

A Work Project, presented as part of the requirements for the Award of a Master's degree in Management from the Nova School of Business and Economics.

FROM A SIMPLE EHR TO THE MARKET LEAD: LEARNINGS FROM GERMANY

ANNABELLE RAUERT

44240

Work project carried out under the supervision of:

João Marques Gomes

17-12-2021

Abstract

Title: From a simple EHR to the market lead: Learnings from Germany

An Electronic Health Record (EHR) is designed to assist clinicians in their daily clinical work and improve patient care. To achieve these goals, it is necessary to identify the problems with current EHRs and the improvements clinicians say are most important. Therefore, a qualitative study using semi-structured interviews was conducted. The results showed that the biggest concern is the user-unfriendliness of current EHRs. Dashboards and algorithms are improvements that doctors would like to see implemented. Based on the interviews, EHR providers were given six recommendations that would allow them to move from a simple EHR to the market lead.

Keywords: Digital Health, Electronic Health Record, Patient-Centred Care, Clinical Decision-Making, Innovation in Health Care, EHR vendors.

Acknowledgments

I would like to thank everyone who supported me in writing this Master's thesis. I would like to thank Professor João Marques Gomes, who supervised this work. I would like to express my sincere gratitude for the constant help and support during the preparation of this thesis. I would also like to thank the experts without whom this work would not have been possible. I thank them for their willingness to provide information.

This work used infrastructure and resources funded by Fundação para a Ciência e a Tecnologia (UID/ECO/00124/2013, UID/ECO/00124/2019 and Social Sciences DataLab, Project 22209), POR Lisboa (LISBOA-01-0145-FEDER-007722 and Social Sciences DataLab, Project 22209) and POR Norte (Social Sciences DataLab, Project 22209).

I. Table of Contents

Abstract	1
1. Introduction	3
2. Literature Review	4
2.1 Electronic Health Records	4
2.2 Market overview	5
2.3 Market players	6
2.4 Challenges and barriers	9
2.5 Needs for improvement and market trends	13
3. Methodology	15
4. Findings	18
4.3 From a simple EHR to the market lead: Learnings from Germany	18
5. Discussion	32
A. Implement workflow automation to ease medical work.....	33
B. Invest in alerts to promote patient safety	34
C. Create value through the offer of a complete set of information.....	36
D. Increase the user-friendliness.....	37
E. Develop a customer success team and design SaaS training	39
F. Implement an improved voice recognition software	41
6. Conclusion.....	44
7. Bibliography	46
8. Appendix	56

1. Introduction

An Electronic Health Record (EHR) stores the patient's medical history over time, gathers all the relevant data of a person who is under the care of a particular provider, and consequently assists physicians in their daily operations, leverages the service quality, and helps decrease medical errors (Glaser 2020; Green 2019).

Nevertheless, users' satisfaction is still low and below the expected, considering the tool's potential. The software developers still have no solution to fundamental problems as the design interface or usability issues, with international surveys stating providers consider the EHR responsible for the rise of medical burnout (Stanford Medicine; The Harris Poll 2018).

Moreover, for traditional EHRs that address the way care services are organized today, but not as Value-Based Health Care (VBHC) requires, there is a problem of differentiation that does not stem from the lack of opportunities: the evolution of the market and consumer needs prove the significant power of the data stored in the EHR not being harnessed (Green 2019). Data could be better used to foresee diagnoses, offer treatment hypotheses, or monitoring.

Thus, one can conclude that EHRs are still far from leveraging the efficiency of health systems. Therefore, this work project aims to provide recommendations to current EHR vendors to solve the referred flaws and enable software developers to become the market lead. For this purpose, this project focuses on better understanding the strengths and weaknesses of the current EHRs, as well as needs for improvement that users consider important. Additionally, the work project identifies which technologies today allow EHR vendors to take advantage of the trends and the market opportunities.

In short, the goal is to understand what kind of offer one should create to have a product perceived as a tool that simultaneously facilitates the work of professionals and better meets the patient's needs.

2. Literature Review

2.1 Electronic Health Records

Health care can be seen as a continuous process that requires data to be collected over time, which is why medical records are important. These systems should ideally capture all information about patient care, support the physician's decision-making process and promote health care activities such as administration, quality assurance, and research (Hannan 1996).

Traditional medical records were mostly paper-based and contained some electronic data such as laboratory or imaging results. These systems made it difficult to store, retrieve and share patient information, which required technological advances (Hannan 1996). In addition, information technology leads to ever-increasing amounts of data being generated and stored for patient care. Still, there is a lack of tools to process information (Shilo, et al. 2020). This scenario results in random noise data or misleading data inputs that can interfere with, rather than support, clinical decision-making.

For this reason, the introduction of digital technologies and the management of data are vital for the development of the health care industry (Priyananadan & Sharma 2016). Therefore, the digitization of health care is reflected in the introduction of Electronic Medical Records (EMRs), which allow for the storage and processing of all health data in an electronic format, typically used as an internal organizational system. Furthermore, Personal Health Records (PHRs) are medical records maintained by the patient (Ambinder 2005).

Finally, EHRs are clinical systems that collect, store, and present data gathered during health care delivery by integrating both EMRs and PHRs (Ambinder 2005). EHR can contain multiple parameters that link patients, practices, clinics, hospitals, health plans, laboratories, and pharmacies. It also stores the patient's medical history, including important administrative, clinical data such as demographics, progress notes, problems, medications, vital signs, previous medical records, and more, in an electronic system that automates access to all this information

over the internet in a confidential and secure manner. This scenario potentially streamlines the physician's workflow, leading to better decision-making and care by improving the accuracy and clarity of medical records and potentially reducing costs (Heart, et al. 2017). An EHR should enable optimal management of individual and population-based care and data exchange between authorized providers, ultimately providing information seamlessly for both providers and patients (Ambinder 2005).

The primary motivation for developing EHRs is the ability to aggregate all information - including tracking and monitoring quality of care - needed for education, practice management, and patient care and make it accessible to any authorized provider. This can lead to a reduction in medical errors, reduce redundant information, and support reimbursement systems. It can also contribute to the development of efficient health systems based on evidence-based medicine. Ultimately, this leads to the use of an EHR for practice management, scheduling of procedures and laboratory tests, documentation, referrals, prescriptions, patient eligibility, decision support, and analysis of patterns of care (Ambinder 2005).

The health care industry is moving toward a value-based model at a time when health care systems need to become more flexible, decentralized, and cost-effective by focusing on patient benefit rather than quantity of service. Therefore, VBHC and digitalization go together. VBHC is one of the drivers of digital transformation, as it requires an unprecedented level of availability of patient data. EHRs and their functions are a great example of such, as they ultimately lead to cost efficiency and better patient care (van Eenennaam, et al. 2020).

2.2 Market overview

To drive digital transformation in European hospitals and institutions, the European Commission has made several commitments in 2018, including the standardization of EHRs across Europe. However, due to complex health care systems, different stakeholder opinions, and different funding packages, digitization is at different stages of development in European

hospitals (Taylor, et al. 2020). The HIMSS Annual European Digital Health Survey found out that of the countries included in the study, patient data is not yet fully available in digital format in most countries. In the UK and Ireland, just 65% of patient data is available digitally. The Netherlands leads the study with 90% (HIMSS 2021). A similar conclusion was reached in a survey by Deloitte, which found out how many clinicians in Europe use EHRs. In the Netherlands and Denmark, over 95% of clinicians use EHRs, whereas Italy comes to 69% (Taylor, et al. 2020). It becomes clear that the individual countries are all at different stages with the implementation of EHRs. This is also because each country spends differently on digitalization and health (Taylor, et al. 2020).

In Europe, the average expenditure on health as a proportion of GDP was approximately 8.5% in 2019, and it can be assumed that this number will increase. In Germany, the percentage of GDP spent on health care was 11.7%, and in Portugal, it was 9.6% (Taylor, et al. 2020). While the global market size in 2015 was predicted to be around USD 22 billion, a market size of approximately USD 40 billion should be reached in 2024 (Statista 2018). The European EHRs market revenue was USD 3,35 billion in 2019 and is expected to reach USD 4,26 billion in 2024 (Statista 2021).

2.3 Market players

Most EHR providers do not operate globally but focus on one or a few markets. Therefore, they usually generate more than 85% of their business only from one market and are also driven by these market dynamics (Green and Liberty 2019).

Nevertheless, there are differences between the American and the European market. In the United States, the market is dominated by three EHR vendors. Epic, Cerner, and Meditech share more than 65% of the EHR market share in 2020. Epic leads the market with a market share of around 31%, closely followed by Cerner with a market share of 25%, and Meditech with 16% (Drees 2021).

In contrast, EHR vendors in Europe differ significantly from country to country, and therefore there is not a single company that currently dominates the field (Green and Liberty 2019). In Europe, one of the biggest markets is the DACH region, including Switzerland, Austria, and Germany. The UK/Eire is also among the larger markets in Europe. Nevertheless, the EHR vendors in these countries differ significantly. France currently has many EHR vendors, making it one of the most fragmented countries in Europe (Green and Liberty 2019).

In the EMEA (Europe, Middle East, Africa) market, the companies with the highest estimated revenue share in 2018 were Cerner, Agfa Health, and Asseco, with a total estimated revenue share of 29% (Green, 2019). Based on this source, it was assumed that these companies are currently the largest in Europe and are therefore considered market leaders.

Of the companies mentioned, Cerner's revenue share was estimated to be the largest at 16%, and the company is particularly strong in the DACH region, UK/Eire, and Middle East (Green 2019). Cerner is a company founded in the United States that has provided software in many different areas for over 40 years. The solutions are offered in various areas, such as clinical, operational, or financial. The company provides data so hospitals can build better operational management and gives clinicians the information and tools they require to deliver good care (Cerner 2021).

Agfa HealthCare comes in second place with an estimated revenue share of 8% and is mainly present in Germany, Austria, Switzerland, and France (Green 2019). Agfa HealthCare is part of the Agfa-Gevaert Group, based in Belgium (Agfa HealthCare 2021). The company provides Imaging IT solutions developed for different specialties to increase patient care. Moreover, the company offers Hospital IT solutions such as Hospital Information Systems and Integrated Care Solutions (Agfa 2020).

Asseco is mainly present in Eastern Europe, with a revenue share of 5% (Green 2019). The company was founded in Poland almost 30 years ago (asseco 2020). Asseco is a company

offering different solutions such as hospital information systems, systems for medical practices, and electronic medical records (Asseco 2021).

In addition to the already long-established companies, a lot has changed in the health sector in recent years, and different start-ups have been founded (AlbionVC n.d.).

Many young companies are entering the market to improve the health industry. Speedinvest analyzed start-ups, of which 626 are funded and still running. Of the 626 digital health firms, over 60% are less than five years old, which indicates that the sector is still very young. The companies are start-ups working in different areas of health care, such as launching EHR software, developing diagnostic devices, or focusing on people's health (Faltin 2020). In the period between 2010 and 2020, the UK is the clear leader of digital health start-ups with 171 start-ups, followed by the DACH region (102 start-ups) and Northern Europe (100 start-ups) (Faltin 2020).

In addition, Albion VC has listed many of the health start-ups in Europe and divided them into different categories. These categories include Chronic Care, Imaging, or Provider Enterprise Software. To get an overview of start-ups in the EHR sector, three of the start-ups listed by Albion VC that offer EHR software or software solutions that can be integrated into EHRs are analyzed below (Ruedig 2021). The companies were selected based on the highest total funding. The first start-up to be explored is Lumeon. Lumeon is a UK-based digital health company founded in 2005 with a total funding of over \$78M (crunchbase 2021). The company offers Care Pathway Management solutions that enable organizations to coordinate treatments efficiently. The software automatically manages routine treatment services and communicates continuously with patients. At the same time, the treating teams are supported and are also alerted if necessary. Popular solutions include patient outreach, appointment reminders, pre-surgical readiness, and care transitions (Lumeon 2021).

Smart Reporting, a German start-up founded in 2014, has a total funding of around €22M (crunchbase 2021). Diagnostic findings and their quality play a central role in medicine. For this reason, Smart Reporting offers structured reporting software that helps customers become more productive, improve quality, and optimize communication (smart reporting 2021). Products include “SmartReports”, a voice-activated reporting solution that allows to manage clinical and operational challenges. The reporting solution offers a fully integrated editor that provides diagnostic report templates (smart reporting 2021).

The last start-up to be analyzed is Heydoc, which was founded in the UK in 2017 and received a total funding of \$12M (crunchbase 2021). Heydoc offers software for medical practice that manages administrative tasks and patients’ medical data to improve healthcare. The company provides solutions for clinicians, admins, management, and developers (Heydoc 2021). The company’s goals include involving patients in the process, enhancing interoperability, and using the vast amounts of data (Heydoc 2021).

2.4 Challenges and barriers

While some studies reveal cost savings and better care with EHR adoption, others indicate inconclusive or negative effects on doctors' productivity (Heart 2017). Therefore, the following section identifies the barriers to greater EHRs efficiency. The study scope includes European and American articles, whose insights are considered to apply equally to the European continent.

Despite the significant investment in health information systems, there are considerable challenges and barriers to overcome for EHRs to fully assist providers in care delivery (Reisman 2017). Among these obstacles, the following statements address the high costs, lack of interoperability, usability issues, physician's burnout, poor training systems, and the difficulty of using data.

According to the existing literature, financial costs remain a primary barrier to EHR adoption. Even though the market evolution enabled the rise of more affordable cloud-based EHR solutions, many smaller practices still lack the resources and the know-how to implement this software efficiently (Reisman 2017).

Furthermore, interoperability – the ability to connect EHRs across all care settings, enabling the share of patients’ data regardless of the software used – is still a major challenge (Reisman 2017). Therefore, this issue impacts medical communication, artificial intelligence (AI) assistance to medicine and research. Since interoperability is not accessible in all care settings, doctors cannot always retrieve information, which can lead to a rise in medical errors due to communication barriers and increase the documentation burden (Lehne et al. 2019). According to Reisman, a 2015 survey registered that only 6% of providers could share patient records with other physicians who used different software (Reisman 2017). Likewise, considering AI, since systems are not fully interoperable, the validation of analysis and the trust in digital technologies is impacted. Moreover, regarding research, the inefficient access to stored data affects the creation of new research possibilities and inhibits care development (Lehne et al. 2019). Thus, the poor standardization and interoperability between systems emerge as a hurdle for the efficient exchange of information (Dagliati et al. 2021).

On the other hand, the complex layout of the user interface, which simultaneously displays patient information, medical records, test results, and an overview of the patient's medical history, ultimately frustrates physicians, contributing to building the perception that the software is difficult to use (Young et al. 2021).

Usability issues increase the time spent with EHRs. Stanford Medicine (2018) affirms that 62% of the time providers dedicate to each patient is spent entering data or navigating in the EHR. Furthermore, research published in the *Annals of Internal Medicine* referred that a provider spends on average 16 minutes using the EHR per consultation, one minute longer than the usual

15-minute consultation period. Providers spent most of the time dedicated to Chart Reviewing (33% of the time), Documenting (24% of the time), and Ordering (17% of the time) (Lee 2020). The decrease in time dedicated to patients in a 1:1 valuable communication translates into a decline in job satisfaction, rise of stress, and lower quality of care (Graffa 2018, Wachter 2018). Consequently, 49% of the physicians surveyed considered EHR decreases their clinical efficiency, with 71% agreeing that the software contributes to professional burnout (Stanford Medicine; The Harris Poll 2018).

The burnout thematic is, in turn, worrying not only considering the physician's exhaustion but also since it translates into reduced patient safety, lower patient satisfaction, a higher index of malpractice claims, and interferes with the work environment (Graffa 2018). Therefore, vendors must streamline user engagement in the way the product should be designed and integrate feedback after implementation (Reisman 2017).

Furthermore, health institutions should not solely purchase the EHR software but also employ qualified IT employees for educational support and training. The learning curve related to adopting EHRs demands a significant period from health professionals, reducing the time dedicated to patient care (Graffa 2018; Tsai et al. 2020). In fact, not every physician possesses high levels of computer literacy. A study from 2021 draws attention to nurses who currently have difficulties with double-clicking the mouse, consequently skipping process steps. Likewise, physicians negatively commented on the substantial time required to summarize a patient's diagnosis and care plans (Young et al. 2021). In this sense, a vendor that simultaneously offers the EHR software accompanied by personal assistance and educational content better fulfills the clients' needs.

Therefore, the referred issues contribute to providers' rise in stress. Among the EHR features that most contribute to this scenario are information overload, slow EHR reactions, consequent inability to navigate the system rapidly, excessive need for data entry, interference in the

provider-patient relationship, notes geared towards billing, and concern about missing something (Kroth et al. 2019). Likewise, a survey from 2019 reflects the features that primarily contribute to lower satisfaction on the EHR systems. These include the high requirements of data entry (86% of physicians negatively reported), the extended progress notes (75.2%), the poor interoperability (73.1%), and the notes made with more on billing than on patient care (73.1%) (PJ et al. 2019). Moreover, in a study that resorted to 31-EHR systems, physicians complained mostly about vendor support (36%), clinician productivity (16%), and the decrease in inpatient care (24%) (Frisina et al. 2020). Additionally, providers criticized the lack of training and the inexistence of some features that contributed to the system's failure to meet clinical needs. Hence, these studies validate the overall providers' dissatisfaction mentioned above and confirm the existing room for improvement (Frisina et al. 2020; Kalra 2018).

On the other hand, besides the medical field, the EHR can also assist clinical research or administrative functions. The EHR should enable physicians to analyze data rapidly, promote the discovery of possible new treatments, unveil security issues, and alert for unusual clinical findings. However, providers still struggle to recover and retrieve relevant information and understand the adequate treatment plan for each patient. Currently, an EHR does not exist to answer the information challenges that clinicians face every day (Reis et al. 2016; Glaser 2020). From 2011 onwards, more than \$39 billion were invested in digital health, with just nearly 20% being allocated to EHRs and data analytics (Agrawal et al. 2021). Moreover, studies reflect the uncertainty concerning the relevancy and quality of data stored in the EHR for outcomes assessment since research highlighted data availability and quality issues (Aerts et al. 2021). Furthermore, Patient Reported Outcomes are still not routinely integrated into any EHR software or IT solution, which inhibits the delivery of care centered on the patient's needs (Garcia et al. 2019). Therefore, the EHR is far from being fully efficient (Glaser 2020).

In short, EHR should be patient-centered, focused on maximizing the quality of the care provided, and shifting the focus from reactive maintenance to proactive health plans. An EHR should highlight the patients' care plans and focus on maximizing the information exchange and decision support rather than clinical transactions to accomplish these goals (Glaser 2020; Thranberend and Haas 2017).

2.5 Needs for improvement and market trends

EU institutions, governments, the health care industry, and respective stakeholders (such as providers, patients, for example) are increasingly interested in digitalizing health care. This is possible by applying cost-effective regulations, reducing workloads, facilitating learning activities for health care professionals, and ultimately developing an EHR system that can be rolled out across the European Union. In addition, patients want to be able to access their entire medical history via a smartphone or other appropriate digital device so that they can share this information with their health care providers (Raeve and Jardim-Gonçalves 2020). EHRs have reached the point where they can manage and track patient data in a system that can document visits, retrieve lab results, and perform various other transaction-based actions. However, these systems are not enough to answer the market needs (Glaser 2020). In this context, it is essential to look at current market trends and how these can be leveraged to fulfill the given needs.

While digitization is undoubtedly the overarching trend, it can be broken down into smaller, more specific trends that can help improve current EHRs. First, machine learning (ML) can be considered a main trend in health care. This technology is particularly important because it can make time-consuming tasks such as planning or research easier and faster and improve information quality, reduce healthcare professionals' workload, and ultimately improve care delivery. AI is also a growing concept in health care. Not only can it be used in data management, but it can also be used in natural language processing (NLP), a technology that is seen as the future for understanding and storing health care data. In addition to these

technologies, blockchain is another concept of interest to current EHR developers as it can help with data security, which is one of the main issues in the sector.

When looking at the major trends in health care, ML is one of the big concepts in the field. Today, it is vital for EHRs to work intelligently on their own, taking into account large amounts of data from either research or patient history and combining it in a way that enables health care professionals to deliver better results (Glaser, 2020). This can ultimately help providers access patient data quickly and easily, in an organized way that uncovers abnormal clinical findings and enables the discovery of new treatment options (Yoo, et al. 2013). If successfully implemented, ML can help EHRs create and track documents, events, and procedures while providers focus on planning. This will lead to a more efficient decision-making process and better care by, for example, highlighting the best-proven treatment options, informing professionals of outdated treatment options, or even whether their performance is not up to the standards (Yoo, et al. 2013).

On the other hand, AI is also a big trend in the industry, as it can both help EHR vendors meet the consumers' needs and at the same time bring several benefits to the overall health care sector. AI allows EHRs to develop a comprehensive database that covers all possible circumstances, from patient status to the preferred treatment method for a particular disease at a particular stage (McCullough, et al. 2019). Consequently, the software can analyze and evaluate individual data and population data. That data from one particular patient can be used to provide better care for another, whilst ensuring that there are no conflicts or redundancies when proposing different treatment options (Cabezas and Villa 2014). To achieve these goals, the health care industry needs to leverage better these new digital technologies to capture and manage patient data in a way that can be integrated into a given system and function properly. Furthermore, security is a significant issue in the health care industry, with millions of patient records being exposed in data breaches over the years (Daley 2021). In this context, data lakes

and blockchain play an important role, as they will ultimately enable the rapid collection and exchange of health data securely and privately (Dagliati, et al. 2021).

Data lakes can be seen as the foundation for this disruptive change, as they enable the collection of vast amounts of data that can be used to gain powerful insights. To better understand this technology, it can be divided into four key steps of data management: collection, organization, analysis, and processing. First, information is collected from various sources such as hospitals, clinics, or even pharmacies, processed through an ingestion framework that supports different types of data, and standardized in a data store. The data is then organized through cleansing and feature extraction, allowing the system to perform advanced analytics on the data using ML (Mathis 2017). This process provides the opportunity to address the market trends for an EHR with automated applications and clear dashboards.

To create such a complex network securely, the concept of blockchain is essential. The technology uses public-key cryptographic techniques to create an immutable, time-stamped content chain. The blockchain allows all patient information to be reconciled with a guarantee of integrity from the time the data is created until it is used and the ability to access it from anywhere (Halambka, et al. 2017). This can help EHRs as they become longer and more complex over time, and so far, hospitals and doctors use different storage methods. In summary, introducing the blockchain concept into an EHR would give patients authority over their entire medical history and allow both patients and providers centralized access to it, while being completely secure.

3. Methodology

As previously stated, the work aims to find out how EHR companies can increase the quality of their product to become the market lead. For this purpose, a qualitative research approach using semi-structured interviews was considered an appropriate method as it offers the opportunity to ask additional questions based on the participants' responses. An interview guide

with main questions was prepared in advance. The interview script is provided in the appendix (see Table 1). Particular emphasis was placed on ensuring that all interviewees were familiar with EHRs or actively working with them.

Author 1 conducted a total of 22 interviews (n=22). Hospital directors (n=2), physicians (n=16), a research dean of a medical faculty (n=1), staff from the Institute of Medical Informatics (n=2), and a project manager of an insurance company (n=1) were interviewed (see Table 2). The physicians include specialists, senior physicians, and chief physicians working in various fields such as gynecology, urology, neurology, and cardiac surgery. All interview partners are based in Germany, so that all interviews were conducted in German and either by telephone or via Zoom.

Author 2 conducted 35 interviews (n=35) in Portugal and Spain. These interviews, range from specialty doctors (n=15) and general practitioners (n=8) to nurses (n=5), hospital managers (n=3), members of health management associations (n=3) and IT experts (n=1). These professionals work in Portugal in public hospitals (n=9), management associations (n=3), outpatient institutions (n=2) and private facilities (n=2) and in Spain in Public Hospitals (n=8), Outpatient Institutions (n=6), Private Clinics (n=2), Private Hospitals (n=1), Public-Private Partnerships (n=1) and IT Companies (n=1) (see Table 3). According to the interviewed preferences, the interviews were conducted in Portuguese, Spanish, and English, by telephone or via Zoom.

Author 3 conducted a total of 10 interviews (n=10). Computer engineers (n=2), a backend developer (n=1), physicians (n=4), executive directors (n=2), and a software developer (n=1) were interviewed (see Table 4). Despite the wide range of specialties, all participants are familiar with the technologies discussed, so they are considered helpful to the topic. All interview partners are based in Portugal, being so, interviews were conducted in Portuguese and either via video call or in person.

The interviews of the three authors lasted between 15 and 60 minutes, depending on the interviewee's time, and took place in October and November 2021. In agreement with all participants, most interviews were recorded to evaluate them at a later stage.

The interviews were transcribed. A thematic analysis was performed, and all statements were coded. Based on the coding, different categories were created and then evaluated and analyzed.

4. Findings

4.3 From a simple EHR to the market lead: Learnings from Germany

The following section first provides a brief overview of the current EHR situation in German hospitals. This is followed by the concerns expressed by physicians regarding the EHR software and additional features and improvements that physicians would like to see implemented.

Overview

Digitization is at different stages in German hospitals. While some doctors reported that their hospital works mainly digital, others stated that digitization is not yet far advanced. According to physicians, this also depends on the type of hospital. In private hospitals, digitization is often more progressed than in public ones.

Doctors agreed that one of the benefits of digitization is that the documents are stored and readable. This usually means complete documentation so that physicians no longer have to search for findings. In addition, the documents can be accessed from any computer and are no longer kept in a paper file in one place. Moreover, when doctors take on a new patient, they can immediately see which examinations have already been performed.

Software from different EHR vendors can be found in the various German hospitals. Since the software from each vendor has different features and functions, each hospital is equipped differently. Physicians reported that they do not have only one EHR software.

"When we talk about Electronic Health Records today, we are talking about three systems: the document archive, a so-called curve, and a program if the patient was in intensive care. (...) These are three separate systems. They only have interoperability on a certain level."

In addition to the EHR software, the various hospital departments have different requirements, which means that each department often needs additional special software so

that a variety of software exists. This includes, for example, software for mammography or ultrasound. *"However, most hospitals don't use just one modular software, but have different software. My hospital has 200-300 different software solutions for different problems. They have their intensive care system, their lab system, etc."*

One chief physician described the purchasing process of an EHR software and how it works in most hospitals. The process for a hospital to purchase an EHR is lengthy and extremely costly. The respective federal state in which the facility is located pays part of the costs. The acquisition of an EHR software means an investment volume of around 10 million euros, depending on the size of the hospital. A hospital must first draw up a so-called requirements specification, which must contain information such as the requirements for the system. This includes, for example, conditions such as the compatibility of the software with already existing systems. The hospital then makes a Europe-wide call for tenders, and the various companies, usually 7-8 providers, reply. The companies are invited to an interview where multiple questions must be answered. Different people from the hospital are present at the interviews, such as doctors, administration, nurses, and the board, to ensure that all relevant people and departments are convinced of the choice of software. The favored software solutions are then visited in reference hospitals to guarantee that the software meets the hospital's requirements and to see how other facilities work with it. According to a chief physician, both the market power of the EHR vendors and the price are deciding purchasing criteria. As a result, larger, already established companies are usually preferred when buying an EHR software, while software from start-ups is also used for smaller applications. According to doctors, the most significant barrier for start-ups is the approval procedures that software has to go through to enter the market. For example, the software needs numerous certifications, which costs time and money.

Challenges with the current EHRs

The following lists the difficulties mentioned by physicians when using EHRs. These can be summarized in 10 categories, starting with the most frequently mentioned. The categories include the following: Usability, Administrative character, Training, System settings, Increased time spent in front of the computer, Interoperability, Interference susceptibility, Differences between the real and the digital world, Service, and System maturity.

Usability

According to physicians, the EHR is complex and clumsily structured, making intuitive operation impossible. Due to the many branches in the programs and the unclear structuring of the digital files, doctors often have to search for individual documents for a long time. It was often mentioned that the EHR is developed by engineers and might be intuitive for them, but not for doctors. Thus, the software may be built by people who have never worked in a hospital and therefore do not know the daily clinical routine. As a result, many issues are not self-explanatory, making many callbacks with the technical support necessary.

In addition, the EHR often runs very slowly, so the speed at which the data is available has been criticized. Consequently, it takes a long time to load different documents, or it takes time to get to the individual files. Thus, physicians reported that this leads to a loss of time that could be used for the patient. On top of that, many different passwords have to be constantly re-entered. Doctors reported that if they do not use the EHR for a short time, the passwords must be directly re-entered. Even though doctors advocate a high level of patient safety, all the security precautions take up much time.

Furthermore, it emerged from the interviews that there are many different, sometimes small, functions that doctors are unaware of and therefore do not use, making the software even more complex. According to doctors, all these points are reasons why the popularity of EHRs is low. All this leads to physicians classifying EHRs as user-unfriendly. The doctors agreed

that they would rather spend as little time as possible with IT and more time having good conversations with patients.

"The programs are often created by people who have never worked in a clinic before. Accordingly, they don't understand the daily routine. A program created by a computer scientist is well-structured for him, but not for a clinician."

Administrative character

In addition, the administrative character of the current EHRs was mentioned. According to the doctors, the existing software is primarily a documentation platform. So basically, the EHRs provide a list of documents that doctors can click through page by page. The issue with the current EHRs is, according to the doctors, that the medical character is missing and thus functions such as a graphical representation of specific values or dashboards. Currently, it is possible to see some vital signs over time, but such functions are still very limited and should be promoted. Physicians want to compare blood values and display them on dashboards to get an accurate overview of the patient. This also includes the mapping of therapy progressions and the evaluation of patient-reported outcomes. The doctors criticized the fact that they cannot see all the information in the system simultaneously, although they would like to have an overview of all the relevant details.

"What I miss is the medical character of the systems. (...) Currently, they have more of a documentation function."

Training

The physicians stated that the EHR providers do not offer enough training opportunities to use the software with all its functions. Training is currently available in some hospitals, but opportunities are limited, so training is often insufficient to understand the whole software. Older doctors particularly reported this. As a result, some doctors are unaware of all functions and thus cannot use them. Therefore, better training options would have to be offered, which

should not take up too much time due to the high workload of the doctors, but still have to be informative.

"There was once an online training session of 20 minutes, but for me, it wasn't enough. This made it difficult for me to deal with the software in general."

System settings

Doctors often have a different overview of patient information than nurses because physicians often have a separate computer view in the EHRs with slightly different information. As a result, when writing a doctor's letter, physicians can take over part of the findings, but not the part that the nurses entered, as this information is often stored separately. Consequently, doctors often have to keep different pages open when writing doctor's letters and thus search for information in a time-consuming way. Ultimately, doctors agreed that this issue also hinders good cooperation between doctors and nurses.

Furthermore, there is currently no possibility to personalize the EHR. Thus, all doctors have the same overview of patient information. However, some specialties require different information about the patient than other medical specialties, so doctors reported it would be beneficial to have the opportunity to customize the screen. This way, each department could see the information they need without clicking through all the partially non-relevant information beforehand.

"When I write a doctor's letter, I always need to have different programs open because nurses often enter their results somewhere else than doctors."

Increased time spent in front of the computer

Most physicians agreed that they spend significantly more time in front of the computer typing all the information into the EHR. In addition, the way notes are entered into the computer was described as more complex than it is with handwritten notes. Unlike handwritten notes, doctors have to log on to the computer, find the right program and then

type the notes. This leads to more time-consuming documentation, and often there is less time for the patient. The patient contact has also changed, as, during the conversation, doctors already try to enter as much information as possible into the EHR. According to doctors, this leads to a changed doctor-patient relationship with less eye contact. This makes treatment tailored to the patient more difficult and increases doctors' frustration.

“It is much quicker to make handwritten notes and then to scan these notes than to enter everything digitally.”

Interoperability

Since hospitals have a diverse IT landscape and many different systems in use, some of which are outdated and no longer being developed or updated, some do not have interfaces with other systems. As a result, it is not easy to transfer data from one system to another. Thus, data may first have to be printed and then scanned before it can be stored in the EHR.

Physicians frequently reported that the intensive care unit often works with a different program than the regular ward or the emergency department. When a patient is transferred from one ward to another (or goes through all three wards), doctors have to go through all the respective programs to find all relevant information. This usually requires physicians to have all different systems open, which is very time-consuming. In addition, there is also no possibility to transfer medication from one ward to another. When a patient is transferred to another ward, a nurse or a doctor has to look up the drug in the old program and move it to the new system. This again costs time and can also lead to errors.

Moreover, when the laboratory results arrive from the house laboratory, it is possible to enter them directly into the EHR. If the lab results come from an external laboratory, the results must first be scanned at a scanning center and can only then be assigned to the respective patient. This leads to much time spent on scanning and sorting.

According to doctors, there are systems where hospitals can purchase the interfaces, but these

are expensive and typically not included in the standard portfolio. If the interfaces are available, they must be regularly checked and financed. Especially when the individual devices receive an update, the extent to which the interfaces still function must be checked regularly.

"You can't transfer documents from one program to another. It drives you crazy."

Interference susceptibility

The EHRs are highly susceptible to errors. Several doctors reported that they could not access patient data when the software crashed until the problem was solved. Then only emergency examinations can be carried out. This can lead to certain treatments being protracted for patients because no information can be retrieved. At the same time, it increases the frustration of doctors. All this leads to limited reliability of the software.

Moreover, many doctors agreed that the WIFI situation in German hospitals is not sufficient to be able to work fully digitally. There is no internet connection in some rooms, so digital work cannot be carried out there. Many doctors mentioned it limits digital work and leads to high dissatisfaction among physicians. Doctors stated that the basic requirements, such as a stable internet connection, are not met in some cases, making it challenging to work digitally.

"When a computer crashes (...), nothing works anymore. Then there is no way to continue working. (...) One is very dependent on the functioning of the electronics."

Differences between the real and the digital world

Doctors mentioned a discrepancy between the information in the EHRs and the current status. Everyone must fully submit to the system to ensure that the information in the EHRs corresponds to the current status. However, this is often not the case, so usually, information must be rechecked. For example, when administering medicines, doctors often have to check again whether a particular drug has been administered. Usually, the medication was prescribed but not entered into the EHR. As a result, the status in the EHR does not

necessarily correspond to the current situation. This leads to a duplication of work for the doctors, as many aspects must be clarified again.

“When I order a medication digitally, I have to check again later in person whether the medication was administered. This is also due to a lack of staff because nurses have too little capacity, but then digital communication is useless if I have to ask for everything again in person.”

Service

The customer service offered by the EHR vendors was criticized. Doctors reported that feedback is not taken into account, and therefore errors in the software sometimes remain for years. Many doctors said that once a hospital has bought the software, the customer service decreases and a hospital has to pay a lot for a particular service. Consequently, doctors often do not use the service and prefer to spend the money on other investments, such as new equipment.

"The service of the companies is very poor. We send feedback regularly, but we have the feeling that it is not taken seriously."

System maturity

Physicians reported that different programs that can be integrated into the EHR are often early entering the market and, as a result, are often not yet fully functional. Doctors estimated that one-third of the programs are technically mature and two-thirds are not yet fully developed. This can lead to very patient-endangering situations. The order in which programs are improved is based on operational and financial aspects of the companies and not on what is most important to the physicians. Consequently, problems sometimes persist for years, or the hospital tries to ensure that it can improve the issues with the help of its own IT.

"I have the feeling that we in the hospital sometimes have to be very experimental with the software."

Even though many EHRs do not meet physicians' expectations, it is a difficult process for a hospital to change the software. The main reasons are the extremely high costs of buying a completely new software and running both software systems simultaneously for a short period to replace the old software. In addition, there are high costs of training for the new system. The procedure is very complex that most hospitals decide not to change it.

Improvements

The following section lists the improvements and additional features physicians would like to have included in their EHR, starting with those mentioned most often. These are both completely new features as well as improvements to the currently existing software. They can be divided into the following nine categories: User-friendliness, Dashboards, Algorithms, Voice recognition, Documentation effort, Systems, Process automatization, Patient involvement, and Handwriting recognition.

User-friendliness

All doctors agreed that the way of using the software must be adapted. In particular, the focus should be on ensuring that physicians can easily and quickly navigate through all the information and that all relevant documents can be viewed with just a few clicks. It should be possible to see immediately what a patient was prescribed yesterday, today, and the next day. In addition, a clear presentation of the patient's previous illnesses, allergies, chronic diseases, and medications is essential. This guarantees that errors, for example, due to unknown allergies can be avoided. According to physicians, all this requires better functionality and usability. In addition, more intuitive use with more straightforward steps would also significantly increase the acceptance of EHRs.

The software design is also of particular importance and should be engaging. This also includes personalization. Doctors pointed out that for some specializations, such as internists, different information is important than, for example, for cardiologists. Therefore, a

customized view with the most important information for the respective specializations is of interest.

"The key thing is that I can move quickly through all the information. If I have a question: Has the investigation been done? What are the results of the investigation? When was the last time it was done? I need to find that kind of information quickly."

Dashboards

Doctors often reported that they don't have the opportunity to retrieve information from dashboards, although most would consider it necessary. Currently, it is often only possible to click on individual values via the labor matrix and see their development over time. Dashboards should provide a clear overview of the patient with graphical and tabular representation.

The doctors emphasized that the visual representation of specific blood values is essential, as well as the graphical illustration of therapy progress, including data points. The focus should be on the clear, easily understandable, and timely presentation of all medical data and processes necessary for treatment. Physicians emphasized that in this way, data collected by doctors through the dashboards could also be used and analyzed to define the most successful therapies or to adjust therapies accordingly.

"It would be very useful if the therapy progressions could also be displayed graphically, i.e., with curves and data points, so that a more objective record could be made."

Algorithms

Although physicians agreed that specific algorithms and artificial intelligence are heavily regulated in Germany, various algorithms were proposed. As a result, artificial intelligence is currently mainly used in research. Doctors agreed that algorithms that indicate drug interactions would be of particular importance even though such a function already exists at some physicians' facilities. This also includes alarm functions that alert when a drug is

administered at too low or too high a concentration or if a medication is prescribed twice. These functions would increase patient safety. In addition, algorithms were mentioned that alert doctors to certain risk constellations, such as patients at risk of thrombosis or allergies. Especially in hospitals, where many different patients are cared for and where it is accordingly more difficult for doctors to get an overview of each health status, it is important to point out risk constellations to doctors. According to physicians, this would lead to a certain level of patient safety, and mistakes can be avoided.

After entering specific keywords in the anamnesis field, diagnostic suggestions were also mentioned as helpful. At the same time, it was stated that specific standard therapies or best practices should be displayed as soon as a diagnosis is entered. This would ensure that best practices can be followed and good results achieved.

"Artificial intelligence or algorithms at a low level would be useful, such as having an algorithm point out constellations of risk. This could prevent mistakes. We don't have anything like that."

Voice recognition

Voice recognition is a technology that can reduce workload and lead to more time for the patient. There are currently two different methods in Germany. Doctors either already use a voice recognition device or speak the text into a cassette, which an employee then types out. The physicians who already use voice recognition reported a simplification of their work. However, some aspects were mentioned why the current devices are not fulfilling. The systems have to be trained in the respective language of the physicians, which takes several weeks. As a result, the systems have a slow learning curve and can only be fully used after weeks of training. In addition, doctors often speak with many abbreviations and medical terms that the current voice recognitions do not know. Consequently, the reports resulting from voice recognition are often erroneous and must be revised again, which takes time. Moreover,

doctors reported that it can take some time for the devices to be activated, so voice recognition is not considered worthwhile for short reports. However, voice recognition helps speed up physicians' work, so such a device is of interest to most physicians. In addition, physicians mentioned that the text generated by the voice recognition devices should be directly available in the EHR.

"When I dictate something, it's a full text, like a story, and the voice recognition systems are bad. Then we use Google or Siri to some extent."

Documentation effort

Doctors spend a considerable amount of time writing reports such as doctors' letters. To reduce the documentation effort, it would be necessary if there were already pre-fabricated forms for some documentation work, such as the creation of doctors' letters. These would then only have to be individually adapted by the physicians. This also includes the provision of individual text modules, technical terms, and a form of auto-correction. Currently, this is not automatically available in most EHRs, but it must be acquired individually through a license and must then be installed by an IT specialist. Therefore, many doctors stressed that it would be important to create such templates themselves or if such templates were automatically available in the EHRs. Ultimately, this could reduce the documentation effort.

"It would be great if there were more templates. Then you wouldn't have to start from scratch again and again but could use certain templates as a guide. That would save time."

Systems

As already mentioned, the interface problem is a significant issue for physicians. Therefore, doctors stated that bringing together different functions in the EHRs would be essential and, above all, would facilitate the processes. However, doctors emphasized that it will not be possible to use a single software for an entire hospital, as many departments require specialized software. Nevertheless, more functions should be integrated into the EHR to

reduce interface issues and the number of programs needed.

According to doctors, nurses and physicians must have the same or at least a similar overview of the patient data in the HER. This would ensure seamless collaboration between doctors and nurses. In addition, this also guarantees that doctors can see all relevant information such as vital signs or blood pressure immediately, without having to extract the data from various documents. This would ultimately reduce the amount of work involved in writing a doctor's letter.

“The combination of many functions in one program would be essential and would facilitate a lot.”

Process automatization

Another feature that was mentioned can be summarized under the term process automatization. This refers to tasks that take a lot of time and could be completed rapidly with the help of appropriate software. These include, for example, forms that doctors have to fill out regularly for the patients. Currently, doctors have to re-enter the patient's data, such as name, weight, etc., into the new forms each time. This is very time-consuming and error-prone. If a patient number, for example, is not entered correctly, the document cannot be assigned to the patient, and documents disappear. Therefore, a system would be needed that could transfer patients' facts from one form to a new one.

In addition, the many e-mail inquiries from patients were mentioned as an example. Patients often send emails asking for reports, lab results, or doctor's letters. Here, a system was suggested that could read the patients' requests from the emails and automatically send the corresponding documents (doctor's letters, etc.). This would save much time for the nurses who currently do this.

“We have to fill out many forms. It would be very helpful if information that has to be entered regularly did not have to be entered manually over and over again, but if software could take

care of something like that. That would lead to fewer errors.”

Patient involvement

Some doctors advocated that patients should access some of the data stored in the EHRs to ensure the best possible care with patient integration. This includes, for example, labor reports that patients could then download on their own. This would allow them to manage their disease actively. In addition, patients could then also fill out different questionnaires about their health status and upload them directly into the EHR. Doctors stated that they could then easily track progress and adjust treatment plans if necessary. With patients' consent, this data could also be used for research purposes, and treatment methods could be continuously improved.

"If we want to achieve good outcomes, we have to work together with the patient. For this, the patient must be actively involved."

Handwriting recognition

A few doctors find handwriting recognition useful, meaning a way to convert handwritten notes directly into the corresponding text. Doctors could take notes directly on an iPad, which could then be converted into text. However, the prerequisite is that all doctors would also be equipped with iPads, which is currently not the case. Nevertheless, doctors could spend less time typing notes in front of the computer.

“Anything that helps to stop sitting in front of the computer (...) would be a great relief. If such handwriting recognition systems would work, that would be great.”

5. Discussion

Most of the problems of current EHRs presented in the literature section, such as usability issues and difficulties in using data, could be confirmed based on the interviews. According to the literature review, technological changes are the main trends associated with EHRs. These include data lakes and blockchain, which can facilitate data sharing and provide for its security; AI and ML, to create a working platform that can be improved over time; and NLP so that language can be recognized, synthesized, and information can be stored accordingly. These trends are only to some extent in line with what was found in the interviews. Based on the interviews, which showed similar results in all countries, physicians have both technology-based and non-technology-based aspirations for future EHRs. Therefore, the following section focuses on the insights from the interviews. Building on the issues and improvements most referred by physicians, six recommendations (A to F) were developed to enable EHR vendors to become the market lead. These include implementing workflow automation to ease medical work, investing in alerts to promote patient safety, creating value by offering a complete set of information, increasing user-friendliness, developing a customer success team and designing SaaS training, and implementing an improved voice recognition software.

It is important to note that the suggestions do not necessarily apply to all EHR vendors. It is essential to bear in mind that the vendors offer software with different functions and, therefore, may already have some of the recommendations implemented. The aim should be to implement the recommendations so that the EHR software becomes more popular amongst physicians. At the same time, it offers EHR providers the opportunity to improve the software, leading to qualitative product differentiation.

An implementation process, examples of best practices and key performance indicators (KPIs) are provided for each recommendation to implement the suggestions in the best possible way. The implementation process describes some of the necessary steps that need to be taken to

successfully implement the recommendations and are based on the insights from the interviews. The best practices are examples of companies working in the same industry that have successfully implemented the recommendations and have therefore been considered best practices. For this purpose, research was conducted, and the companies that performed well either according to facts or figures were taken. The corresponding KPIs are either KPIs used by the companies from which the best practices come, KPIs built upon the interviews or KPIs from the existing literature. The recommendations are explained in detail below.

A. Implement workflow automation to ease medical work

EHR developers should promote automation by simplifying repeatable tasks. This idea includes streamlining the documentation process. For instance, EHRs should offer pre-edited forms for each service or clinical act. Doctors then only have to enter the information about the patient without having to create a template beforehand. Furthermore, data such as socio-demographic or hospitalizations information, already stored in the EHRs, should be automatically integrated into all the documents required to reduce tasks duplication and the time spent editing reports. Moreover, EHRs vendors must develop an intelligent writing system. These systems should propose words and sentences and correct mistakes to decrease the documentation burden.

By investing in these functionalities, EHR vendors reduce the workload of physicians, as they do not have to spend time preparing templates. Furthermore, pre-edited forms reduce free log reporting, promoting the standardization of data and thus easing its use. Moreover, by having a feature that automatically integrates the data already stored in other documents into new forms, clinicians only must add the most relevant information. Furthermore, this investment enables physicians to focus on care delivery, raising motivation, and reducing burnout.

Implementation process

To develop pre-edited forms, EHR vendors should talk to many physicians to determine which documents can be pre-edited and how these documents can be organized to include all relevant

information. Moreover, EHR developers must invest in technological resources to automatically review the written text and integrate the data into any required report. For this purpose, vendors can leverage machine learning and its ability to read and categorize data to achieve automation capabilities and improve usability.

Best practices

Cerner is an EHR vendor with a solid European presence that invests in increasing workflow automation. Cerner's feature Essential Clinical Dataset (ECD) enabled New Jersey's hospital to speed up nurses' triage assessments by rearranging pre-edited forms. This was possible by evaluating the relevant fields on the admission and patient history forms and eliminating duplicate areas and irrelevant information. This approach enabled physicians to benefit from a more straightforward documentation process, not requiring additional training. Nurses saved an average of 62 seconds per patient consultation, translating into 190 hours saved per year, and 15 clicks per patient encounter, which equals 165,360 fewer clicks per year (Siwicki 2020).

Key performance indicators

Based on Cerner to assess the success of these recommendations, EHR vendors should focus on measuring the decline in time spent editing reports and the decrease in documentation errors.

B. Invest in alerts to promote patient safety

EHR developers should invest in features able to leverage patient safety. This scenario can be achieved by controlling prescriptions. For example, EHR vendors could invest in features such as alerts that notify providers in case of drugs prescribed twice, dosage excess, allergies, side effects of drugs, or medications interference with other medicines. In addition, EHR vendors must give access to critical information on time. This includes alerting clinicians when patient values surpass the usual standards. Furthermore, EHRs should measure risk - surgical, cardiac, among others.

These features would allow physicians to leverage patient safety, reducing professionals' risk of overlooking important details among the high amount of information.

Implementation process

EHR developers must first learn from data to then be able to provide algorithms that can then alert automatically on pre-defined circumstances.

Best practices

Cerner also stands out for initiatives aligned with an increase in patient safety.

Regarding drugs prescription, the Yavapai Regional Medical Center, by partnering with Cerner, implemented a program to monitor drug prescription to help clinicians recommend the exact amount of medicine the patients need. The system enabled professionals to reduce prescribed opioids by 6%, thus preventing situations of incorrect prescription (Cerner 2020).

Moreover, the EHR option that alerts providers in situations where the patient's condition might deteriorate, enabled the Children's Cancer Hospital in Egypt to prevent the worsening of diseases. The facility registered with the support of this functionality a reduction in code blue (call for essential life support directly) and yellow (transference for urgent Intensive Care Unit (ICU)) situations to 28% and 44%, respectively. Cerner has also helped increase the accuracy of transferring patients to the ICU by 90% (Cerner 2021).

All these investments considerably leverage the Cerner product quality, increasing its demand and revenue, which register an increase of 7% year-over-year (Sheth 2021).

Key performance indicators

To assess the success of the alerts implemented, companies should focus on measuring the decrease in prescription errors and the time in which critical patients are assisted to ensure they are receiving a quicker response. These metrics support the rise in safety standards.

C. Create value through the offer of a complete set of information

EHR developers should offer health care professionals a complete set of data to analyze their performance better and raise efficiency.

Therefore, EHR vendors must allow doctors to study different information categories, such as exam results, medications' reaction, treatment outcomes, procedural costs, among others. This information should be displayed over time through interactive dashboards. These dashboards should also allow physicians to filter information, analyze data in more general and detailed perspectives, change the parameters to study with just one click, and preview scenarios by editing the data presented.

These improvements would allow providers to evaluate their performance better. Consequently, facilities would understand the conditions in which they deliver the more remarkable outcomes, thus moving towards specialization. Patient monitoring would be leveraged, decreasing the risk of overlooking important information. Likewise, physicians would spend less time looking for information since it would be available on interactive dashboards. Finally, this investment would ease clinical research, promote medical progress, and achieve the best clinical practices.

Implementation process

There is a need to standardize data and develop data curation, mining, and analysis processes for the three recommendations stated. EHR developers should measure outcomes according to the following organizations and include those metrics into the EHR for this procedure to be possible. Those organizations are the International Consortium of Health Outcomes Measurement (ICHOM) and the Patient-Reported Outcomes Measurement Information System (PROMIS). They work for international outcomes standardization. This measurement ensures access to the most relevant information and allows conclusions to be drawn about the efficiency of treatments. Finally, EHR vendors should invest in the technical resources to

appropriately display the outcomes measured and enable professionals to compare them over time through interactive dashboards.

Best practices

Health Catalyst is a data platform that helps healthcare organizations optimize their services by integrating and learning from information in their data warehousing. The company has a presence in 250 hospitals and 3000 clinics and impacts nearly 70 million Americans (Health Catalyst 2021). The company helped Mission health, a nonprofit organization, in improving data analytics. Due to a decline in reimbursement rates, the organization wanted to redesign clinical pathways to optimize care and reduce errors in operating room workflows. To do this, the organization needed more valuable information on the topic to ensure efficient decision-making processes. Through collaboration, Mission Health gained access to a customized dashboard. This dashboard intuitively displayed information, summarized data, and enabled providers to filter data. This investment allowed professionals to make more proactive decisions. Moreover, there was a decrease in 85% of professional hours dedicated to data analysis and a rise in 20% in the readiness of professionals and equipment (Health Catalyst 2015).

Key performance indicators

To assess the value created for professionals, EHR companies should focus on measuring the time spent analyzing data, operational gains, increased successful patient outcomes, and new research initiatives.

D. Increase the user-friendliness

The poor user experience and complex user interface of EHRs make a change in usability imperative. Usability in this context means that the EHR should be used effectively, efficiently, and with high satisfaction. To achieve this, the EHR vendors must ensure that some aspects are adapted and new ones are implemented.

First, the EHR should be simply structured so that doctors can easily navigate their way around and find all relevant documents quickly. For instance, more information should be included in each patient file so that doctors can see all information about the patient at once. Moreover, greater simplicity is essential so that doctors can use the software easily without a lot of training upfront. In addition, customizable features are required to meet the individual needs of doctors and each department. This includes, for example, different layouts within the EHRs that physicians and the individual departments can customize. This way, physicians and the departments can only see the information that is relevant to them. Last but not least, the user interface is usually very outdated. Therefore, the design of the EHR should be adapted accordingly. The design of the software should be minimalistic but still appealing.

Doctors can spend less time documenting and searching for files with a more user-friendly EHR. This, in turn, means that more time can be spent with the patient, and the popularity of the EHR software can be increased.

Implementation process

To successfully implement the above recommendations, it is first and foremost crucial to talk to many doctors to understand the clinical workflow. Observing the doctors directly at work and conducting interviews about problems, needs, wishes and understanding the environmental impacts is necessary. This way, it can be ensured that the desired changes will be appropriately implemented. Even during the implementation phase, it is crucial to keep asking for feedback to ensure that doctors are satisfied with the changes. This process ensures that the modifications requested by the end-users are implemented in the best possible way.

Best practices

Despite the high level of dissatisfaction, a few providers still meet doctors' expectations. Medscape surveyed 15,285 physicians and found out that "Amazing Charts" scored highest in the category "Ease of use" in several years and can therefore be seen as best practice. According

to Medscape, ease of use means simple data entry and quick software learning (Peckham 2016). This enables doctors to work effectively with the software, leaving more time for patient care. The EHR software was founded by a physician himself, who can therefore understand the needs of physicians and has paid particular attention to a high level of usability. To achieve this, the company has emphasized making the EHR look like a paper chart so that it is easy to use for all users (amazingcharts 2021).

Key performance indicators

To determine the extent to which usability has been increased, two KPIs were proposed by the interviewees. Firstly, a survey should be conducted before the implementation and after introducing the changes with different questions that can be answered, for example, on a scale from "strongly agree" to "strongly disagree". After conducting the surveys, EHR vendors should compare the results to the pre-change feedback to determine how much the user experience has or has not improved. Moreover, the EHR providers should measure the time doctors spend on a specific task. The shorter the processing time, the better the user experience and thus the success of the implementation.

E. Develop a customer success team and design SaaS training

The users will only be open to the EHR functionalities if they understand it and its benefits, thus increasing the perceived usefulness. When introducing new software or updates, one of the most important tasks is ensuring that customers are involved and understand how it works. To achieve this, EHR vendors should invest in training programs.

Training programs should be directed to new and existing users. For customer success, it is important to explain software features in detail so that employees understand the full benefits of the software. To add on, content – such as videos – that explains how certain actions are performed, should be provided. The videos should be short and clear so that customers can use them in a moment of need. Consumers should be told about this content, which must be

available within the EHR. The EHR vendors should offer two types of content, demos for short tasks, and online help explaining certain functions or features. In addition to instructor-led training and providing a hands-on experience, it is also important to provide self-paced learning, as this is usually less expensive, faster, and easy to maintain as new updates are made.

These training opportunities will be essential to ensure that both new employees understand the software and existing employees stay up to date. The better informed a customer is, the higher their value and chances of success. By improving customers' product knowledge, their perception of value increases, and it is possible to reduce churn. By increasing value perception, customer experience is improved. Through good experience and feedback, the software can strengthen customer advocacy and attract more customers. In addition, all these benefits lead to proactively guiding the customer to success.

Implementation process

Designing effective training can be challenging because the software can be updated or changed, and previous training may become irrelevant. Therefore, the design must be as effective as it is compelling yet flexible enough to adapt to new changes. It is essential to talk to the target audience, whether they are managers, physicians, nurses, or others, and who the key users are. This is critical to adopt a centralized strategy with a model focus on the customer. This model should not only consist of a Customer Success Team but also include Product, Sales, Support, and Marketing teams to ensure that the customer is truly satisfied.

Best practices

To understand the benefits that can come from deploying a customer success team and providing training to ensure the best possible experience, one can look at CloudShare. CloudShare specializes in providing hands-on virtual demos and training, which ultimately leads to higher user engagement, customer retention, and lower support costs. The company, which works with names such as Dell and Salesforce, has delivered results such as increased

visibility into partner usage, which allows companies to understand how active users are in the environment. It also enables a significant reduction in management-related tasks in due time, improves partner efficiency by helping to streamline and optimize the work process, and significantly enhances the user experience, resulting in an increase in overall activity (CloudShare s.d.).

Key performance indicators

To understand if learning systems are effective and to assess their performance, the company should focus on indicators such as the number of learners/ enrollments to understand how many employees are currently participating in training and whether it is readily available. It is also important to verify the number of completions. Together with the previous indicator, it allows the company to determine whether customers are embracing the training sessions and do not give up. Furthermore, it is vital to assess the hours engaged with training; by analyzing this metric, it is possible to adapt future training to the attention span of customers, thus making it more effective. Lastly, assessing customer satisfaction is also essential, as it allows the company to determine if the training provided meets customer expectations or if it needs to be improved.

F. Implement an improved voice recognition software

Although NLP and voice recognition are not yet part of a market standard, based on the study conducted, more and more EHR vendors are adopting this new technology to improve workflows and meet clinicians' needs.

Therefore, the recommendation for EHRs vendors that want to stand out in an increasingly saturated market is consequently to implement health-oriented voice recognition software. One of the main advantages of this technology is that it saves physicians much time. Therefore, it is important that the software can recognize all clinical terms and has high accuracy - typically, medical transcriptionists quote an accuracy rate of around 99%, while current speech recognition software only achieves 70-90% (Nibity 2020) - so the software needs to be in the

upper range of expectations to be useful. Given this liability, there must also be a way for physicians to edit and correct the text derived from what has been said. Finally, it would also be advisable to have either a button or a voice command so that the software understands when to start "listening"; in this way, it would be possible to reduce the complexity behind the software, increase accuracy, and improve implementation results.

This increases the attractiveness of the product and suggests higher customer satisfaction, which in turn increases acceptance.

Implementation process

The EHR providers can either outsource development or develop it itself to implement such complex software. Although most experts favor outsourcing development, both options offer advantages and challenges.

On the one hand, when outsourcing, the company can expect the software to be available faster, with a quality guarantee and constant support in case of updates or other problems. As mentioned above, experts consider outsourcing the best option, as it is crucial to get to the market quickly, and it is the faster and more reliable method. In addition, by outsourcing the development, the voice records used are stored by the software vendors, and issues with the European Commission Health Policy Platform are out of the hands of the EHR providers, which is a major advantage compared with developing the software internally. However, this option also brings some disadvantages. There can be language barriers – since most companies that develop such technologies do it in English – and it can be difficult to find a good and reliable partner in countries like Portugal, Spain, or Germany.

On the other hand, EHR vendors may choose to develop the software in-house. It is essential to keep in mind that additional investment in a tech development team is required, and the entire process takes longer. Still, this option provides the opportunity to develop a voice recognition

software that focuses on precise clinical terms and, more importantly, is designed for a specific language.

Regardless of the option chosen, there are some key features to consider when implementing the technology, and these are the ones the EHR providers must focus on. First, physicians and administrators seem to agree on three key outcomes: The process must be cost-effective - unlike current medical transcriptions; it must improve patient care, and it must be profitable.

Best Practices

To better understand the benefits and prospects of this technology, one can turn to Nuance Communications. The company has been developing voice recognition software for more than 20 years and has extensive expertise in the field.

According to the company, it has achieved positive results in two different environments. In one of them, on an outpatient department, not only were turnaround times (time for the doctor to get back to the patient) reduced from several weeks to a few days, but outsourced transcription costs were also significantly reduced. In addition, clinicians' workloads were reduced considerably, allowing them to admit more patients. Another application that shows the technology benefits was in the emergency department, where clinicians were able to save up to 40% of their time (about three and a half minutes per patient), improving overall processes. In addition, similar results were found in the primary care and mental health departments (Nuance Communications 2020).

Key performance indicators

Voice recognition software is designed to understand conversations in real-time. To ensure accurate recording, some key criteria should be observed and analyzed to evaluate its effectiveness (Vallath 2020). If it is effective, it can be used successfully. According to Vallath (2020), the leading indicator must be the word error rate (WER) – useful to test the software. It indicates how many words were correctly entered by the software. It considers substitutions (S)

– when an incorrect word was recorded; deletions (D) – words that were not recorded by the software; insertions (I) – words that were not spoken; and the total number of words (N); and goes according to the formula. This ratio is particularly important for testing clinical term recognition and should be less than 25% to be considered average.

The aforementioned metrics are important for understanding how effective the software is. Nevertheless, one should also evaluate the technology's benefits to its users. Therefore, analyzing other key metrics, such as perceived usefulness, that is particularly helpful in understanding whether the software is helping physicians improve their workflow; cost efficiency; and time spent per patient to understand if it can improve the overall clinical process.

6. Conclusion

The demands on current EHRs must encourage EHR vendors to rethink their product. This becomes evident, among other reasons, because no EHR vendor has yet managed to become the market lead in the European market. The software should support doctors in their daily clinical routine, leaving more time for the patients. However, the workload has increased, leading to doctors' dissatisfaction and sometimes even burnout. In addition, there are interoperability problems that make seamless communication between the IT systems difficult. Furthermore, new technologies such as AI or ML are also shifting the demands on EHRs in the future, which must be considered.

To understand the challenges doctors have with their current EHRs and to find out about their suggestions for improvement, a total of 57 interviews were conducted with physicians and experts in Germany, Portugal, and Spain. Additionally, nine interviews were performed with technical specialists to find out more about the feasibility of implementing breakthrough technologies such as blockchain, ML, and NLP. Based on the insights of the interviews, a total of six recommendations could be given to the EHR vendors. These include implementing workflow automation to ease medical work, investing in alerts to promote patient safety,

creating value by offering a complete set of information, increasing user-friendliness, developing a customer success team and designing SaaS training, and implementing an improved voice recognition software.

Implementing the recommendations and adapting the EHR will reduce the workload of doctors, improve patient care and increase the popularity of the EHR. Consequently, EHR providers will be able to move from a simple EHR to the market lead.

7. Bibliography

Acker, O., Naydenova, E., & Roberts, S. 2016. "Private Equity & Digital Transformation"
PWC.

Aerts, H., Dipak, K., Saez, C., Ramírez-Anguita, J., Mayer M., Garcia-Gomez, J., Hernández, M., Thienpont, G., and Coorevits, P. 2021. "Is the Quality of Hospital EHR Data Sufficient to Evidence Its ICHOM Outcomes Performance in Heart Failure? A Pilot Evaluation."
<https://doi.org/10.1101/2021.02.04.21250990>.

Agfa HealthCare, 2021. <https://global.agfahealthcare.com/about-us/>. Accessed 2021-12-13

Agfa. 2020. <https://www.agfa.com/corporate/about-us/our-company/business-groups/>.
Accessed 2021-12-13

Agrawal, A., Kellner, K., Krishnanand, J., and Reddy, P. 2021. "How HST Companies Can Boost Productivity with Data" McKinsey. [https://www.mckinsey.com/industries/health care-systems-and-services/our-insights/how-health care-services-and-technology-companies-can-boost-productivity-with-data-and-analytics](https://www.mckinsey.com/industries/health-care-systems-and-services/our-insights/how-health-care-services-and-technology-companies-can-boost-productivity-with-data-and-analytics).

AlbionVC. n.d. Accessed December 5, 2021. <https://www.albion.vc/sites/default/files/2021-09/HeathTech%20Primer%202021.pdf>.

Amazingcharts. Accessed December 13, 2021. <https://amazingcharts.com/2020/09/16/the-key-to-finding-a-user-friendly-ehr/>.

Ambinder, E. 2005. "Electronic Health Records. Journal of Oncology Practice" 1(2), 57-63.

Asseco. 2021. <https://asseco.com/offer/healthcare/>. Accessed: 2021-10-25

Asseco.2021. https://asseco.com/files/public/uploads/Asseco_company_profile_2020_EN.pdf.
Accessed 2021-12-13

Balasubramanian, Sai. 2020. "Northwestern University Has Developed An AI System That Helps Detect Covid-19 On Chest X-Rays."

<https://www.forbes.com/sites/saibala/2020/11/29/northwestern-university-has-developed-an-ai-system-that-helps-detect-covid-19-on-chest-x-rays/>. Accessed 2021-11-29

Bhardwaj, R., Nambiar, A., and Dutta, D. 2017. "A Study of Machine Learning in Health care." IEEE 41st Annual Computer Software and Applications Conference. IEEE.

Bjorn, Berg, Grant Longley, and Jordan Dunitz. 2018. "Improving Clinic Operational Efficiency and Utilization with RTLS." *Journal of Medical Systems*. (Springer) 43(3).

Boetto, E., Carullo, G., Fantini, M., Golinelli, D., Landini, M., & Nuzzolese, A. 2020. "How the COVID-19 pandemic is favoring the adoption of digital technologies in health care: a literature review." *Journal of Medical Internet Research*, 22(11).

Boulos, Maged, and Geoff Berry. 2012. "Real-time locating systems (RTLS) in healthcare: a condensed primer." *International Journal of Health Geographics* 11(25).

Burns, E., Laskowski, N., & Tucci, L. 2021. "What is artificial intelligence?"

Cabezas, I., and Villa B.. 2014. "A review on usability features for designing electronic health records." 16th International Conference on e-Health Networking, Applications and Services.

Centrak. n.d. "Real-Time Location System for Hospitals: Improving Facilities for Patients and Staff." <https://centrak.com/products/real-time-location-services/>. Accessed 2021-12-10

Cerner. 2020. "Prescription Drug Monitoring Program Helps Decrease Opioid Prescriptions, Saves Providers Time at Yavapai Regional Medical Center - Client Achievements."

<https://www.cerner.com/client-achievements/prescription-drug-monitoring-program-helps-decrease-opioid-rx-saves-providers-time-yavapai-regional>. Accessed 2021-11-10.

Cerner. 2021. "Children's Cancer Hospital Egypt-57357 Reduces Patient Deterioration with Help from Early Warning Score - Client Achievements | Cerner." n.d. Accessed December 15, 2021. <https://www.cerner.com/client-achievements/childrens-cancer-hospital-egypt-57357-reduces-patient-deterioration>. Accessed on 2021-11-05.

Cerner. 2021. Cerner: <https://www.cerner.com/about>. Accessed on 2021-11-28

CloudShare. n.d. "How Venafi Partner Activity & Efficiency With Cloudshare." Accessed November 28, 2021. https://fs.hubspotusercontent00.net/hubfs/20688800/Case%20Studies/Venafi_Case_Study_July_2021.pdf. Accessed 2021-12-13.

crunchbase. 2021. Crunchbase: <https://www.crunchbase.com/organization/lumeon>. Accessed on 2021-11-28

crunchbase. 2021. Crunchbase: <https://www.crunchbase.com/organization/heydoc-6b13>. Accessed on 2021-11-28

crunchbase. 2021. <https://www.crunchbase.com/organization/smart-reporting-gmbh>. Accessed 2021-12-13

Dagliati, A., Malovini, A., Tibollo, V., and Bellazzi, R. 2021. "Health Informatics and EHR to support clinical research in the COVID-19 pandemic: an overview." *Briefings in Bioinformatics*, 22(2), 812-822. <https://doi.org/10.1093/BIB/BBAA418>.

Daley, S. 2021. "How Using Blockchain in Health care Is Reviving the Industry's Capabilities." <https://builtin.com/blockchain/blockchain-health-care-applications-companies>.

Davenport, T., and Kalakota, R. 2019. "The potential for artificial intelligence in health care." *Future Health Care Journal*, 6(2), 94-98.

Deloitte. 2019. "Smart health communities and the future of health."

Deloitte. 2020. "2020 Global Health Care Outlook."

Deloitte. 2021. "2021 Global Health Care Outlook. "

Drees, Jackie. 2021. "EHR market share 2021: 10 things to know about major players Epic, Cerner, Meditech & Allscripts" <https://www.beckershospitalreview.com/ehrs/ehr-market-share-2021-10-things-to-know-about-major-players-epic-cerner-meditech-allscripts.html>. Accessed 2021-12-14.

Eisenstein, J. 2019. "Introduction to Natural Language Processing." The MIT Press.

El Naqa, I., and Murphym M. 2015. "What Is Machine Learning." In *Machine Learning in Radiation Oncology*, 3-11. Springer.

Faltin, F. 2020. "Speedinvest.". <https://www.speedinvest.com/blog/digital-health-in-europe-analysis-of-600-european-startups-from-the-last-decade>. Accessed on 2021-11-28

Frisina, P., E., Finnie, J., Oakley, J. Munene, and G. Ganesan. 2020. "Analysis of end-user satisfaction with electronic health records in college/university healthcare." *J Am Coll Health*.

Garcia, S., and Kristine R. 2019. "Persistent Systems o Beth Nauman, Director of Health Services Research at LPHI Advancing the Collection and Use of Patient-Reported Outcomes through Health IT."

Gholamhosseini, Leila, Farahnaz Sadoughi, and Aliasghar Safaei. 2019. "Hospital Real-Time Location System (A Practical Approach in Healthcare): A Narrative Review Article." *Iranian Journal of Public Health*, 593-602.

Giakoumelou, A., Raimo, N., Rubino, M., Salvi, A., & Vitolla, F. 2021. Online information on digitalisation processes and its impact on firm value". *Journal of Business Research*, 124, 437-444. Elsevier.

Glaser, J. 2020. "It's Time for a New Kind of Electronic Health Record." *Harvard Business Review*: <https://hbr.org/2020/06/its-time-for-a-new-kind-of-electronic-health-record> abgerufen. Accessed on 2019-11-05.

Graffa, R. 2018. "The Benefits and Challenges of Electronic Health Records." *Sehealth*: <https://www.sehealth-carequalityconsulting.com/2018/09/18/the-benefits-and-challenges-of-electronic-health-records/>. Accessed on 2019-11-08.

Green, A. and Liberty, M. 2019. "EMR-EHR in Acute and Ambulatory Applications." Amazon AWS: <https://s3-eu-west-2.amazonaws.com/signifyresearch/app/uploads/2019/03/27141607/EMR-EHR-in-Acute-and-Ambulatory-Applications-World-2019-Knowledge-Centre.pdf>.

Green, J. 2019. "Who Are the Largest EHR Vendors." 2019. <https://www.ehrinpractice.com/largest-ehr-vendors.html>.

Halambka, J., Lippman, A., & Ekblaw, A. 2017. "The Potential for Blockchain to Transform Electronic Health Records". Harvard Business Review: <https://hbr.org/2017/03/the-potential-for-blockchain-to-transform-electronic-health-records> abgerufen

Hannan, T. 1996. "Electronic Medical Records" Health Informatics: An Overview, 133.

Health Catalyst. n.d. "The Health Catalyst Approach" <https://www.healthcatalyst.com/who-we-are/the-health-catalyst-approach/>. Accessed 2021-11-10.

HealthCatalyst. 2015. "Operating Room Efficiency: Driving Improvements with the Use of Advanced Analytics." https://www.healthcatalyst.com/success_stories/operating-room-efficiency/. Accessed 2021-10-05.

Heart, T., Ben-Assuli, O., & Shabtai, I. 2017. "A review of PHR, EMR and EHR integration: A more personalized health care and public health policy." Health Policy and Technology, 6(1), 20-25.

Heydoc. 2021. <https://www.heydoc.co.uk/>. Accessed 2021-12-13

Heydoc. 2021. <https://www.heydoc.co.uk/about-us>. Accessed 2021-12-13

HIMSS. 2021. "HIMSS Annual European Digital Health Survey 2021." <https://www.plugandplaytechcenter.com/resources/7-leading-ai-healthcare-companies-2020/>.

Jack, A. 2021. "How Covid wrongfooted the health experts". Financial Times: <https://www.ft.com/content/a6de19b7-b28c-47c4-947d-5b0637fd4aef>. Accessed on 2021-10-08.

Jena, D., Mohanta, B., Patnaik, S., & Satapathy, U. 2020. "Survey on IoT security: Challenges and solution using machine learning, artificial intelligence and blockchain technology." Internet of Things, 11.

Kalra, D. 2018. "Making greater use of electronic health records to accelerate research."
Accessed on 2021-12-05

Kock, N., Parente, R., & Sonsini, J. 2004. "An Analysis of the Implementation and Impact of Speech-Recognition Technology in the Health care Sector." *Perspectives in Health Information Management*, 1(5).

Kroth, P., N. Morioka-Douglas, S. Veres, S. Babbott, S. Poplau, F. Qeadan, C. Parshall, K. Corrigan, and M Linzer. 2019. "Association of Electronic Health Record Design and Use Factors With Clinician Stress and Burnout." *JAMA Netw Open*.

Ku, L. 2021. "9 Leading AI Health care Companies in 2020".
<https://www.plugandplaytechcenter.com/resources/7-leading-ai-health-care-companies-2020/>.
Accessed on 2019-10-29.

Kyobe, M., & Mushore, R. (2019). "Optimizing the business value of digital transformation by aligning technology with strategy, work practices and stakeholder interests." *IEEE 10th Annual Information Technology, Electronics and Mobile Communication Conference*. 403-408: IEEE.

Lehne, M., Sass, J., Essenwanger, A., Schepers, J., and Thun, S. 2019. "Why Digital Medicine Depends on Interoperability." *NPJ Digital Medicine* 2019, 2(1): 1–5.
<https://doi.org/10.1038/s41746-019-0158-1>. Accessed on 2021-11-05.

Lumeon. 2021. "Next Generation Patient Access" Lumeon: <https://www.lumeon.com/next-generation-patient-access/>. Accessed 2021-12-13.

Mathis, C. 2017. "Data Lakes." *Datenbank Spektrum* 17 (3): 289–293.

McCullough, J., Greenwood, B., and Atasoy, H. 2019. "The Digitization of Patient Care: A Review of the Effects of Electronic Health Records on Health Care Quality and Utilization." *Annual Review of Public Health* 40: 487-500.

McKinsey. 2021. "The new digital edge: Rethinking strategy for the postpandemic era."
<https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/the-new-digital-edge-rethinking-strategy-for-the-postpandemic-era>. Accessed on 2021-10-28.

Nibity. 2020. "Speech Recognition 2020 Accuracy." Nibity: <https://nibity.com/speech-recognition-2020-accuracy/>. Accessed on 2021-11-28

Nikuliak, A. 2020. "Voice Recognition Technology for Effective Healthcare."
<https://www.scnsoft.com/blog/speech-recognition-healthcare>. Accessed 2021-11-29.

Nofer, M., Gomber, P., Hinz, O., & Schiereck, D. 2017. "Blockchain" Business & Information Systems Engineering, 59(3), 183-187.

Nuance Communications. 2020. "Reducing clinician burnout with speech recognition." Nuance Communications: <https://www.healthcareitnews.com/video/emea/reducing-clinician-burnout-speech-recognition>. Accessed on 2021-11-28

Peckham, C. 2016. "Medscape EHR Report 2016: Physicians Rate Top EHRs."

Potts, J., Davidson, S., and De Filippi, P. (9. March 2016). "Economics of Blockchain." Social Science Research Network: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2744751. Accessed on 2021-10-28.

Priyananadan, R., & Sharma, B. 2016. "Digitalisation: The Future of Health Care." Journal of Business Management, 126-135.

Raeve, P., and Jardim-Gonçalves, R. (2020). "Digitalising the healthcare ecosystem in the European Union." Health Europa, 13.

Reis, J., Perciani, E., and Bonacin, R. 2016. "Intention-Based Information Retrieval of Electronic Health Records." Proceedings - 25th IEEE International Conference on Enabling Technologies: Infrastructure for Collaborative Enterprises, WETICE, 217–22. Institute of Electrical and Electronics Engineers Inc. <https://doi.org/10.1109/WETICE.2016.56>. Accessed on 2021-11-05.

Reisman, M. 2017. "EHRs: The Challenge of Making Electronic Data Usable and Interoperable." Vol. 42.

Ruedig, Christoph. 2021. "AlbionVC." Albion VC: <https://www.albion.vc/blog/market-map-health-tech-startups-europe>.

Saenz, J., & Revilla, E. 2014. "Creating More Resilient Supply Chains." MIT Sloan Management Review.

Shahanz, A., Qamar, U., & Khalid, A. 2019. "Using Blockchain for Electronic Health Records." *IEEE Access*, 7(147), 782-795.

Siwicki, Bill. 2020. "How St. Joseph's Health Reduced Fields, Time and Clicks in Cerner EHR | Health care IT News." <https://www.healthcareitnews.com/news/how-st-joseph-s-health-reduced-fields-time-clicks-cerner-ehr-1>. Accessed on 2021-11-05.

Smart Reporting. 2021. <https://www.smart-reporting.com/de/firma/ueber-uns?hsLang=de>. Accessed 2021-12-13

SmartReporting. 2021. SmartReporting: <https://www.smart-reporting.com/de/products/smart-reports?hsLang=de>. Accessed on 2021-11-28

Stanford Medicine; The Harris Poll. 2018. "How Doctors Feel About Electronic Health Records National Physician Poll by The Harris Poll 2 Background, Objectives, and Methodology."

StartUs Insights. 2020. "5 Top NLP Startups Integrating Electronics Health Records (EHRs)." <https://www.startus-insights.com/innovators-guide/5-top-nlp-startups-integrating-electronics-health-records-ehr/>. Accessed on 2021-10-29.

Stasha, S. 2021. "The State of Health care Industry – Statistics for 2021." <https://policyadvice.net/insurance/insights/health-care-statistics/>. Accessed on 2021-10-30.

Statista. 2018. Statista: <https://www-statista-com.eu1.proxy.openathens.net/statistics/938799/ehr-market-size-forecast-globally/>. Accessed on 2021-11-28

Statista. 2021. <https://de.statista.com/statistik/daten/studie/1186389/umfrage/marktumsatz-fuer-digitale-patientenakten-ehr-in-europa/>. Accessed: 2021-12-05

Taylor, K., Properzi, F., Bhatti, S., Ferris, K. 2020. “Digital transformation Shaping the future of European health care.” Deloitte Centre for Health Solutions

Thomas, M. 2020. “15 Examples of Machine Learning in Healthcare That Are Revolutionizing Medicine.” <https://builtin.com/artificial-intelligence/machine-learning-healthcare>. Accessed on 2021-10-22.

Thranberend, T., and Haas, P. 2017. “SPOTLIGHT HEALTH CARE Electronic Health Records.”

Tsai, C., Eghdam, A., Davoody, N., Wright, G., Flowerday, S., and Koch, S. 2020. “Effects of Electronic Health Record Implementation and Barriers to Adoption and Use: A Scoping Review and Qualitative Analysis of the Content.” *Life* 2020, 10(2), 327. <https://doi.org/10.3390/LIFE10120327>. Accessed on 2021-11-05.

Vallath, S. 2020. “Key Metrics for Evaluating Speech Recognition Software.” <https://blog.symbli.ai/blog/key-metrics-and-data-for-evaluating-speech-recognition-software/>. Accessed on 2021-11-09.

van Eenennaam, Fred, Lena van Selm, and Marlou Smits. 2020. “Digital transformation for more effective healthcare: inspiring VBHC initiatives.” <https://www.apdh.pt/artigo/2>. Accessed 2021-12-10

Wachter, R., Goldsmith, J. 2018. “To Combat Physician Burnout and Improve Care, Fix the Electronic Health Record.” *Harvard Business Review*: <https://hbr.org/2018/03/to-combat-physician-burnout-and-improve-care-fix-the-electronic-health-record>. Accessed on 2021-11-05.

Y. Lee, Bruce. 2020. “How Doctors May Be Spending More Time With Electronic Health Records Than Patients.”

<https://www.forbes.com.cdn.ampproject.org/c/s/www.forbes.com/sites/brucelee/2020/01/13/electronic-health-records-here-is-how-much-time-doctors-are-spending-with-them/amp/>.

Accessed on 2021-11-05.

Yoo, S., Kim, S., Lee, S., Lee, K.H., Baek, R.M., and Hwang, H. 2013. "A study of user requests regarding the fully electronic health record system at Seoul National University Bundang Hospital: challenges for future electronic health record systems." *International Journal of Medical Informatics*, 5(82), 387-397.

Young, S., Hwang H., Keehyuck L., Donghyun L., Yoo, S., Kahyun L., Ho-Young L., and Kim, E.. 2021. "User Perspectives on Barriers and Facilitators to the Implementation of Electronic Health Records in Behavioral Hospitals: Qualitative Study." *JMIR Form Res* 2021, 5(4): <https://doi.org/10.2196/18764>. Accessed on 2021-11-05.

8. Appendix

Table 1: Interview Script

Interviewee	Questions
Physician	What do you understand by an Electronic Health Record
Physician	What is the EHR system operating in your facility?
Physician	What are, in your opinion, the main features and functionalities of the EHR software operating in your facility? What is the essential support you get from this software?
Physician	From your point of view, what are the most significant flaws of the EHR system?
Physician	Do you think that the System already answers all the needs of health professionals? What is missing?
Physician	How do you rate: <ul style="list-style-type: none"> a. The ease of accessing information through the System b. Technical support and Education on the System c. Decision making support d. Flexibility in document editing e. Sharing of opinions between the medical staff
Physician	To the best of your experience, do you consider that the EHR system you invest in makes it easier to measure final results, such as success rate in operations, mortality rate, and other quality indicators or progress charts? In other words, do you consider that the EHR software invested allows for better patient monitoring and inference when something is going less efficiently, making it possible to have a more effective results analysis and discussion meeting? If not, what are the barriers to this not happening? Do you think it would be essential to have an EHR oriented in this direction?
Physician	What improvements would you recommend?
Physician	Would you consider the following solutions useful? <ul style="list-style-type: none"> a. Handwriting Recognition b. Voice Recognition c. Increase in Training Programs d. Personalized User Interface e. Pre-defined EHR to draw attention when a patient's values go out of the usual picture
Management	How does the investment in the EHR systems work? Is this a public or private investment? Does the management board hold the buying decision to purchase the most suitable products?
Management	In terms of the product price, do you have any limitations in terms of investment? Do you have the liberty to purchase a higher-priced product that offers more convenient features?

Source: Annabelle Rauert & Maria Madalena Silva (2021): Own elaboration.

Table 2: Data from the professionals interviewed

Country	Region	Facility Type	Professional's Position	Facility	EHR
Portugal	Coimbra	Public Hospital	Intern (1)	Coimbra Hospital and University Center	S-clínico
	Lisbon	Management	Coordinator for Planning, Architecture, Compliance and Engineering	Shared Services of the Ministry of Health	-
	Lisbon	Management	Head of Advanced Analytics and Intelligence	Shared Services of the Ministry of Health	-
	Lisbon	Management	Former Hospital Administrator & Invited Assistant Professor	National School of Public Health, New University of Lisbon	-
	Lisbon	Outpatient Institutions	General Practitioner	Carnide Family Health Unit	S-clínico
	Lisbon	Outpatient Institutions	General Practitioner	Public Health Unit of the ACES Loures-Odivelas	S-clínico
	Lisbon	Private Hospital	Production Management	CUF - Descobertas	Glantt
	Lisbon	Public Hospital	Intern in Internal Medicine (1)	Santa Maria	EPR
	Lisbon	Public Hospital	General Surgery Internship (1)	West Lisbon Hospital Center - Sao Francisco, Egaz, Santa Cruz	S-clínico
	Lisbon	Public Hospital	Anesthesiologist (1)	Santa Maria	EPR

	Lisbon	Public Hospital	Anesthesiology Resident (2)	Hospital Dona Estefânia	S-clínico
	Lisbon	Public Hospital	Nurse	São José	S-clínico
	Lisbon	Public Hospital	Hospital Administrator Department of Medicine and Medical Specialties	Santa Maria	Sonho - Administrative EHR
	Porto	Private Hospital	Pediatrician	Lusíadas	Private Investment
	Santa Maria da Feira	Public Hospital	Executive Member of the Board of Directors & Clinic Director	CHEDV - Centro Hospitalar de Entre o Douro e Vouga, E.P.E.	Medtrix
Spain	Asturias	Private Clinic	Radiologist	Private Clinic	Private Investment
	Asturias	Public Hospital	Rheumatologist	Central University Hospital of Asturias	Millennium by Cerner
	Astúrias	Public Hospital	General practitioner & Interventional radiologist	Central University Hospital of Asturias	OMI-AP - General Practice Millennium by Cerner - Hospital
	Barcelona	Public-private partnership	Nurse	Hospital Clínic de Barcelona	SAP
	Galicia	Public Hospital	Otolaryngologist	Santiago Clinical University Hospital	IANUS
	Galicia	Public Hospital	Operating room nurse	Santiago Clinical University Hospital	IANUS
	Madrid	IT Facility	Healthcare data scientist	Bonsai Veritas	-
	Madrid	Outpatient Institutions	General practitioner	Centro de salud Los Fresnos	AP Madrid

Madrid	Outpatient Institutions	General practitioner	Centro de salud Los Fresnos	AP Madrid
Madrid	Outpatient Institutions	General practitioner	Centro de salud Brújula	AP Madrid
Madrid	Outpatient Institutions	General practitioner	Centro de salud Los Fresnos	AP Madrid
Madrid	Outpatient Institutions	General practitioner	Centro de salud Goya	AP Madrid
Madrid	Outpatient Institutions	Pediatrician	Centro de salud Los Fresnos	AP Madrid
Madrid	Public Hospital	Endocrine & Nutrition	Hospital Gregorio Marañón	HCIS
Madrid	Public Hospital	Nutritionist	HGU Gregorio Marañón	HCIS
Madrid	Public Hospital	General practitioner	Centro de Salud Brújula	AP Madrid
Navarra	Private Clinic	Internist and Hepatologist Investigator	Clinica Universidad de Navarra Principal	EHR specifically developed for the clinic
Santiago	Public Hospital	Nurse	Santiago Clinical University Hospital	IANUS
Zaragoza	Private Hospital	Nurse	San Juan de Dios	WinGesHos - Private

Observations:

- (1) - Use Alert in the Urgency Service
- (2) - Also gave insights on Soarian, used by Beatriz Ângelo

Source: Maria Madalena Silva (2021): Own elaboration.

Table 3: Interviewee's data

City	Professional's Position	Facility
Duesseldorf	Clinic Director	Universitätsklinikum Düsseldorf
Muenster	Clinic Director	Universitätsklinikum Münster
Emden	Chief Physician	Klinikum Emden
Muenster	Senior physician	Universitätsklinikum Münster
Duesseldorf	Senior physician	Universitätsklinikum Düsseldorf
Emden	Senior physician	Klinikum Emden
Munich	Senior physician	LMU Klinikum
Duesseldorf	Senior physician	Universitätsklinikum Düsseldorf
Wuerzburg	Senior physician	Universitätsklinikum Würzburg
Wuerzburg	Senior physician	Universitätsklinikum Würzburg
	Physician	LMU Klinikum
	Physician	Universitätsklinikum Düsseldorf
	Physician	Universitätsklinikum Düsseldorf
Berlin	Physician	Vivantes Klinikum
Hamburg	Physician	Klinikum Itzehoe
Augsburg	Physician	Universitätsklinikum Augsburg
Duesseldorf	Physician	Universitätsklinikum Düsseldorf
Berlin	Physician	Vivantes Klinikum
Munich	Dean of Research at the Faculty of Medicine	LMU Klinikum
Muenster	Research Associate; Institute for Medical Informatics	Medizinische Fakultät Münster
Muenster	Head of the Medical Data Integration Center	Medizinische Fakultät Münster
-	Project Manager	AOK

Source: Annabelle Rauert (2021): Own elaboration.

Table 4: Interviewee's data

City	Professional's Position	Facility
Porto	Physician	São João University Center
Porto	Physician	São João University Center
Porto	Executive Member of the Board of Directors	Hospital da Trofa
Porto	Software Developer	Knok
Porto	Computer Engineer	Critical Software
Porto	Computer Engineer	Critical Software
Lisbon	Physician	Hospital de Santa Maria
Lisbon	Physician	Hospital de Santa Maria
Lisbon	Executive Member of the Board of Directors	Hospital de Santa Cruz
New York	Backend Developer	Verbit

Source: António Maria Costa (2021): Own elaboration.