

eHealth in Denmark: A Case Study

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Abstract Denmark is widely regarded as a leading country in terms of eHealth integration and healthcare delivery services. The push for eHealth adoption over that past 20 years in the Danish health sector has led to the deployment of multiple eHealth technologies. However, in reality the Danish healthcare suffers from eHealth system fragmentation which has led to eHealth's inability to reach full potential in delivering quality healthcare service. This paper will presents a case study of the current state of eHealth in the Danish healthcare system and discuss the current challenges the country is facing today.

Keywords Denmark · eHealth · Electronic medical records · Healthcare · Fragmentation

Introduction

Delivering healthcare to patients include a multitude of computer systems and digital tools that collaborate with each other to deliver enhanced services. The deployment of health-related Information and Communications Technology (referred herein as eHealth) is aimed at improving diagnosis and treatment, disease prevention, facilitating patient safety and care coordination, promote better use of resources and reduction in waiting times and treatment errors by exchanging data.

Today a multitude of eHealth technologies have been designed to significantly change the way healthcare is delivered in the health care sector. These include Electronic Medical Records (EMRs), Electronic Health Records (EHRs), telemedicine and e-Prescribing (e-RX).

Over the last years, countries have taken advantage of the technological opportunities and have pushed for the deployment of eHealth in order to achieve less intrusive and more personalised health care. The EU, for example, is experiencing a strong political momentum in advancing e-health solutions for better, safer and more efficient healthcare systems. However, change is difficult to achieve because European health systems are still largely highly fragmented and the EU lacks the competence to regulate healthcare directly. European nations have different perspectives and national programs differ throughout Europe. Some of the European countries lag behind while Denmark, for example, is widely regarded as a world leader in eHealth adoption [1–4].

The country's success stems from over 20 years of incorporating eHealth into the healthcare sector. However, the country's pursuit of achieving a high adoption rate has also resulted in the existence of several eHealth technologies that are unable to fully exchange clinical data. This outcome cannot be solely attributed to care organizations choices of investing into non-interoperable technologies but rather several interplaying factors ranging from the country's highly decentralized administrative structure, 2007 structural reform and national IT strategies.

To address these challenges, Denmark is undertaking a series of national and regional initiatives to develop infrastructures capable of supporting the coordination of care across the entire health sector through the means of the electronic exchange of clinical data.

The purpose of this paper is to present a case study of the current state of eHealth in the Danish healthcare sector and discuss the issues that the country faces today as well as their plans to address these challenges. The results of this case study will have implications for other nations who are interested in following and learning from the Danish model of eHealth adoption.

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Overview of the healthcare system

Denmark is a modern welfare state and the public healthcare system can best be described as a Beverage-inspired system based on general taxation and strong state regulatory influence [5, 6].

The Danish healthcare sector has three political and administrative levels consisting of the following three authorities: the State, the Regions and the Municipalities. It is highly decentralized and the authorities are responsible for making the decisions concerning the healthcare services provided and introducing new interventions [7, 8].

Healthcare coverage is universal, compulsory and is not linked to any insurance scheme memberships for the 5.5 million residents. The 2007 Danish Health Act declares that all registered residents in Denmark are entitled to healthcare services and non-residents are entitled to acute treatment but not to elective treatment. Residents in Denmark receive free access to public healthcare which is largely financed through taxation at the State level. Government financial assistance is also available to fully cover the reimbursement of prescription expenses for chronically and terminally ill patients. Medications and drugs prescribed at hospitals are free at the point of delivery whereas drugs prescribed by GPs are subject to co-insurance. Danish residents can also opt to purchase private supplementary voluntary health insurance (VHI). This form of insurance is organized by profit-making companies and is used to reduce co-payments through reimbursement and to ensure access to the private hospital sector if needed. VHI is paid by the employer and employees are tax-exempted. Complementary VHI is also available for purchase and includes either full or partial coverage for services that are excluded from or only partially covered by the statutory health system. A major provider of complementary VHI is the non-profit-making mutual health insurance association “danmark”.

Current state of eHealth in primary and hospital care

In recent years, eHealth systems have become an integral part in the daily workflow of healthcare practitioners and have become the tool of trade in the primary care and hospital sector. This section describes how both sectors are structured and the role of eHealth.

Primary care

The primary healthcare sector is responsible for general health problems and care. The sector consists primarily of private (self-employed) general practitioners, dentists, pharmacies, specialised practitioner services (i.e. otolaryngologist, ophthalmologists, physiotherapists and dermatologist). There are 3,646 general practitioners and 1,098 specialists. There is a yearly occurrence of 41 million consultations with general

practitioners and 5 million consultations with private specialists' services.

General practitioners (GPs) act as gatekeepers to specialists and inpatient and outpatient hospital care services except in the case of acute illness. They are the first point of contact in the primary healthcare sector and are professionally responsible for referring patients to specialized services (Fig. 1).

In 2004, the GPs union and the Danish Regions signed a contract that mandated GPs to use computers and EMR systems compliant with standards set by the organisation ‘MedCom’ for the purposes of managing patients medication lists, sharing clinical notes, viewing diagnostic images and laboratory test results, and sending reminders to patients. This enabled the GP’s EMR systems to use electronic text-based clinical messaging when exchanging data with the eHealth systems of specialists, pharmacies, laboratories, and hospitals [9]. Financial incentives and technical support have also been used to encourage the adoption of technology in primary care practices. This approach appears to have borne fruit as Olejaz et al. [7] reported that “in 2010, 90 % of all clinical communication between primary and secondary care was exchanged electronically”. As of June 2011, MedCom’s website lists 16 EMR systems used in the primary care sector (Table 1).

GPs are automatically notified when their patients are admitted into the emergency department of a hospital and they receive electronic reports when their patients visit an out-of-hours care centre. However, the primary care and hospital sectors use different EMR systems that are not always fully interoperable, which has meant that some systems are not able to retrieve up-to-date clinical information about a patient [7]. GPs issue prescriptions by using a central database maintained by the National Danish Medicines Agency called the “Receptserveren”.

Hospital care

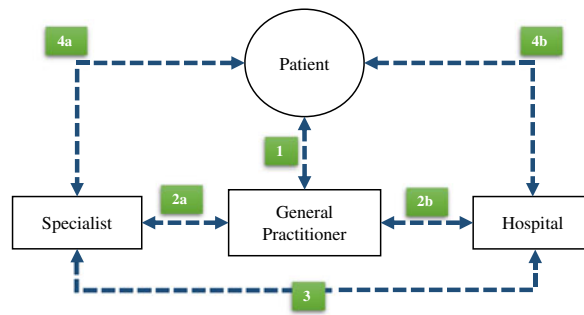
The hospital sector is responsible for providing care for patients with medical conditions that require specialised treatment, equipment and intensive care. Patients reserve the right to choose which hospital they would like to receive their treatment.

Danish hospitals are publicly owned and administered by the five Regions of Denmark. There are 53 public hospitals consisting of 18,303 care hospital beds. In 2010, the number of acute care hospital beds in Denmark was measured to 2.9 per 1000 population [11].

A report published in 2010, revealed that 18 different Electronic Medical Record (EMR) systems were used by the Danish hospitals to register patient data and they differ from the systems used by GPs [7, 12]. As of September 2013, MedCom’s website lists 15 approved hospital EMR systems (Table 2).

The Danish Regions have initiated a series of strategies to reduce the number of hospital EMR systems to a total of four.

Fig. 1 Health service interaction between patient, general practitioner, specialists and hospitals



- 1. Patient visits GP.
- 2a. The GP creates a referral for a specialist visit and exchanges information.
- 2b. The GP creates a referral for a Hospital visit and exchanges information.
- 3. Specialist and hospital communication.
- 4a. Patient and specialist consultation.
- 4b. Patient and hospital consultation.

All hospitals that belong to a particular region use a regional EMR system designated by the regional authority.

Although all hospitals have EMR systems, a report in 2011 revealed that only two hospitals in Denmark have become paperless when storing medical records [14]. The report further stated that hospitals run a dual system where data is both stored electronically and filed in paper form.

Electronic clinical messaging and interoperability standards

A study in 2010 reported that 90 % of GP systems used the EDIFACT standard for text based clinical messaging but a push to migrate towards using XML standards is taking place [9]. Figure 2 displays the average number of EDI Messages exchanged per month. The current flow of electronic clinical messaging in the Danish healthcare system is illustrated

in Fig. 3. There are problems in the structure of the current format when messages are exchanged between different EMR systems. MedCom’s plan to eliminate this involves developing a format which incorporates XML version called FNUX-format (Fælles Nordisk Udvekslingsformat i XML). This will enable GPs to exchange information in a structured form [15]. As of September 2013, only six EMR systems have been approved by MedCom as FNUX compliant.

In terms of interoperability standards, hospitals currently use EMR systems that are based on regional/local models, European pre-standard Health Informatics Service Architecture (HISA), Health Level 7 (HL7), and European pre-standard Electronic Health Care Record Architecture (EHCRA) [17].

Telemedicine

A report published in 2010 revealed that between 2006 and 2009, E-mail consultations between GPs and patients increased from 1.2 % to 4.4 % and telephone consultations declined from 42.8 % to 39.1 % [18].

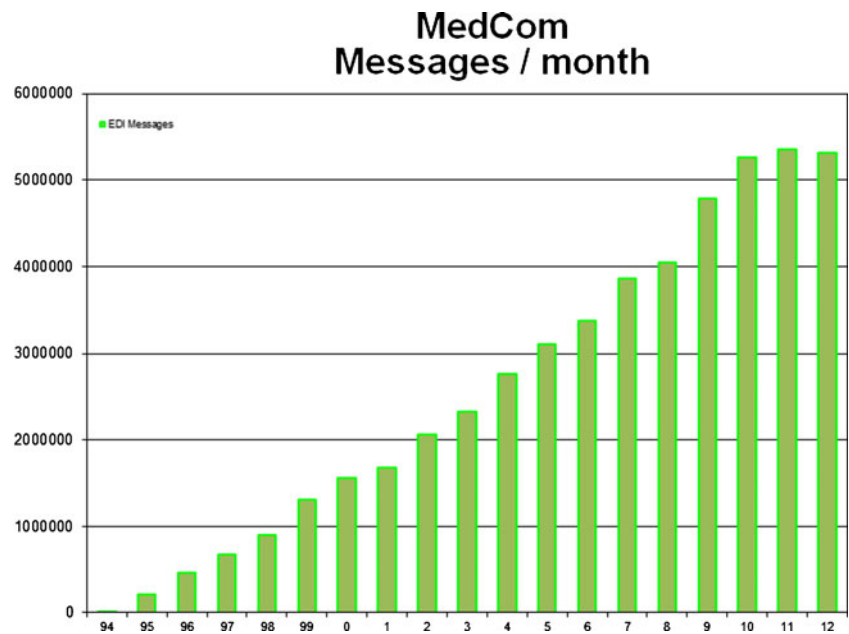
Table 1 Names of EMR systems used in the primary care sector as of June 2011 [10]

EMR Name	Number doctors in the primary care sector using the EMR
CompuGroup Medical XMO	672
MedWin	661
Novax	512
Darwin	203
PLC	214
Ganglion	144
PC-Praxis	130
Emar	241
Docbase	93
MyClinic	53
MultiMed	86
Other	13
Dan-Med-soft	2
Patina	5
Formatex	4
Medol	1

Table 2 Hospital EMR’s approved by MedCom as of September [13]

Hospital EMR Name
Logica, Viborg
ACURE Medicare, Sygehus Fyn
IBM (IPJ), Kolding
CSC Opus Patient/forløb medicin, Sjælland
MidtEPJ Columna/Systematic
FICS Danmark A/S (FICSSAG), Slagelse
ACURE-EPM, H:S
ACURE-EPN, Københavns Amt
Cosmic (Logica), OUH
MyClinic
ACURE-EMS, Ribe
ACURE-EPM, Frederiksborg
ACURE-EPM, Bornholm
GS-Opus, Hovedstaden
Clinical Suite, Nordjylland

Fig. 2 SDN traffic: Average EDI messages exchanged per month (1994–2012) [16]

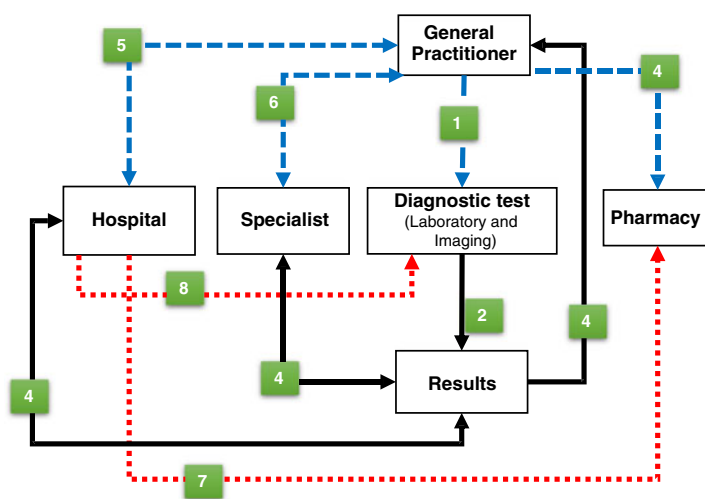


In August 2012, the Danish government funding of a new national *Action Plan for Telemedicine*, which follows the design guidelines set by Continua Health Alliance (CHA). The CHA established the reference architectures and national standards to “ensure the seamless and secure collection, communication and storage of personal health data from patients’ homes to healthcare providers across the country”.

The Danish Regions published their own telemedicine strategy in 2011 consisting of 24 key goals. This includes working on common standards to ensure that telemedicine systems are interoperable with the eHealth systems used by hospitals, GPs and other care providers [19].

Driving forces of eHealth

Denmark’s small population (5.5 million) essentially makes it easier to administer and manage the implementation of eHealth technologies on a national level. The country’s 2007 structural reformation reshaped the administrative landscape of the public sector by creating “larger” municipalities and regions. This involved merging existing municipalities and counties. Prior to the reform, Denmark comprised of 13 counties and 271 municipalities. Today Denmark has 98 municipalities and five “Regions”. The Regions replaced the 13 counties and are tasked with the operational responsibilities for running the health care service.



1. GP orders diagnostic tests (laboratory requisitions and x-ray referrals)
2. Laboratory creates lab reports and/or Imaging departments create x-ray reports.
3. GP creates a prescription order and sends it to the pharmacy
4. Results from tests are retrievable by the GP, Hospital and Specialist
5. GP creates a referral for the hospital. The hospital creates discharge letters.
6. GP creates a referral for a specialist. The specialist creates discharge letters.
7. Hospital creates a prescription order and sends it to the pharmacy
8. Hospital creates x-ray referrals, discharge reports and lab requisitions.

Fig. 3 Flow of Electronic clinical messaging

Since the late 1990s, Denmark has used national IT strategies to create roadmaps intended to guide the country through the process of transforming itself into an ICT-driven society equipped with technologies capable of delivering high quality healthcare services. This is best exemplified when EMR systems were made mandatory for use in 2004 by the Danish Government. Denmark has also embedded a culture of patient empowerment into the society where patients are able to choose their GP and hospital and access their own health records using the internet. All of these enabling factors and tools are described in the following section.

National and regional IT strategies

The Danish government's political objective is to make Denmark a world leading ICT driven nation. National IT Strategies have been established over several years with the purpose of creating a framework to fully 'digitize' the national healthcare service in order to improve patient safety, deliver quality care and improve overall cost savings.

The State and the Danish Regions (Regional authorities) are responsible for achieving these goals where:

- a. The Ministry of Health and its various agencies are the authority for the overall coordination and decision-making of national standards, registers and national infrastructure. The agency "National eHealth Authority" are responsible for developing the relevant common frameworks and standards within eHealth. This includes establishing the standards for communication between sectors.
- b. The Danish Regions manage and develop the eHealth projects for the public hospitals and observe the framework and requirements set by the State. In 2010, the Danish Regions formed by the Regional e-Health Organisation (RSI). The RSI are tasked to coordinate the implementation of the eHealth initiatives in the five Danish regions.

Health information exchange

Several initiatives exist that enable the electronic sharing and viewing of a patient's clinical data. These initiatives include technical platforms, communication standards and health portals. This section summarizes the key initiatives deployed to enable the facilitation of these processes.

1. Sundhed.dk is the public health portal established in 2003 by the Danish Regions, Ministry of Health and Prevention, Local Government Denmark and the Association of Danish Pharmacies. The online portal provides practitioners and residents with a single point of access to information about the health services in Denmark and serves the purpose of facilitating the electronic communication between other care practitioners and patients. Residents can use the

portal to access general health and treatment options, view their medical records, medication history, laboratory results, hospitals visits, book appointments with their general practitioner and renew prescriptions, and access their medication data. Healthcare professionals can use the system to view records and laboratory test results for their own patients.

2. The 'Danish National Health Data Network' (SDN) was established by the organisation MedCom to facilitate Electronic Data Interchange (EDI) communication standards for the messages most commonly used between GPs, hospitals, pharmacies, homecare providers and specialists. This consists of text-based clinical messages such as referrals to hospitals; prescriptions; requests for diagnostic tests; test reports; discharge letters; notifications of discharges to community and home care services and reimbursements.
3. The national prescription server (Receptserveren) enables patients and healthcare professionals to electronically retrieve their prescriptions at any pharmacy through the sundhed.dk portal. GPs are automatically notified when a patient retrieves their prescription from the pharmacy. However, healthcare professionals often "still do not have access to all the information needed to make clinical decisions, especially in emergency care or out of hours", due to the different systems combined "with technical, organizational, and professional challenges" [20].
4. The Shared Medication Record (FMK) is a relatively new central database designed to provide healthcare practitioners with an electronic overview of the patient's current prescriptions and the patient's medication history from the past two years. The FMK was created because GPs and hospitals use different systems to administer e-prescribing and the majority of hospital physicians faced struggles because their systems lacked the functionality to electronically prescribe medications [21]. The data can be accessed by the patients using sundhed.dk and by the physicians and pharmacies that have been authorised by the patient.
5. The National Service Platform is the central communications platform that enables access to national health services, registries and registration solution. All national ICT systems in Denmark have to adhere to the NSP national standards in order to reduce integration problems between the different systems.
6. E-Journal is a system built by the Danish Regions and is designed to extract information from hospital EMR systems from all regions, which will provide healthcare practitioners with an overview of a patient's medical record in relation to a hospital visit. The E-Journal is directly accessible to hospital clinicians through the hospital's EMR system. GPs and citizens have to use the sundhed.dk portal to access the data. Information which

cannot be accessed includes the patients medication record, diagnostic imaging (x-rays) and test results.

Major failed eHealth initiatives

The State has failed on two major occasions to create the following projects: (1) The nationwide specifications and standards for all EMR systems to adhere to (known as the G-EPJ project); and (2) A technical platform (NPI) that would link all the different eHealth systems together. The failures of these ‘major’ projects are described below.

1. **G-EPJ Project:** In 2001, the National Board of Health attempted to address interoperability problems by developing specifications for all EMR systems to adhere to in order to facilitate the full clinical exchange of information between systems [22]. Unfortunately, the requirements specified by the State were too problematic to integrate into the existing hospital EMR systems and staffs existing workflows. The G-EPJ project was eventually abandoned in 2006 [23].
2. **National Patientindex:** In 2011, the Danish National Board of e-Health (National Sundheds-IT) initiated its plans to develop a technical platform called the National Patient Index (NPI). The NPI purpose was to link all health-related information systems in Denmark together by 2013. This included the Shared Medication Record, EMRs, public registers, etc. [24, 25]. After investing more than \$2.8 million into the project, it was officially abandoned due to several delays and the outcome of a business case evaluation stating that it was not a feasible project [26].

Discussion

Denmark’s push for eHealth technologies in the healthcare system through the enactment of policies and development of technological infrastructures has resulted in a high level of ICT usage in the care sector. On the other hand, the outcome of this strategy has resulted in several struggles to deliver quality healthcare services due to fragmentation.

The lack of coordination and a decentralized approach by the State resulted in the deployment of multiple EMR systems in both the primary care and hospital sector. The rapid adoption of EMR in 2004 led to the failure of the systems to communicate and transmit clinical data, for example into an electronic health record.

Although MedCom provides the service of EDI clinical messaging, the different EMRs used by primary care and hospital sector are not fully compatible due to limitations of the current structural format to exchange data. The lack of interoperability has led to several events where patient’s health have been put at risk due to the physicians inability to retrieve

their clinical information such as the medication history [27]. Studies have shown that the lack of ability to share information led to several readmissions for chronically ill patients [28]. The outcome is concurrent with studies that have researched the effect of missing clinical information which showed that patients may be adversely affected if doctors lack information to administer the proper treatment, prevent avoidable drug interactions, reduce duplication of diagnostic testing, minimize missed or delayed diagnoses [29, 30]. Without the capability to fully exchange all clinical information, the current EMR limitations will prevent Danish practitioners in making informed clinical decisions and therefor put patients’ lives at risk.

The 2007 structural reform played a critical role in the case of EMR fragmentation due to its effect on the hospital sector: the National Board of Health decided to reduce in the number of acute care hospitals from 40 to 25; and (2) the regional authorities had to reorganise their hospital systems, close small hospitals, merge hospitals together and build new hospital infrastructures. At this point of time, there may already have been up to 40 different hospital EMR systems in use with interoperability problems, which explains why the State had initiated the G-EPJ and NPI projects.

The failure of the G-EPJ and NPI systems reveals that the Danish Regions have lost trust in the State’s ability to use resources properly in attempting to address problems. The Danish Regions have chosen to take full control of their own eHealth projects and pursue the development of a common hospital EMR system within their respective region rather than establishing a common hospital EMR system for the entire nation.

Another negative side-effect of the aggressive push for eHealth systems has led to disruptions in practitioners’ workflow. The mobile nature of healthcare work requires practitioners to continuously access multiple workstations within the same care organization institution which requires them to repeatedly sign-in several times during the day and frequently update their passwords [31]. To save time, healthcare practitioners share passwords and do not sign out of a workstation in order for others to use it [32]. Clinicians may have chosen to use this approach to counter the effects of frequent password changes which increases the burden on human memory [33]; decrease the likelihood of recalling a specific password when the number of passwords they have to remember increases [34]; and (3) are only able to remember up to five unrelated passwords [35]. Even though there is a sense of urgency for practitioners to quickly access the patients’ medical records, the current practices of sharing passwords and failing to sign out of workstations have compromise the security and privacy of a patient’s sensitive information. At the same time, it makes it difficult to perform audit trails and determine the identity of the person accessing and editing the medical records. This means that the way in which

data breaches occur become more difficult to prevent and track. Data breaches can create a real risk of significant harm. Denmark has so far been fortunate in this matter as the 2010 Annual Report by the Data Surveillance Board indicated that only 4 % of reported breach cases were related to the health sector (medical companies, clinics and physicians) [36].

Why four hospital EMRs?

The issues highlighted in the preceding section raise the following question: Why aren't the Danish Regions combining resources to invest into a common hospital EMR system, instead of working with different vendors to implement individual systems?

Their decision making process may be due to: (1) the decentralized setup of the Danish healthcare system; (2) the conclusion that increasing vendor competition would improve the quality of the end-product; (3) the elimination of a single vendor having monopoly of the Danish hospital EMR market; and (4) fear of repeating previous major IT failures that were designed to be a common national solution such as the infamous and costly 'Amanda' system [37].

In particular, the last reason may prove to be the strongest arguing point as evidences from attempts to implement projects on a national level associated with small scale implementations experienced the problems seven-fold [38]. The Regions approach could inadvertently limit any potential financial damage of a failed common EHR system project such as what was seen in the United Kingdom. The UK abandoned implementing a nationwide EHR after already having invested £1,4 billion on it since 2002 [39, 40]. Cresswell's et al. [41] study of the UK's EHR project concluded that "implementing EHRs in an ongoing process and needs to be expected to continue in line with changing local and national needs as well as political landscapes" and that "appropriate time and resources need to be allocated nationally to allow the process of local accommodation to occur. Centrally negotiated contracts may inhibit these desired developments."

A nationwide solution is not simple matter of replicating a case of successful EMR implementation. Coiera [42] emphasizes that "building national healthcare IT systems involves defining a policy and standards framework that can shape the convergence of public and private, local and central systems into a functional national system."

Denmark could potentially end up having four 'successful' hospital EMR systems. The subsequent challenge would then be to develop the infrastructure to interlink the technologies so that they are capable of fully exchanging clinical data without any limitations or loss of data.

One could argue for or against Denmark's choice not to pursue a national EMR for all hospitals. Should Denmark learn from the pitfalls of the British experience and attempt a

national solution or continue developing regional EMRs at the risk of compromising the exchange of clinical data and fuel fragmentation?

Another nation that opted to launch a National Electronic Health Record System (NEHR) is Singapore, which is comparable to Denmark in terms of population (5.1 million) and ICT integration. Their goal is to have all public healthcare institutions, selected community hospitals and GPs on the NEHR system by 2012. The first phase of the NEHR went live in 2011 and the second phase is expected to last from 2012 through 2015. The NEHR enables a single patient health record for clinicians to access across the healthcare continuum. The NEHR system is available to all public healthcare institutions (comprising eight restructured hospitals, eight specialist centers, and 18 polyclinics), five community hospitals, two nursing homes, a hospice, selected general practitioners (GPs), and users from the Agency for Integrated Care (AIC) [43]. Denmark and Singapore will be interesting nations for other countries to follow in terms of contrasting the outcome of their respective approaches to implementing EMRs.

Other issues that could increase fragmentation: Private hospitals, clinics and extended free choice hospitals

There is an increasing number (249) of private hospitals and clinics in Denmark, which is an increase of 42 % from 2006 to 2010 [44, 45]. The majority of the patients (31 %) were admitted into the private hospitals after having received referrals in accordance with the "Extended Free Choice of Hospitals", a legislative act which gives patients the right to receive treatment at a private hospital or foreign hospital if the waiting time for treatment at a public hospital exceeded 1 to 2 months. Private insurance also played a role as private insurance constituted 28 % and privately-financed patients constituted 18 %. In 2010, the expenditures for operations were financed by patients (11 %), the patients region of residence (64 %) and private insurance (25 %) [44].

Taking into the account that there are only two common EMR systems linking the public and private hospitals according to the MedCom's website, the likelihood for non-interoperability and the limited exchange of clinical data could increase. As the number of patients being admitted into the private hospitals increases, so is the likelihood of the patients' health records being scattered across different organizations which are unable to electronically exchange clinical information.

Examples of fragmented eHealth impact: Cancer patients

There is some evidence that Denmark's current eHealth systems have led to failures in providing timely treatment to patients such as those afflicted with cancer.

Previous studies have reported that this may be due to poorly structured clinical pathway that resulted in long waiting between the different stages of treatment [46, 47] and the GP gatekeeping system where Danish citizens have a poorer cancer prognosis than citizens from other countries [48].

However, there are reported cases that show that the delays of cancer treatment were due to healthcare practitioners being unable able to electronically receive and access the cancer patient's data.

In one case, a cancer patient's information got "lost" three times between hospital departments. His treatment was delayed and when the patient was offered chemotherapy, he was already too weak to receive the treatment and died shortly afterwards [27]. The Danish Health and Medicines Authority reported that there had been 26 cases during that quartile due to failure of transferring the appropriate clinical documentations. Both chairman's of the Danish Medical Association and Danish Nurses' Organization directly blamed the healthcare services failure of transferring patient records to the many EMR systems [49].

In a recent case demonstrating fragmentation of the EMR system, a female cancer patient was interviewed about her experiences. In November 2012, the patient was referred to a gastroenterologist. The gastroenterologist sent an electronic referral for an MRI scan at Gentofte hospital where patient was a resident. Gentofte hospital replied that they do not have an MRI and that the patient should be sent to Herlev hospital. The gastroenterologist arranged for Gentofte hospital to forward the referral to Herlev hospital. Gentofte replied one month later that they had "lost" the patient's paper and electronic records. The patient returned to the gastroenterologist, who issued another referral request in early January 2013 for an MRI at another hospital (Bispebjerg) in the Region. After more than 2 months of waiting, an MRI scan took place in late March. The scan found metastatic cancer and a tumour pressing on a vein that would have led to a fatal blood clot in the brain. Bispebjerg claimed that they relayed the information to the patient's GP for urgent care. In Denmark, urgent action within 14 days is required if cancer is detected the results of the tests. However, the GP did not receive the results of the MRI scan electronically, by post or by phone. The result was only accidentally discovered when the patient phoned her gastroenterologist 2 weeks after the MRI test. The gastroenterologist had just received the scan result. A CT scan was requested and within 14 days, the test was conducted. Two days after the CT scan, Bispebjerg hospital claimed that the hospital had tried to contact the GP both electronically and by telephone since the early morning because the CT scan confirmed that the patient was in an advanced stage of cancer (4b) development. After futile attempts, the hospital contacted the gastroenterologist. Because the patient did not belong to the Copenhagen

commune, the patient's case was transferred to the Gentofte hospital which contacted the patient immediately and scheduled an early morning appointment within two days of the call. The patient then informed her GP who claimed that he did not receive a phone call or electronic records of the CT scan. When the patient arrived at Gentofte hospital at the scheduled time, the records of the patient could not be found. It took 5 hours of frantic search and communication before her eHealth records were retrieved. A CT scan and biopsy test were conducted. The patient was referred to Herlev Hospital for treatment and appointment with the Oncologist two weeks after the tests. During the hospital consultation with the Oncologist, the doctor tried to electronically retrieve the data (CT scan) but discovered that it was still not made available in her computer due system problems.

This particular case, demonstrates that patients records and clinical data are lost when forwarded electronically between different healthcare practitioners. Patients are not contacted under urgent matters for cancer diagnosis. The implications of this incidence illustrate that the fragmentation of eHealth systems is a cause for cancer diagnosis and treatment delay due to poor interoperability between the GP, specialists and hospital systems.

Lessons for other nations

Denmark's health care IT system is rated as one of the most efficient in the world. Other countries which are seeking to rapidly increase eHealth adoption can learn from the Danish experience in healthcare. In order to improve their health care systems, countries must not only review and assess their performance but also their neighbours' health care system. Denmark offers many lessons that can help other organizations save time and improve efficiency.

Denmark's transition to electronic health record is not seamless. It has been accomplished by evolution rather than revolution of the systems.

Denmark has implemented national-level strategies to coordinate health IT adoption. Denmark stands out for having the national vision to adopt eHealth even before other countries dared thread the path. An important lesson to be learned is that long term goals need to be defined from the outset, but need to be regularly reviewed and adapted as user needs and technology change. The Danish success can be attributed to its clear goals, and commitments as they learn from their past failures and success.

This strategy is needed to ensure that resources are invested wisely and through careful planning in larger scale projects to reduce the risk of delays and failures. This can be done by conducting business case evaluations early in the project to examine the feasibility of a national ICT project prior to investing large sums of money on development and then

eventually abandoning the project. An evolutionary process allows for inevitable mistakes and failures to be corrected faster and at lower costs. Sustainable eHealth necessitates continuous investments over time.

An infrastructure needs to be created to support Health Information Exchange and ensure that all systems adhere to the required interoperability standards. These systems need to be able to fully electronically exchange clinical data using a messaging format such as MedCom's new XML format that ensures data arrives complete and properly structured. All systems need to undergo testing for approval for certification prior to entering the market to ensure that they fulfil the messaging requirements.

Denmark does not have nationwide EMRs. Instead, there are multiple providers of software to choose from. The key is to ensure that the systems communicate and work together. The Danish Health Data Network (Medcom) acts as a data integrator to ensure interoperability. It facilitates effective data transfer between several actors of the health service and allows fast information flow in form of reliable data exchange among the respective software systems of the participating healthcare providers. A permanent national infrastructure with adequate expertise is thus critical for the national eHealth strategy to succeed.

The market plays an important role in setting new standards as software providers develop new solutions to technical problems that have been encountered. Setting data standards and specifications is essential. Regular involvement and communication with the software industry plays a key role for assuring interoperability of the systems.

The strength of having multiple EMRs is also Denmark's weakness. Getting the electronic record systems to talk to one another is still a challenge. Making the systems interoperable has still not been fully resolved.

An important lesson learned by the Denmark is the realisation of the need to create National IT Strategies with stricter guidelines and policies that limit the number of eHealth systems permitted per region. This would reduce the potential of several non-interoperable systems being used in the health sector. Denmark's current strategy is to reduce the number of EMR's to one common system per region and to strengthen national standards. The ultimate goal is the convergence of the local systems so that all information on the database can be accessed in one place by medical providers.

As Denmark continues to grind forward, it will most likely make more significant eHealth progress as it strives to build the best e-health care system possible.

Limitations

The study has some limitations. Some of the data sources found were based on publicly available information retrieved from Danish governmental websites and were written in

Danish. Bias in the data analysis may have been introduced as some of the information is limited to official material published by the Danish authorities. Further studies are required to examine the in-depth perspectives of healthcare practitioners, policy makers and patients regarding the current and future deployment of eHealth in Denmark.

Conclusion

Denmark's healthcare system and use of eHealth may be regarded as excellent in terms of world standards. However, this case study reveals that the country still has room for improvements as Denmark suffers from EMR fragmentation as a result of the State's failure to issue any common standards for interoperability and a technical platform to ensure health information exchange.

On the surface Denmark may appear to be leading the pack in high adoption and usage rates of eHealth but the reality is that the Danish healthcare system faces several challenges that impede its ability to deliver quality healthcare services. eHealth when rushed does not provide a cure for a fragmented system. In spite of its flaws, the country's system is thriving and learning from its mistakes.

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References

1. Bhanoo SN (2010) Denmark Leads the Way in Digital Care. *The New York Times*
2. Harrell E (2009) In Denmark's Electronic Health Records Program, a Lesson for the U.S. - TIME. *TIME Magazine*. Time Inc.,
3. Economist (2011) Future-proofing western Europe's healthcare. A study of five countries. *Economist Intelligence Unit*
4. Dobrev A, Haesner M, Hüsing T, Korte WB, Meyer I (2008) Benchmarking ICT use among General Practitioners in Europe. *European Commission, Information Society and Media Directorate-General*
5. van der Zee, J., and Kroneman, M. W., Bismarck or Beveridge: a beauty contest between dinosaurs. *BMC health services research* 7: 94, 2007. doi:10.1186/1472-6963-7-94.
6. Strandberg-Larsen M, Krasnik A (2008) Does a public single payer system deliver integrated services? A national survey study among professional stakeholders in Denmark, vol 8. 2008, vol 5. *Igitur*.
7. Olejaz, M., Nielsen, A. J., Rudkjøbing, A., Birk, H. O., Krasnik, A., and Hernández-Quevedo, C., Denmark: Health System Review. *Health Systems in Transition* 14(2):1–192, 2012.
8. laegemiddelstyrelsen (2012) Danish healthcare sector at a glance. Danish Health and Medicines Authority. http://www.sst.dk/English/The_Danish_healthcare_sector. Accessed 10 Oct. 2012

9. Protti D, Johansen I (2010) Widespread Adoption of Information Technology in Primary Care Physician Offices in Denmark: A Case Study. *The Commonwealth Fund*
10. MedCom (2013) Lægesystemer i Danmark. MedCom.dk. <http://www.medcom.dk/wm109996>. Accessed Sep 19 2013
11. OECD Health Data 2012 (2012) <http://www.oecd.org/els/healthpoliciesanddata/oecdhealthdata2012.htm>. Accessed 15 November 2012
12. RSI (2010) Udviklingen i regionale epj-landskaber 2007–2010 (trans: Sundheds-it RR). RSI: Regionernes Sundheds-it, vol RSI: Regionernes Sundheds-it. NextPuzzle ApS, Copenhagen
13. MedCom (2013) Sygehus-epj-systemer. MedCom.dk. <http://www.medcom.dk/wm111413>. Accessed Sep. 19 2013
14. Rigsrevisionen, *Elektroniske patientjournaler på sygehuse*. Rigsrevisionen, Copenhagen, 2011.
15. MedCom (2012) PLO-XML-/FNIX-format. MedCom.dk. <http://www.medcom.dk/wm111572>. Accessed 20-Sep 2013
16. Medcom (2013) MedCom Messages per Month. MedCom. <http://www.medcom.dk/wm110000>. Accessed 20 Sep 2013
17. Electronic Health Records: A Global Perspective. A Work Product of the HIMSS Enterprise Systems Steering Committee and the Global Enterprise Task Force. (2008). Healthcare Information and Management Systems Society (HIMSS).
18. Det digitale samfund 2010 (2010). IT- og Telestyrelsen,
19. RSI (2011) Telemedicinstrategi.
20. Rudkjøbing A, Olejaz M, Birk HO, Nielsen AJ, Hernández-Quevedo C, Krasnik A (2012) Integrated care: a Danish perspective. *BMJ* 345. doi:10.1136/bmj.e4451
21. Boysen, M., Hospitalslæger har svært ved at håndtere recept-server. *Dagens Medicin* 02(11):2010, 2010.
22. Beskrivelse af GEJ—på begrebsniveau (2004). National Board of Health,
23. Aanestad, M., and Jensen, T. B., Building nation-wide information infrastructures in healthcare through modular implementation strategies. *The Journal of Strategic Information Systems* 20(2):161–176, 2011. doi:10.1016/j.jsis.2011.03.006.
24. Nationalt Patientindeks. (2012) National Sundheds-it. <http://www.ssi.dk/Sundhedsdataogit/National%20Sundheds-it/National%20Patientindeks.aspx>. Accessed 19 Sep. 2012
25. National-Sundheds-it (2012) What initiatives have we launched? National Sundheds-it. <http://www.ssi.dk/English/HealthdataandICT/National%20Board%20of%20e-Health/What%20initiatives%20have%20we%20launched.aspx>. Accessed 19 Sep. 2012
26. Lund, S. R., Staten ramt af ny it-fadæse. *Kommunen* 19(05):2013, 2013.
27. Jyllands-Posten, Livsfarligt rod i patienters journaler. *Jyllands-Posten*, 5(Dec.), 2010.
28. Drevsfeldt S (2010) Kroniske patienter mangler oplysning og indlægges oftere. *Information.dk*, 3. August 2010,
29. Smith, P., Araya-Guerra, R., Bublitz, C., Parnes, B., Dickinson, L., Vorst, R. V., Westfall, J., and Pace, W., Missing clinical information during primary care visits. *JAMA* 293(5):565–571, 2005. doi:10.1001/jama.293.5.565.
30. Elder, N. C., and Hickner, J., Missing clinical information: The system is down. *JAMA* 293(5):617–619, 2005. doi:10.1001/jama.293.5.617.
31. Christiansen, M., and Nøhr, C., *Undersøgelse af klinisk anvendelse af sundheds-it-systemer 2011 (trans: Informatics VC/H)*. Aalborg Universitet, Aalborg, 2012.
32. Region-Syddanmark (2012) Strategi og arkitektur for Effektiv Systemadgang. Region Syddanmark
33. Stanton, J. M., Stam, K. R., Mastrangelo, P., and Jolton, J., Analysis of end user security behaviors. *Computers & Security* 24(2):124–133, 2005. doi:10.1016/j.cose.2004.07.001.
34. Vu, K.-P. L., Proctor, R. W., Bhargav-Spantzel, A., Tai, B.-L., Cook, J., and Eugene Schultz, E., Improving password security and memorability to protect personal and organizational information. *International Journal of Human-Computer Studies* 65(8):744–757, 2007. doi:10.1016/j.ijhcs.2007.03.007.
35. Adams, A., and Sasse, M. A., Users are not the enemy. *Commun ACM* 42(12):40–46, 1999. doi:10.1145/322796.322806.
36. Datatilsynet (2011) Datatilsynets Årsberetning. .
37. Prosa (2008) It-kirkegården. <http://www.prosa.dk/aktuelt/nyhed/artikel/it-kirkegaarden-1/>. Accessed 1 May 2013
38. Robertson A, Cresswell K, Takian A, Petrakaki D, Crowe S, Cornford T, Barber N, Avery A, Fernando B, Jacklin A, Prescott R, Klecun E, Paton J, Lichtner V, Quinn C, Ali M, Morrison Z, Jani Y, Waring J, Marsden K, Sheikh A (2010) Implementation and adoption of nationwide electronic health records in secondary care in England: qualitative analysis of interim results from a prospective national evaluation. *BMJ* 341. doi:10.1136/bmj.c4564
39. Campbell D (2011) NHS told to abandon delayed IT project. *The Guardian*, Thursday 22 September 2011
40. Dismantling the NHS National Programme for IT. (2011) Department of Health. <http://mediacentre.dh.gov.uk/2011/09/22/dismantling-the-nhs-national-programme-for-it/>. Accessed 12 Oct 2012
41. Cresswell, K. M., Robertson, A., and Sheikh, A., *Lessons learned from England's national electronic health record implementation: implications for the international community*. Paper presented at the Proceedings of the 2nd ACM SIGHIT International Health Informatics Symposium, Miami, 2012.
42. Coiera, E., Building a National Health IT System from the middle out. *J Am Med Inform Assoc* 16(3):271–273, 2009. doi:10.1197/jamia.M3183.
43. National Electronic Health Record (NEHR) (2011). Ministry of Health: Singapore
44. Sundhedsstyrelsen, *Aktivitet på Private Sygehuse 2006–2010*. Sundhedsstyrelsen, Copenhagen, 2011.
45. Den private sygehussektor i tal. En faktuel rapport om den private sygehussektor udarbejdet på baggrund af en spørgeskemaundersøgelse sommeren 2010 (2010). Brancheforeningen for Privathospitaler og Klinikker., Copenhagen
46. Olesen, F., Hansen, R. P., and Vedsted, P., Delay in diagnosis: the experience in Denmark. *British journal of cancer* 101(Suppl 2):S5–8, 2009. doi:10.1038/sj.bjc.6605383.
47. Hansen, R., Vedsted, P., Sokolowski, I., Sondergaard, J., and Olesen, F., Time intervals from first symptom to treatment of cancer: a cohort study of 2,212 newly diagnosed cancer patients. *BMC health services research* 11(1):284, 2011.
48. Vedsted, P., and Olesen, F., Are the serious problems in cancer survival partly rooted in gatekeeper principles? An ecologic study. *British Journal of General Practice* 61(589):e508–e512, 2011. doi:10.3399/bjgp11X588484.
49. Jyllands-Posten (2010) Politikere: Journalerne er blevet svigtet. *Jyllands Posten*, 05.12.10