Aalto University
School of Science
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Evaluation of a large electronic health record implementation: Epic in the UK and Denmark

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ABSTRACT OF
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The increasing need for comprehensive health care technologies, which combine health care systems and information, have highlighted the importance of large Electronic Health Records (EHRs). Although EHRs have provided a great amount of benefits for care providers, there have been challenges with the technology as well.

This thesis is a literature review piecing together the key issues, affecting successful implementation of a large EHR, Epic, in Europe. More precisely, this thesis compares European countries the United Kingdom and Denmark, and their experiences of implementing Epic as a part of their health care system. As one of the European countries implementing Epic, Finland is a newcomer and is now at the early stages with the use of the system. Therefore, this thesis also reflects the learning gained from the UK and Denmark thus assisting countries, such as Finland with their implementation.

The thesis identifies the issues UK and Denmark had with Epic implementation. The issues are considered through technical, social and organizational factors. Moreover, the thesis concludes the implementation results the countries achieved with Epic, viewed through user satisfaction, productivity and a level of adoption and utilization of EHR functions (EMRAM-level). The most relevant issues with Epic relate to user interface and complexity of the system, which increases the uncertainty with the system among clinical personnel. Additionally, difficulties integrating Epic to the old systems increased challenges with transferring information within the system.

The occurred issues did not prevent the countries to gain benefits from Epic, rather they slowed down the process of achieving them approximately 2 years. Since, after the patient information was in the system and clinical personnel were more familiar with the system, improvements started to appear. Therefore, future research should focus on the transfer of information and end user training. The general implications from this thesis include the fact that continuous control of Epic is extremely important for care providers in order to gain the optimized use of these technologies.

Keywords:	EHR, Epic, Implementation
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Terveydenhuollon kasvava tarve teknologioille, jotka yhdistävät toisistaan erillisiä järjestelmiä ja informaatiota, ovat nostaneet maailmanlaajuisesti terveydenhuollon tietojärjestelmien tarvetta (engl. Electronic Health Record). Vaikka terveydenhuollon tietojärjestelmillä on saavutettu hyötyjä, liittyy järjestelmien käyttöön vielä haasteita.

Tämä kandidaatintyö on kirjallisuuskatsaus laajan Amerikkalaisen Epic-tietojärjestelmän, käyttöönotosta Euroopassa. Työ vertailee Iso-Britannian ja Tanskan käyttöönottokokemuksia, ja etenkin haasteita, joita käyttöönotossa ilmeni. Yhtenä Euroopan maista, Suomi on vuonna 2020 ottanut Epicin käyttöön. Työn tavoitteena onkin tiivistää opit Iso-Britannian ja Tanskan käyttöönottokokemuksista Suomen kaltaisille maille, jotka ovat vasta alkuvaiheissa Epic-käyttöönoton kanssa.

Tutkielma perustaa johtopäätöksensä aikaisempien tutkimusten tuloksiin. Iso-Britannian ja Tanskan vertailussa kiinnitetään huomiota ongelmiin, joita käyttöönotossa ilmeni. Ilmenneitä ongelmia tarkastellaan teknillisellä, sosiaalisella sekä organisaatiollisella tasolla. Lisäksi maiden välisessä vertailussa huomioidaan tulokset, joita maat saavuttivat Epicilla. Nämä tulokset ovat tarkasteltu tuottavuuden, kansainvälisen digitalisaatio mittarin (EMRAM) sekä käyttäjätyytyväisyyden kautta. Löydösten perusteella, suurien terveydenhuollon tietojärjestelmien käyttöönotot ovat haasteellisia. Suurimmat haasteet liittyivät Epicin käyttöliittymään sekä koulutukseen, jota käyttäjät saivat. Lisäksi integraatio haasteet Epicin ja vanhojen järjestelmien välillä nousivat esiin. Kyseiset integraatio haasteet estivät mutkattoman tiedonkulun.

Ilmenneet ongelmat hidastivat onnistunutta käyttöönottokokemusta, mutta eivät kuitenkaan estäneet sitä. Iso-Britannia ja Tanska alkoivat saavuttaa hyötyjä järjestelmästä henkilökunnan tutustuttua järjestelmään paremmin ja kun potilastiedot oli saatu siirrettyä Epic-tietojärjestelmään. Tästä johtuen tulevaisuudessa tutkielmien tulisi keskittyä henkilökunnan kouluttamiseen sekä mutkattomaan potilastietojen siirtoprosessiin. Tutkimuksissa tulisi myös keskittyä enemmän tekijöihin, jotka vaikuttavat onnistuneisiin käyttöönottoihin.

Avainsanat:	EHR, Epic, Käyttöönotto
Kieli:	Suomi

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1 Introduction

In the recent years multiple countries have transitioned towards a more patient-centric healthcare, that focuses more on the individual patient's preferences, needs and values. One of the most relevant things affecting the patient-centric care negatively, has been the insufficient spreading of patient information between separately working systems (Kruse et al., 2014). This so-called fragmentation of the systems has decreased the effortless information flow between the systems and therefore affected the quality of care. Thus, healthcare technologies combining these individual systems have become more prevailing. In fact, Ammenwerth et al. (2020) highlight the importance of being able to access clinical information across institutions. Central factors of these combined healthcare systems are referred to as electronic health records (EHRs) (Black et al., 2011). Kruse et al. (2014) state that EHRs are a hypernym for systems, such as electronic patient records (EPRs), electronic medical records (EMRs), computerised patient records, and digital medical records. Furthermore, EHRs can be thought of as complex systems combining digitized healthcare records, including the above-mentioned and all the information associated with those records (Bansler, 2021). Hertzum and Ellingsen (2019) state that EHRs have direct and indirect effects on the healthcare system; direct effects including digitization of documentation and indirect effects consisting of process efficiency, quality of care, staff satisfaction and hospital finance. The same authors then continue concluding, EHRs connect and obligate collaboration between departments, specialties and staff.

As the importance of digitization in health has increased, standardized EHRs that combine systems have grown in a number of countries. In recent years, a few European countries have included Epic, an American EHR, to their healthcare systems. Epic is a large EHR system with an extensive variety of functionalities, which can be customized for the customer's needs and integrated to already existing systems (Epic, 2021). These functionalities vary from billing systems to patient administrations. Due to the possibility of customizing and combining separate healthcare systems, Epic has proven to be a valuable contender as an EHR (Bansler, 2021). However, since the system is originally developed for the US markets, there have been some unexpected struggles with it in Europe (Hertzum and Ellingsen, 2019).

This thesis is a literature review piecing together the key issues, affecting successful implementation of an extensive EHR, Epic, in Europe. More precisely, this thesis aims to compare European countries the United Kingdom and Denmark, and their experiences of implementing Epic as a part of their healthcare system. As one of the European countries implementing Epic, Finland is a newcomer, implementing Epic in 2020 in a regional healthcare sector called Joint Authority of the Helsinki and Uusimaa Hospital

District (HUS). In Finland Epic has been implemented under a project called Apotti (Apotti, 2020). This thesis reflects the learning gained from the UK and Denmark thus assisting countries, such as Finland with their implementation.

The research problem of this thesis seeks solutions on how countries could be successful with a large Epic implementation. To provide a part solution to the problem this thesis answers to these two research questions:

- What are the impacts of Epic implementation?
- What are the key issues affecting a successful implementation of Epic?

The thesis is structured as follows. Chapter 2 provides an explanation on EHRs in general, including definition, benefits and challenges recognized. Furthermore, chapter 2 will introduce Epic. Chapter 3 reviews UK's implementation experience, whereas Chapter 4 reviews Denmark's experience. Chapter 5 compares the UK's and Denmark's implementations with Epic, including the results of the implementations. Lastly, Chapter 5 concludes the thesis and presents the future directions of research with Epic.

2 Background

To gain a comprehensive understanding of EHRs and especially of Epic, Section 2.1 presents EHRs in general, including issues and benefits there have been with the technology and the concept of successful implementation. Section 2.2 presents Epic and how it can be customised.

2.1 Electronic Health Records

Hertzum and Ellingsen (2019) define EHRs as complex systems combining different types of patient information. The structure of EHRs differs with the needs of the user since the systems can vary from small local EHRs, used in specific practices, to a region or nation wide EHRs (Häyrinen et al., 2008). Bansler (2021) states that EHRs are not static technologies, implying they are interactive and changeable. Hence, continuous control of configurations and usage of EHRs are required to achieve the optimized use of these technologies.

Similarly to the structure, benefits gained from EHRs can vary greatly, since the need for these technologies depends on the situation and customer needs. Main purpose for EHRs

is to consolidate systems, specialists and practices, thus these technologies are an extensive and important part of healthcare (Nguyen et al., 2014). Häyrinen et al. (2008) state that typically with EHRs, care providers seek to improve factors, such as quality of care and information as well as the efficiency of the overall care. Quality of EHRs can be thought of as data quality, system quality from the perspective of clinical personnel and patients, as well as service quality (Nguyen et al., 2014). More concretely, Häyrinen et al. (2008) conclude that the typical functionality sought with EHRs include the ability to modify patient records in real-time, allowing more congruent and usable systems. In addition, the writers argue that functionalities, such as accessibility by multiple authorized users and secure handover of information between various sectors, are pursued with EHRs. Hence, these benefits enable improved personnel and patient satisfaction (Nguyen et al., 2014).

Generally, EHRs have improved healthcare in many ways. Especially beneficial outcomes with the systems have been with factors, such as documentation accuracy and workflow efficiency of physicians. Although implementations of EHRs have been in multiple cases thought to be successful and eventually improved healthcare, often the implementations have been slower than anticipated (Häyrinen et al., 2008). Nguyen et al. (2014) state that typically in these situations the expectations towards EHRs have been too high and multiple acquired functions have not been used after implementations.

Despite the fact that current EHRs have improved healthcare in many ways, there still have been challenges with the systems (Häyrinen et al., 2008). General challenges to be recognized with these technologies are related to fragmentation of the systems and thus delivering information, data ownership and complex user interfaces (Agrawal and Prabakaran, 2020). Implementing new EHRs on top of existing technologies can have major challenges, including increased expenses (Agrawal and Prabakaran, 2020). Hence, EHR integration on top of old technologies can provide fragmentation of systems, affecting negatively on the smooth information flow and therefore efficiency and safety of healthcare. Furthermore, Agrawal and Prabakaran (2020) emphasise that challenges with information flow complicate the communication, and therefore smooth workflow, between different sectors using EHRs. Since the technology can be integrated and used extensively throughout a healthcare system, there are a lot of paper records and legacy systems involved. Thus, it usually requires large investments (Hertzum and Ellingsen, 2019).

Agrawal and Prabakaran (2020) state that one major challenge with EHRs is to determine data ownership, since it is not always clear who should have the rights to, for instance, look into certain patient's records. The authors conclude that data ownership of EHRs relates to a lack of regulations and systems to manage ownership and responsibility of

data. Ammenwerth et al. (2020) discuss that a shift to better healthcare technologies and to a better understanding of data ownership, needs involvement from actors, such as national health politicians and investors as well as improvements from factors, such as healthcare organizations and national laws. Hence, improvements with the above-mentioned consumes a lot of time.

The third common challenge according to Agrawal and Prabakaran (2020), is the complex user interfaces and therefore usability of EHRs. Large EHRs are combining different functionalities and applications, assisting different user groups (Edwards et al., 2008). Edwards et al. (2008) state that these user groups can include, for instance physicians, nurses, technicians and pharmacists. Since a large EHR should be used in a variety of work environments, it is challenging to customize user interfaces for all the specific user group's individual needs (Edwards et al., 2008). Usually, the challenges with user interfaces occur as reduction of efficiency (Agrawal and Prabakaran, 2020). Furthermore, Edwards et al. (2008) argue that improvements with usability consumes a lot of time and resources.

Evaluating EHR Implementation

To better understand the meaning of successful implementation the term successful has to be determined. Measuring successful implementation and usage of EHRs is not a simple task. The term successful can have many interpretations depending on who is viewing the situation. Success can mean a very different thing for vendors and for hospital managers, physicians or patients. To simplify the meaning of successful implementation, this thesis describes success as an indicator, focusing whether the original goals compared to the outcomes have been achieved with EHRs. More precisely, this thesis measures successful implementation through the outcomes in productivity, user satisfaction and Electronic Medical Record Adoption Model -level (EMRAM). EMRAM is an analytic tool used to specifically measure the adoption and utilization of EHR functions, created by Healthcare Information and Management Systems Society (HIMSS) (EMRAM, 2021). Main purpose for this tool is to measure the overall digitisation of an EHR system through levels from 0 to 7 (Kose et al., 2020). Level 0 indicates a minimal digitisation, whereas level 7 indicates a fully digital system (EMRAM, 2021).

According to Cresswell and Sheikh (2013), health information technologies should be considered through technical, social and organizational characteristics. Hence, the authors highlight the process of combining and aligning the three aspects. To better keep track on how the implementations have affected the tree aspects, this thesis categorizes the issues of implementation and usage through technical, social and organizational

factors. Technical characteristics in this thesis are thought to be factors that will have relative advantages in terms of usability and accessibility. Additionally, technical aspect includes the factor that new technologies should be integrable to the existing technology. Social characteristics are thought to be factors including individual perspective. Finally, organizational aspects are thought as factors including personnel working within an organization and communication between each other.

2.2 Epic

Epic systems is an American vendor providing custom EHRs for hospitals. Epic is one of the dominant EHRs in the world, having more than a 50% market share in the large hospitals of the US (Bansler, 2021). Epic differs from other vendors with its extensive variety of offered features and with the ability to modify the product into the client's needs (Bansler, 2021). For clients, the overall product acquired from Epic Systems is a mixture of the software and services, further explained next, customized for their needs (Epic, 2021).

Epic is a modular technology that comprises the core and modules that can be appended on top of the core system. Compound core functionalities and the database are the key for effective operation guidance, data collection and quality control (Apotti, 2020). The core conducts the information flow within the system, compatibleness of the modules and the overall usability of the system, by providing a base to where modules can be developed or already existing systems can be integrated (Epic, 2021). Most of the modules are created with the system's own tools that are placed in Epic Foundation System (Epic, 2021). Foundation System includes modules built by previous Epic clients (Apotti, 2020). For care providers it is possible to use the already existing modules or to create their own modules. These modules can include, for instance, functionalities of patient monitoring and ongoing patient care, tailored screens and workflows, mobile version of the system and a portal for patients to access their medical information (Epic, 2021).

The modules care providers can provide for themselves are created within trained clinical personnel (Apotti, 2020). In fact, Bansler (2021) states that usage of Epic relies heavily on the training provided for the physicians. Application Coordinators and Physician Builders are educated physicians or other clinical personnel who will work full time in the program. They will develop and configure the administrative as well as the clinical modules (Metcalf-Rinaldo and Jensen, 2016). In order to work as an Application Coordinator or Physician Builder, clinical personnel have to receive a certification from Epic, as an evidence they are specialized in some part of the system (Metcalf-Rinaldo and Jensen, 2016). Bansler (2021) states that the purpose of these programs is to ease the

burden of hospital IT departments as well as gradually decrease the responsibility from the vendor at the implementation phase. Additionally, Epic will provide certification courses for Subject Matter Experts (SME), who are specific groups validating the administrative and clinical content created by Application Coordinators and Physician Builders (Metcalf-Rinaldo and Jensen, 2016). Since Epic is a large and pervasive system, it requires these experts to be a type of an interface between the technology and the users. In addition to the training programs, Epic provides support with implementation, technical services, ongoing service and continuous improvements for its customers (Epic, 2021).

Usually, Epic implementation follows a quite standard pattern. First, requirements are determined and personnel are educated (Metcalf-Rinaldo and Jensen, 2016). Hertzum and Ellingsen (2019) state that with the go-live Epic systems prefers so-called big bang implementation, meaning the system is implemented all at once. The same writers reveal that this approach enables personnel to not have to use two systems, the old one and Epic, at the same time. Hence, this approach should be more efficient than a gradually implemented system. After the go-live Epic provides support systems and training for its customers to get the optimal benefits of the system (Epic, 2021).

3 Epic in the UK

The United Kingdom has the largest public healthcare of the world, mostly paid with taxes (Wilson and Khansa, 2018). According to Hertzum and Ellingsen (2019), the United Kingdom introduced Epic in 2014 in Cambridge University Hospital (CUH) and the implementation included the whole hospital with 1480 beds, 8930 staff, and outpatient attendance of 1,336,900. The implementation cost over 275 million euros. Thus, it was a massive transition for Epic. This section presents the implementation of Epic in the UK. More specifically, the section covers the attained features, desired results and the issues resulted from the implementation of Epic. The issues are analyzed from the technical and social perspective.

3.1 Attained Features and Desired Results

Hertzum and Ellingsen (2019) conclude that the main vision for CUH with Epic was to get rid of all the paperwork and improve the overall digitization. In fact, EMRAM rated CUH digitally as 1 on a range from 0 to 7, since almost all the patient records were in paper format (Hertzum and Ellingsen, 2019). More precisely, level 1 indicates that only the three major ancillary clinical systems, determined by EMRAM, are installed,

including pharmacy, laboratory and radiology systems (EMRAM, 2021). Furthermore, Wachter et al. (2016) reveal that CUH was one of the first medical centers taking part in the UK's National Health Service (NHS) project, which goal was to achieve a paperless NHS by 2020 while increasing the overall well-being of patients. More specifically, the authors argue that the improved quality of care resulting from the NHS project would enable more personalized healthcare and a more balanced financial situation for health providers. As part of the National Health Service, consisting of all the publicly funded healthcare systems, CUH implemented Epic in the hopes of acquiring the same benefits aspired by the NHS project (Wachter et al., 2016).

According to Hertzum and Ellingsen (2019), in order to achieve the above-mentioned goals, the technologies CUH attained from Epic were full patient administration system, pathology, radiology, e-prescribing systems, specialist modules, nursing and clinical observations and documentation, order communications and a specialist theatre system. In addition to the core system, the UK combined MyChart feature into the system, in hopes of engaging more patients with the system. Besides the technology, the UK acquired nine-week training for the clinical personnel (Hertzum and Ellingsen, 2019).

3.2 Issues After Implementation

Technical Issues

Immediately after Epic went live, the UK was facing multiple issues. Hertzum and Ellingsen (2019) reveal there were major problems with transferring patient data from the old system to Epic, which resulted in a loss of data and difficulties in collecting patient information. This could indicate that the transferring process of the records was slower than anticipated. The same authors then continue stating that the missing and therefore fragmented information occurred as difficulties in delivering test results and matching the results to the correct patient. The difficulties with the new technology included outcomes, such as some medicines were not prescribed correctly and label printers were not working accurately (Hertzum and Ellingsen, 2019). The problems could indicate integration problems between the old system and Epic.

Social Issues

Due to the technical problems, personnel were unsatisfied with the system, which occurred as challenges to follow guidelines (Hertzum and Ellingsen, 2019). Not following the guidelines suited for the system, affected negatively on standardization and the overall

efficiency of the care (Hertzum and Ellingsen, 2019). Furthermore, the above-mentioned technical issues with Epic affected negatively the ability of reporting and taking actions on patient data (Hertzum and Ellingsen, 2019). According to Hertzum and Ellingsen (2019), this affected the overall healthcare efficiency and the quality of care. Most likely, dissatisfaction with physicians resulted in reduction of system quality from a perspective of clinical personnel, and service quality.

3.3 Immediate Impacts of Implementation

Immediately after the implementation CUH had a large productivity dip for 2 years, including a 20% decrease in the emergency departments performance (Hertzum and Ellingsen, 2019). Furthermore, the first few months the UK disbursed 1.4 million euros a week more than anticipated. This could imply that the hidden cost that for instance occurred from the difficulties in using new technology were not thought of (Hertzum and Ellingsen, 2019).

4 Epic in Denmark

Denmark has a tax paid healthcare system. The country is divided into five regions, from which in two of them, Capital region and Zealand region, Epic went live in 2014-2015 (Hertzum and Ellingsen, 2019). The implementation for both regions together cost 375 million euros (Hertzum and Ellingsen, 2019). This thesis considers only the Capital region's Herlev and Gentofte Hospital (HGH). For HGH the implementation included the whole hospital with 949 beds, 6449 staff, and outpatient attendance of 742,900 (Hertzum and Ellingsen, 2019). This section presents the implementation of Epic in Denmark. More specifically, the section covers the attained features, desired results and the issues resulted from the implementation of Epic. The issues resulted from Epic are analyzed from the technical, social and organizational perspective.

4.1 Attained Features and Desired Results

According to Hertzum and Ellingsen (2019), HGH's old system had semi-digital documentation and ordering processes, more precisely, it was rated by EMRAM as 3 on a range from 0 to 7. Generally, level 3 implies that 50% of nursing documentation is in a digital form. Additionally, administration record application and role-based access control are implemented (EMRAM, 2021). Hertzum and Ellingsen (2019) discusses that

with Denmark level 3 implied that all data except additional systems including, laboratory and radiology systems which stored their data in a clinical data repository, were papery. The concerned data repository also included most nursing documentations, excluding other records that were in different paper formats (Hertzum and Ellingsen, 2019).

Hertzum and Ellingsen (2019) reveal the main goals for HGH to achieve with Epic were to have more patient-centric care, to digitize clinical work and enable a more standardized healthcare system. Additionally, Metcalf-Rinaldo and Jensen (2016) emphasise, reduction of non-integrated systems and therefore optimized smooth information flow were as well sought with Epic. Hence, with the old system information transferred between the non-integrated systems was prone to significant amounts of errors (Metcalf-Rinaldo and Jensen, 2016). The features Denmark obtained from the vendor, in order to achieve the desired goals, included modules, such as intensive-care, anesthetics and medicine modules (Hertzum and Ellingsen, 2019). Hertzum and Ellingsen (2019) conclude that to engage patients to the system and to improve contact between patient and clinical personnel, HGH attained MyChart feature as well. The same writers state that in order to match the Danish healthcare system, Epic had to make adjustments to the user interface and underlying functionality.

To achieve the desired results, Epic assisted HGH with the implementation phase. According to Metcalf-Rinaldo and Jensen (2016), additionally to the core system, Epic offered services that would assist with the development and implementation of clinical and administrative content. The writers state this content included treatment plans, medical record templates, department specific workflows and different views of patient related data. The training Epic provided for the physicians with the clinical and administrative content, were Application Coordinator, Subject Matter Expert and Physician Builder programs (Metcalf-Rinaldo and Jensen, 2016). Furthermore, HGH had access to the Foundation System where the educated Physicians could take inspiration for the development process (Epic, 2021).

4.2 Issues After Implementation

Technical Issues

With Denmark, Epic integration to the national medicine register (FMK) and laboratory system (Labka) was legally mandatory. The integration process had a significant number of challenges, which led to information, such as patient records, not being accurately registered into the system (Metcalf-Rinaldo and Jensen, 2016). Furthermore, there were requisitions and prescriptions disappearing as well as orders and other information were

neither registering nor transferring correctly. Hertzum and Ellingsen (2019) argue that more precisely, problems related to information registration included incidents, such as data disappearing between some of the medical equipment and Epic, newborn babies lost their identities, some medical orders had occasional duplicates and many blood test orders remained unknown since the reason they were ordered was unclear. These problems affected negatively on the time usage and the overall trustworthiness of the hospital (Metcalf-Rinaldo and Jensen, 2016).

Besides the integration challenges, major problems with Epic were related to documentation (Metcalf-Rinaldo and Jensen, 2016). According to Metcalf-Rinaldo and Jensen (2016), writing records was time consuming and challenging due to an unintuitive user interface. The writers state that doctors felt the user interface had too many windows and it required a lot of clicking for instance, when executing a simple task, such as prescribing the right medicine for a patient. Hence, after Epic implementation the quality of medical records became worse (Metcalf-Rinaldo and Jensen, 2016). One reason for the unintuitive user interface is that every task has its own billing code for insurance purposes (Metcalf-Rinaldo and Jensen, 2016). Thus, Epic is designed for the US markets where healthcare is heavily reliant on insurance business. According to Metcalf-Rinaldo and Jensen (2016), these billing codes are used to determine the reimbursement of every task and service provided by a hospital. In Europe, where healthcare is not that reliable on insurances, these billing codes produce enormous amounts of unnecessary work for the physicians (Metcalf-Rinaldo and Jensen, 2016).

Additionally, the same authors argue that the system was translated poorly which led to misunderstandings and a lack of important nuances, which Epic should have provided for the care providers. These nuances, described by the patient, helped doctors find predefined definitions of a health condition from the system. In addition to the nuances, the system was lacking SmartPhrases, shortcuts that should help doctors with writing the documentation as well as reduce the time used in that. (Metcalf-Rinaldo and Jensen, 2016). Metcalf-Rinaldo and Jensen (2016) denote the lack of nuances and SmartPhrases resulted in difficulties to gain access to medical histories and diagnosis of the patient. The authors state that overall, the insufficient documentation leads to a decrease in quality and efficiency of care. These problems with documentation were due to lack of qualification of Subject Matter Experts, insufficient change management, poor training and user involvement as well as not optimizing clinical and administrative content (Metcalf-Rinaldo and Jensen, 2016).

Social Issues

Epic required new tasks to be executed by physicians, such as entering requisitions and medical records to the system (Metcalf-Rinaldo and Jensen, 2016). Metcalf-Rinaldo and Jensen (2016) conclude that complexity of the system created uncertainty among doctors, since they lacked routines and knowledge with the mandatory tasks. This uncertainty occurred as dissatisfaction towards the system (Hertzum and Ellingsen, 2019). In addition, previously described problems with documentation reduced the time doctors could concentrate on a patient (Metcalf-Rinaldo and Jensen, 2016). In fact, Metcalf-Rinaldo and Jensen (2016) conclude that some doctors wrote their notes onto paper just so they could pay more attention to the patient and afterwards wrote the notes to the system. The writers conclude that uncertainty with the system was due to lack of end user training.

Organizational Issues

Previously mentioned challenges with SmartPhrases and nuances could indicate that Denmark had problems with Physician Builder and Subject Matter Expert (SME) programs, since they were responsible for creating those shortcuts. In fact, Bansler (2021) concludes that the Physician Builder program had problems with the execution. The author argues that these problems occurred from focusing too much on the standardization and not on the local conditions. Due to the standardization, the physicians needed to have wide organizational understanding, thus the number of physicians thought to be suitable for Physician Builder program was low (Bansler, 2021). However, as the need for builders increased, less experienced clinical personnel were accepted to the program as well (Metcalf-Rinaldo and Jensen, 2016). Hertzum and Ellingsen (2019) conclude that builders and SMEs were not trained properly, and they had to learn how the system worked as they proceeded with it. The authors state that this was due to the training starting late. Furthermore, lack of ownership of business-critical components highlighted the issues above-mentioned (Metcalf-Rinaldo and Jensen, 2016). Hence, the same authors reveal that clinical personnel were not sure of which component's development they were responsible for. Overall, these problems with SME and Physician Builder Programs appeared as a lack of standardization and inefficient workflows (Metcalf-Rinaldo and Jensen, 2016).

4.3 Immediate Impacts of Implementation

Due to the above-mentioned issues the overall productivity of Denmark decreased massively. Hence, 18 months after the go-live the productivity had not recovered to the baseline (Hertzum and Ellingsen, 2019). This was surprising since Hertzum and Ellingsen (2019) discuss that HGH assumed they would recover from the productivity dip in three weeks. It is unknown what these optimistic estimates were based on (Hertzum and Ellingsen, 2019).

5 Results of the Comparison

With the comparison between the UK and Denmark it needs to be acknowledged that they are in a different phase of Epic implementation and usage, Denmark still finding the best practices suited for them. When comparing the UK's and Denmark's implementation journeys it is safe to say that for both it was not an easy task. Both had a significant number of problems, especially during the first year of the implementation. However, despite the challenges there were some things done right, since both countries gained some benefits, later discussed.

Table 1 will provide the baseline from which the UK and Denmark started their implementation projects and features the countries gained from Epic. The countries attained similar features from Epic, including specialist modules and systems, such as patient administrative system and clinical observations. Additionally, to engage patients to the healthcare systems, both countries acquired the MyChart feature. The UK's starting point was different compared to Denmark's, since the UK was only at level 1 at EMRAM, whereas Denmark was at level 3. Thus, the UK also attained the ancillary systems, including laboratory, pharmacy and radiology systems. With Denmark these were just integrated to Epic. Additionally, the implementation Denmark's HGH did, was not as extensive as the UK's implementation, since HGH is a smaller hospital than CUH is.

5.1 Implementation Issues

Quickly after the implementation both countries faced multiple issues rather than the desired outcomes. This section will view the issues summarized in Table 2. The issues the UK and Denmark faced within the implementations are thought through technical, social and organizational perspective.

Table 1: Starting Point

	UK	Denmark
Baseline	• CUH was rated as 1 in EMRAM • Almost all the patient documentation were papery • In CUH the implementation cost 275€ million • Included 1480 beds, 8930 staff, and outpatient attendance of 1,336,900	• HGH was rated as 3 in EMRAM • 50% of patient documentation were papery • Implementation cost 375€ million in the Capital (HGH is located here) and Zealand region • In HGH implementation included 949 beds, 6449 staff, and outpatient attendance of 742,900
Attained features	• Digitized healthcare • Ancillary systems renewed with Epic • Systems to support the care • Specialist modules • MyChart feature	• Standardized and digital healthcare system • The already existing ancillary systems were just integrated to Epic core • Specialist modules • MyChart feature • Services that would assist with creating of clinical and administrative content

5.1.1 Technical Issues

With both countries there were issues with integration to the old systems. Metcalf-Rinaldo and Jensen (2016) claim that the integration problems indicate incompatibilities with the old system's technical architectures and Epic. Additionally, with Denmark integrating Epic to the national patient database (FMK) was legally mandatory. The technical differences between the patient database and Epic caused issues with the integration. These issues were not relevant to the UK since they did not have to integrate Epic to a nationwide patient database. Moreover, with both countries there were too

Table 2: Implementation Issues

	UK	**Denmark**
Technical	• Information disappearing • Delayed testing	• Information disappearing • Delayed testing • Unintuitive user interface • Lack of nuances and SmartPhrases • Translation errors
Social	• Issues with the usage of the system • Dissatisfaction among clinical personnel • Difficulties with following guidelines	• Issues with the usage of the system • Dissatisfaction among clinical personnel
Organizational	• Delayed training of clinical personnel	• Lack of training in education programs such as Physician Builder program • Ownership of critical components was unclear

little technical testing before the go-live. Thus, these integration problems came as a surprise (Hertzum and Ellingsen, 2019). Due to the above-mentioned issues, information disappeared and was not transferring within the system (Hertzum and Ellingsen, 2019). This disturbed information flow affected negatively to the efficient workflow and patient care safety. Moreover, these issues affected the quality of data, system and service. Since, issues with the integration affected registrations of patient records and therefore delivering right test results, they affected the quality of data and system. Furthermore, requisitions written by physicians did also disappear which had a negative effect on the quality of service.

The unintuitive user interface seems to be an issue for Denmark. Although with UK challenges with following guidelines could indicate that they had also issues with the user interface. According to Metcalf-Rinaldo and Jensen (2016), the user interface created dissatisfaction, which affected quality of care. More precisely, quality in this case indicates system and service quality. Furthermore, with Denmark there were translation problems with the system (Metcalf-Rinaldo and Jensen, 2016). These translation problems were causing ineffective workflow and misunderstandings within the system (Metcalf-Rinaldo and Jensen, 2016). These kinds of problems were not relevant to the UK since the system did not need translation.

5.1.2 Social Issues

With Denmark and the UK one general problem with Epic was that it was inconvenient and complicated to use. One reason for the above-mentioned user interface is that every task has its own billing code for insurance purposes (Metcalf-Rinaldo and Jensen, 2016). These billing codes required a much more complicated user interface with an extensive amount of clicking. In addition to the billing codes, Hertzum and Ellingsen (2019) denote that internalizing new technology and its best practices also requires time. The increased amount of work did show as dissatisfaction and frustration among physicians (Hertzum and Ellingsen, 2019). The overall uncertainty indicates a lack of testing.

Uncertainty with the new technology increased the gap between the technology and personnel (Hertzum and Ellingsen, 2019). Previously mentioned problems with the system occurred as irritation of personnel and challenges in following guidelines (Hertzum and Ellingsen, 2019). Hertzum and Ellingsen (2019) reveal multiple physicians used the system the best way suited for them, which resulted in not reaching the system's maximum performance. When the premier purpose for Epic is not to help physicians with their work, patient-centric healthcare is neglected (Agrawal and Prabakaran, 2020). This is problematic since both of the countries desired to improve their healthcare to become more patient-centric.

5.1.3 Organizational Issues

Metcalf-Rinaldo and Jensen (2016) reveal that with Denmark there were major issues with the training programs, including Subject Matter Expert and Physician Builder programs. Problems with the programs were due to lack of training, which started late. Ownership of the components and responsibility of creating them were not clear, indicating that change management had problems. Moreover, Bansler (2021) concludes

that these challenges occurred since care providers focused too much on standardization and not the local conditions. The literature of the UK's implementation process did not cover the experiences with the education programs Epic offered. However, Hertzum and Ellingsen (2019) state that with the UK the training began later than anticipated, only nine weeks before the go-live. (Hertzum and Ellingsen, 2019) state that despite delayed testing of clinical personnel, both countries still wanted to start the implementation.

5.2 Results After Implementation

Despite all the challenges UK and Denmark faced with Epic there have been improvements within their healthcare systems. Although due to the issues described above, Hertzum and Ellingsen (2019) state that these improvements were slower than anticipated. After most of the issues were resolved, especially after the clinical and administrative documents were in the system and physicians increased familiarity with the system, both countries started to gain some positive results from the system as well. The implementation results are viewed through user satisfaction, EMRAM-level and productivity, summarized in Table 3.

5.2.1 User Satisfaction

With HGH, four years after the implementation a survey of user satisfaction revealed that 27% of clinical personnel were satisfied with the system, 40% dissatisfied and 32% did not know (Region Hovedstaden, 2019). While clinical personnel thought the system was faster and more stable the user-interface and therefore, user-friendliness was at poor state (Region Hovedstaden, 2019). Similarly to Denmark, UK's personnel were also feeling dissatisfaction towards the system at the beginning. After some significant changes to the system, two years after the implementation usage and therefore user satisfaction of the system improved. These significant changes included, for instance improving the user interface. Additionally, CUH patients have a par coded wristband linked to the EHR which has increased safety since misidentifying is harder (Wachter et al., 2016). According to Hertzum and Ellingsen (2019), the enhancements were partly due to CUH's personnel increased knowledge with Epic.

5.2.2 EMRAM-level

Both countries improved with their EMRAM-level after the implementation. With Denmark the number of unrelated notes reduced after all the documentations were on

Table 3: Results After Implementation

	UK	Denmark
Results	• Two years after the implementation staff was satisfied with the system • Five years after the implementation CUH reached EMRAM-level 7 • Two years after the implementation productivity recovered to baseline and was increasing • Two years after the implementation CUH saved 530,000€ a year in staff time	• Four years after the implementation 40% of users were still unsatisfied with the system • Three years after the implementation HGH reached EMRAM-level 5 • Four years after productivity was not fully recovered to the baseline but was increasing

the system. Thus, documentation was more digitized. In fact, HGH improved with its EMRAM-level and rose form level 3 to level 5 in three years (HIMSS Analytics, 2021). Level 5 indicates that the complete physician documentation including for instance progress and consult notes, discharge summaries diagnosis list with structured templates and distinct data is implemented for at least 50% of the hospital (EMRAM, 2021). In addition, level 5 requires detection and prevention of intrusion to the system. Hence, security at this stage should not have any loopholes (EMRAM, 2021). In the UK the EMRAM-level improved as well and in 2018, 5 years after the implementation, CUH reached level 7 on EMRAM, which is the highest level to be able to achieve (Epic, 2021). Basically, this level indicates that all patient data is in a digital form and that the transfer of information between departments is continuous (Kose et al., 2020).

5.2.3 Productivity

Despite the difficulties and rather high percentage of dissatisfaction among employers, the overall productivity of HGH was gradually increasing after two years of the

implementation, however still not reaching the baseline (Region Hovedstaden, 2019). Hertzum and Ellingsen (2019) reveal it is estimated that in HGH Epic will become financially beneficial in 2022. With the United Kingdom Hertzum and Ellingsen (2019) describe that after two years of the implementation productivity of CUH came back to its baseline and started to further improve. Moreover, after the integration of all patients' administrative and clinical information was done information flow was significantly improved (Hertzum and Ellingsen, 2019). According to Hertzum and Ellingsen (2019), two years after the implementation CUH saved 530,000 euros a year in staff time.

5.3 Finland compared to the UK and Denmark

In order to better consider the outcomes Finland can gain from this thesis, it is important to understand what the baseline for Finland is before implementing Epic. Therefore, this section will conclude Finland's current healthcare situation and the reasons why the country attained Epic.

Similarly to Denmark and the UK, Finland's public healthcare is paid with taxes. Majority of healthcare is public thus most physicians, over 70%, work in the public sector (Vainiomäki et al., 2020). In addition to public healthcare, Finland has a private sector (Vainiomäki et al., 2020). As a result of a project called Apotti, in Finland Epic went live in 2020, in one regional healthcare sector called Joint Authority of the Helsinki and Uusimaa Hospital District (HUS), consisting of 25 hospitals (Apotti, 2020). HUS has hundreds of different EHRs in use that are not communicating together. The fragmentation of the systems reduces patient safety as patient records are not available for specialists in treatment situations, since information is not transferring within the system (Apotti, 2020). Due to the fragmentation of the systems, with Epic HUS was seeking to improve the overall healthcare and to acquire a comprehensive EHR that will improve the information flow, system control and thus ensure better quality of care (Apotti, 2020).

The starting state for Finland was pretty similar to Denmark's. Finland has Omakanta, which is a database where all the public records can be transferred (Apotti, 2020). Whereas Denmark has the FMK (Metcalf-Rinaldo and Jensen, 2016). The EMRAM-level of HUS was not found from the literature. However, in Oulu, one of Finland's biggest cities, a university hospital had received the stage 6 in EMRAM in 2016 (Finnish Society of Telemedicine and eHealth, 2016). Since Finland's healthcare is mostly paid with taxes, the Oulu's EMRAM-level could indicate that HUS could have the level 6 as well.

6 Conclusion and future Directions

The literature review evaluated implementation of Epic in a long term. The review recognizes the issues affecting a successful implementation through technical, social and organizational perspective. The issues are focusing on the uncertainty caused by the complexity of the system, and to the fact that Epic had compatibility issues with the already existing systems. Furthermore, the three major challenges related to EHRs that Agrawal and Prabakaran (2020) discuss, were as well the relevant challenges UK and Denmark faced with Epic. The challenges include complicated user interface, data ownership and issues with smooth information flow, affecting the quality, safety and efficiency of healthcare. In addition to the issues, this thesis concludes the results UK and Denmark attained with Epic implementation.

First, especially in the case of Denmark, the estimation of the overall benefits and when they would be achieved were estimated in a highly incorrect fashion. Kruse et al. (2014) note that in general the benefits gained from EHR implementation are achieved in the long run, whereas usually, care providers believe to gain the benefits in the short run. In the implementation projects of the UK and Denmark this was probably the situation. The number of undesired issues, occurring after the implementations, could indicate that the requirements and obtained results were not obvious for the care providers. Hertzum and Ellingsen (2019) state that at the early stages of implementation it is unnecessary to focus on the measurable benefits of efficiency and economy, which was the situation in the Danish case. For Finland, as there is a large regional Epic shift, it is more beneficial to focus more on the treatment quality and effortless coordination between clinical personnel and the hospitals.

Second, the issues the UK and Denmark faced imply that the countries did not realize the importance of configurations and adaptations of the system. New information from the system should be immediately analyzed to improve the system, upholding a clear picture on how the changes will affect clinical personnel's work assignments and responsibilities. In fact, Hertzum and Ellingsen (2019) state that the continuous control of the system should not end at the go-live. With the two countries, the standardized routines and processes were not determined before the go-live. Thus, the cohesion of the system decreased. Furthermore, as in the Danish case, the fact on whose responsibility was to create certain components was unclear. Thus, for countries, such as Finland that are at the early stages of the implementation it is important to focus on the continuous control of the system. However, as Hertzum and Ellingsen (2019) denote, the far-reaching decisions about standardization of routines can be difficult to determine, since usually the best practices are figured out as the system is developed.

Third, similarly to Denmark, in Finland Epic has to be integrated to the healthcare context (Apotti, 2020). Hence, there should be a great amount of IT specialized physicians working with the implementation of Epic. Hertzum and Ellingsen (2019) state that currently the career path of clinical personnel is fixed and does not include IT knowledge. The author continues that in the past physicians have not participated in a large EHR implementation. Hence, this is something that can be difficult to affect on a hospital level. However, as the technical solutions within the healthcare industry are increasing, in the future IT specialized physicians can be a preferable profession.

Lastly, with both countries many of the issues mentioned in section 5.1 Implementation Issues, were due to integration problems within the old system and Epic. Commonly speaking, difficulties with continuous information flow between individual EHR systems, not communicating together, is a major problem in healthcare (Agrawal and Prabakaran, 2020). In general, there should be more collaboration and cooperation between EHR vendors to tackle this problem. However, obviously vendors seek profit within their business and aim to differ from their competitors. Therefore, centralized standards are needed to increase the effortless information flow between individual systems. For Finland, these standards could be laws and restrictions focusing on the structure of EHRs.

The discussion in this thesis is mainly intended towards care providers. The thesis provides insights on the types of issues there can be with Epic implementation. Although care providers are not able to have an influence on each of the issues mentioned in this thesis, it's beneficial for them to acknowledge the existence of the issues. By naming the issues care providers are better suited to make decisions considering the requirements and resources of Epic implementation.

6.1 Limitations

This thesis succeeded in identifying the key issues affecting a successful Epic implementation. However, since there is little research conducted on the results countries have gained with Epic in Europe, this thesis cannot give full insights into how these issues affect the results of the Epic implementation. Moreover, the literature on this topic provided more information on Denmark's implementation process, which can create an imbalance for the comparison between the two countries.

6.2 Suggestions for Future Research

Despite providing some preliminary conclusions of which factors have affected successful implementation of Epic, the topic requires more extensive research. With both Denmark and the UK, the productivity started to increase after clinical and administrative documents were in the system and after physicians increased familiarity with the system. This indicates that more research should be conducted about the transfer of information and training of the end users. Additionally, the available research is mainly focused on the issues countries face with Epic. This takes attention away from the actions made towards reaching beneficial outcomes. In fact, there is a limited amount of research about the benefits of Epic. For future Epic users to gain wide knowledge from the research, it should focus on the factors, which positively affect Epic implementation, as much as it focuses on the issues.

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