorthShore acquired at the beginning of 2009, and also connecting ambulatory clinics to the Surescripts (formerly SureScripts-RxHub) ePrescribing network to deliver patient-specific formularies and medication histories to doctors at the point of care. Complete access for all the 550 physicians of the primary care medical group and about 50 outside doctors—and more to come—to all other data of patients treated at *NorthShore* hospitals or clinics is under way, so that referrals are much faster for these physicians than with others from the outside. A plan is also in the works to allow access to physicians outside of the system. Epic offers a product called *EpicCare Link,* a community medical record for affiliated physicians that includes secure messaging and the capability of online consultations. *NorthShore* has been testing it to permit outside physicians to access the health system's scheduling software, enter orders within the hospital and receive results electronically, and a wider roll-out is planned.

[25] Smith et al., p. 18
[26] Versel, Neil: Rethinking EMRs - Clinical Leaders on the Features Next-Generation Systems Need. CMIO Magazine (http://www.cmio.net/magazine) April 2009, p. 16

Nevertheless, still many documents received from outside the *NorthShore* system need to be scanned so that they can be viewed electronically, but scans are nothing more than images, not computable data. The same applies to dictations or typed notes by its professionals. What is needed is to transfer this and other unstructured information into discrete data, i.e. in a structured format rather than as free text. And that comes back to better structured workflows. "The art of medicine has to change. It's wasteful if it doesn't," observed W. Ed Hammond, MD, professor emeritus of biomedical engineering at Duke University. "Healthcare in the future is not about physicians. It's about me, the patient," he said. In his opinion, it doesn't matter if it takes the doctor an extra minute to get a piece of information if the information is pertinent to the case at hand. "The whole purpose of this is improving health and healthcare. If we're not doing that, we're doing things wrong."[27] And *NorthShore* has the potential to fully go into this direction and realise those visions one of these days.

3.2 Transferability

Transferability can and should be examined at several levels. A conclusion of the eHealth IMPACT study[28] was that purely technical components of eHealth are more easily transferred to other contexts than organisational features. And even this does not secure transferability of success, because another key factor is the knowledge, commitment and engagement of the local people and their motivation and interaction.

Usually, *technological* transferability refers to the possibility to install the ICT system in another setting. As *NorthShore* is using a commercial system, transferability should be a reachable goal. Of course, as each hospital and each context will differ somewhat, an adaptation to local contexts will be mandatory. The component-based architecture should allow such adaptations to be made with relatively low effort.

The *organisational* transferability depends as much on the system to be transferred, as on the setting in which it is to be transferred. The healthcare sector is well known for its peculiarities and local specificities in working and clinical practices determined by care professionals, local, regional and state rules and regulations as well as political and various other factors. Here, quite independent from technical details, the planning and implementation approach characterised by strong leadership and commitment by management, by facilitating full involvement of professionals, securing their acceptance and charging them with changing working practices is surely transferable.

These enabling conditions point to a relatively high level of transferability of this case to other contexts, not only in the USA but in a wide variety of contexts. The risks associated with an actual transfer seem to be associated more with the receiving side rather than with the flexibility of the overall change approach and system observed at *NorthShore*. It took a combination of high-level, visionary people at the clinical, the technical and the operational level, supported by people who excel in health informatics to succeed. This combination of people and circumstances is difficult to achieve on purpose.

3.3 What it means for decision makers

The implications for decision makers are numerous and may serve both as encouragement and guidelines. *NorthShore* is another great example of successful investment in a comprehensive interoperable clinical system integrating various elements and modules for storing and managing health data, for supporting ordering procedures, including the prescription of drugs, and for supporting management, workflows, and administrative processes. At the same time,

[27] Versel, Neil:, p. 17.
[28] eHealth IMPACT (2006): Study on economic and productivity impact of eHealth - developing a context-adaptive method of evaluation for eHealth, including validation at 10 sites - covering the whole spectrum of eHealth applications and services. www.ehealthimpact.eu (14-01-2010)

the lessons learned make it clear that success - be it measured in improvements in net cash flow, be it in improved net socio-economic benefits - is by no means an automatic consequence of investments in eHealth.

3.3.1 Useful experience

Five key aspects from *NorthShore's* experience should be useful for decision makers at other healthcare provider organisations in planning and managing investments in interoperable EHR and ePrescribing and comprehensive hospital information systems.

Clinical leadership

Perhaps the most important experience to be considered when learning form this case is the strong and univocal *clinical* leadership of the whole planning sand implementation process. With several of the department chairmen on board, early into the project *NorthShore's* physician leaders passed a rule that physicians would have to use the EMR when seeing patients. No longer paper documentation was allowed, no just asking a nurse to do this for them, or write the information down on a piece of paper and deal with it later.

Also critical was leadership's immediate attention to any concerns, including resistance among physicians. Hospital leadership and the Physician Advisory Group always responded with the attitude that the project was going forward regardless, but that the system could be shaped and changed to meet clinicians' needs.

Workflow redesign

Closely related to clinical leadership is workflow redesign or re-engineering. Implementing new, IT-facilitated health service chains was based on redesigning all clinical and many administrative processes first, *and only then* designing and building the new hospital information system (HIS) to support these workflows. Thus integrated, seamless services were facilitated by providing for continuous access to all relevant patient information across all personnel participating in the care delivery process.

Training

As mentioned already above, an outstanding characteristic of this case is the a massive, extended training programme undertaken, which not only involved teaching the functionalities of the system, but also introduced everyone to the new work flows. This move from file folders to a computer-based system almost overnight required quite a bit of preparation. Each physician had to complete 16 hours of training and pass a proficiency test with a minimum score of 85 percent. Designated so-called super-users walked the floors during respective ward rollouts, and heavily staffed so-called command centres helped each facility through the transition.

CIS versus CPR system

NorthShore is now one of the very tiny minority of USA hospitals using a completely electronic health record system that is built around the patient rather than the provider. The key feature of the system is its ability to function as a comprehensive, state-of-the-art suite of software products that work together in a unified fashion. This tightly integrated functionality distinguishes the system from many other electronic health record systems.

Most of the benefits at *NorthShore* are the result of the combination and interplay between various IT modules and sub-systems. A simple clinical patient record (CPR) system consisting of comprehensive records for each patient as a sum of all available information would most probably not have led to the financial and socio-economic returns observed. The benefits are related to the right amount, kind, and quality of information being at the right time in the right place. A success factor was a comprehensive adjustment and change in work flows, data

access, and data sharing between wards. Thus, a useful EHR system must become a holistic clinical or hospital information system (CIS) and transcend the mere recording of all possible information.

ICT and change

Introduction and implementation of the overall IT system went rather smoothly at *NorthShore*. Evidence suggests that this feast was accomplished not the least due to clear and strong executive and professional leadership, an enormous, well-planned training and education effort as well as the dedicated implementation approach supported by a high ratio of support staff to clinical users at this highly critical stage.

Project leadership, user involvement and the governance structure described in section 3.3 have been a very important aspect of successfully implementing a new EHR system at *NorthShore*. An important feature of the strategy was to use the IT system to not only support, but to fundamentally facilitate the change of process and work flows, i.e. the IT system became a "must have" part of the daily work.

3.3.2 Summary of lessons learnt and success factors

In summary, the following factors and change management aspects can be identified as key contributors to the overall success of the case described above:

- Strong executive and professional staff leadership right from the beginning of the planning process through to full implementation
- Well-designed, communicated and implemented overall project governance and clearly defined core objectives
- Clearly articulated expectations of behaviour with respect to both training involvement and usage of the new system by physicians
- Physicians, who had the trust of the operations staff, as champions and team leaders of clinical pathway redesign and standardisation
- Comprehensive training programme of 55 different courses for all staff with full support by super-users; only physicians that passed the competency test allowed to access the system. For two weeks from the start of each go-live phase in each hospital, a command centre was staffed 24/7
- Open, organisation-wide and intensive communication processes to engage and commit all leaders, managers and users
- Recognition and rewards to motivate people
- Strong support from technology and IS staff, highly reliable and fail-save system.

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