

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:

WHAT TECHNOLOGIES TO ADD

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**Title**

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**Abstract**

Electronic health records (EHRs) can store, capture, and present patient data in an organized way that improves physicians' workflow and patient care. This makes EHRs key to addressing many of today's health care challenges. An interdisciplinary review and qualitative study of artificial intelligence, machine learning, natural language processing, and real-time location services in health care was conducted. The results show that in an industry where digitization is key, several recommendations can be made to leverage these technologies in ways that can improve current systems and help EHR vendors become the market lead.

**Keywords**

Digital health; Patient-Centred Care; Clinical Decision-Making; Product Design Innovation in Health Care; Electronic Health Record.

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## **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: What technologies to add**

In today's world, technology and digitalization can be critical to value creation. Digital technology can help us as individuals to transcend our intellectual boundaries and companies to improve their performance by using it as a tool for value creation, exponential growth, and further business model optimization. (Acker, et al. 2016, Giakoumelou, et al. 2021).

McKinsey (2021) notes that a strategic approach to technology is essential, as better overall technological capabilities are associated with better economic outcomes. But some industries lack opportunities to invest in areas where digital disruption is imminent.

This section aims to provide a comprehensive analysis of the current impact of digitalization on the health care industry. To this end, this section looks at the most in-demand functions for the industry, examines companies that are leading the way in the era of health care digitization, analyzes the feasibility of the respective technologies and, finally, the challenges and benefits in their implementation.

The health care industry, which includes companies that provide medical services, manufacture medical devices or drugs, offer health insurance, or otherwise facilitate health care for patients, has a total global market value of \$8.45 trillion (Stasha 2021). According to Deloitte (2019), however, it has not yet reached even a quarter of its market potential, which points to additional growth opportunities. Further analysis highlights the long-term growth potential due to higher demand for health-related services and products, driven by macroeconomic effects such as global population growth, the aging of society and an increase in lifestyle-related diseases (Deloitte 2019). This explains the estimated compound annual growth rate (CAGR) of more than 3.9% from 2020 to 2024 and forecasts that the industry will outpace global market growth in the short and long term (Deloitte 2021).

Needless to say, as one of the most impactful disruptions of the century, COVID-19 has exposed vulnerabilities in the health care industry, exposing the mismatch between demand for health care and the supply of staff and other resources (Deloitte 2020). Therefore, the industry was forced to reassess its systems and opportunities on how to improve health care delivery (Jack 2021). As a result, digital solutions and advanced technological tools are being rapidly adopted in health care, as they can help solve or even mitigate many problems and ultimately improve care (Boetto, et al. 2020).

As in any industry, there are several digital technological breakthroughs. Therefore, it is important to assess which ones are critical and target them to take full advantage of the growing market. Companies should focus on what health care providers and patients are looking for, ultimately improving market adherence.

Being said, speech and handwriting recognition, as well as ML, a subcategory of AI, should be considered to facilitate research, develop new medical procedures, process patient data, keep records and treat chronic diseases (Thomas 2020), ultimately allowing to automate health care systems.

### **Literature Review on technology and digitalization**

The business world is going through a new era of digitalization in which data is the key to competitive advantage. However, there is still a lot of confusion about how to take full advantage of the new digital trends. Companies want to optimize their value but are hindered by organizational challenges, such as grafting new processes onto an existing infrastructure or developing a system that works flawlessly and is easy to use (Kyobe and Mushore 2019).

Although technological breakthroughs are happening in almost every industry, largely due to the enormous economic potential of digitization, McKinsey (2021) shows that there is still a significant gap before industries reach the digital frontier. The same report states that the health

care industry itself is still a quarter of the way there, with the main drivers (lower than the average industry) being automation and the supply chain, as well as the digital workforce.

Even though the health care industry is going through an era of digitalization, a new wave is coming that includes technologies such as AI (AI), blockchain, ML, automation, and other AI-based technologies that have been proven to improve business performance (McKinsey 2021). This wave is necessary to address one of the biggest challenges associated with digitization: security. That is why the technologies mentioned above are important, especially since they can improve current systems in a secure way (Jena, et al. 2020).

As the security problem can be overcome, it is also necessary to consider the needs of the market and health care providers and how to develop an attractive system. Most physicians believe that digital technologies such as voice and handwriting recognition can be very helpful as they have the potential to improve medical reporting, and hospitals and providers do too as they improve their processes and reduce costs and liabilities (Kock, et al. 2004), thus, these technologies should also be considered.

With this in mind, it is necessary to take a closer look at these technologies and understand how useful they can be and whether they can be used in health care.

### Artificial Intelligence

AI involves analyzing large amounts of data, looking for patterns or correlations, and then using these results to make predictions (Burns, et al. 2021). Therefore, AI requires both hardware and software that can write and train ML algorithms.

Due to the rising amounts of complex data in health care AI is gradually becoming more prevalent in the industry and bringing innovations to medical practice (Davenport and Kalakota 2019), ranging from robotic surgeries to reducing dosage errors and predicting diagnoses. These applications are expected to save the health care industry \$150 billion by

2026 (Ku 2021). A great example of the use of AI in health care is the experience of Northwestern University, whereby training software with hundreds of thousands of chest X-rays, it was possible to develop an algorithm that can detect respiratory diseases with more than 83% accuracy (Balasubramanian 2020).

Some examples of companies developing their business specifically in the health care AI market include Remedy Health, which has developed a platform that allows non-physicians to diagnose chronic diseases through phone screening interviews. This approach allows them to diagnose patients earlier and more accurately than their competitors, who primarily use scarce historical medical data. Earlier diagnosis not only enables preventive care, better health outcomes and lower costs, but the company can also hire cost-effective staff to collect data in a timely manner. Another example is Quid, which uses its proprietary algorithms to mine large amounts of data and create dynamic visualizations that provide quick insights rather than requiring going through reports or even extensive research.

### Blockchain

The blockchain is a distributed and immutable ledger platform that allows a person to track tangible or intangible assets. It consists of records made up of a chain of "blocks" that contain information about multiple transactions (Nofer, et al. 2017). This technology does not require third-party verification as it uses a powerful consensus mechanism with cryptographic algorithms to verify the authenticity of a transaction, making it secure even in the presence of powerful or hostile third parties (Potts, et al. 2016). Although this technology is mainly associated with financial transactions, its wide range of benefits is also useful for several other industries that use it as well. One of the main concerns in the health care industry is data privacy, and the use of blockchain can do just that. It enables secure, private, confidential, and decentralized data transactions, which is ideal and even necessary in the age of digitalization.

Health care faces three major data problems that blockchain technology can solve. First, there is a problem with interoperability and how different information systems share information. There are multiple EHR systems in different hospitals and no defined standard. Second, there is a problem with information asymmetry: physicians have difficulty accessing their patients' data because most of the times it is all centralized in a single health care provider platform (Shahanz, et al. 2019). In addition, data breaches are also a challenge. One study found that more than 173 million pieces of data have been compromised between 2009 and 2019, posing a serious threat to the industry (Argaw, et al. 2019).

So how does the technology work? First, a new transaction is made by a user on the blockchain, which requires the creation of a new block with the information. The transaction is then sent to all connected nodes on a peer-to-peer network and further validated using algorithms to ensure the user is authenticated and part of the network. The block is then added to the blockchain, and the transaction is considered complete. The way it works ensures that the information is decentralized, as it is distributed across the network and not stored at a single access point. In addition, the cryptographic functions that protect the data also make it temper proof and secure. An example of implementation of this technology in EHRs is MedChain, a company that is leveraging these capabilities to create a health care ecosystem that provides interoperable, secure and easily accessible medical records for patients, health care providers and other third parties while protecting patient privacy.

### Machine Learning

ML is a subfield of AI that aims to simulate human intelligence by learning from acquired data (El Naqa and Murphy 2015). It is undoubtedly one of the most commonly used terms when talking about AI as is the foundation on which systems can develop neural networks and deep learning algorithms. (Davenport and Kalakota 2019).

With the exponential increase in data, mainly with the presence of EHRs, it can be hard to categorize and take valuable insights from all this information. The data can be structured, thus categorizable, such as patients' weight or temperature. But it can also be unstructured in the form of reports or discharge notes, per example, making it hard to categorize and quantify (Bhardwaj, et al. 2017).

Nowadays, this technology is primarily used to predict which protocols will be most effective in treating a particular condition, depending on the patient and context, thus helping physicians. At the same time, it can alert patients when they need to make an appointment. This will ultimately help reduce rising health care costs and improve the patient-doctor relationship.

One example of the application of this technology in health care is Alixir, a start-up that uses deep learning to detect calcifications or cancerous abnormalities on mammograms. It is able to generate the report in seconds, making the entire screening process faster and more accurate, leading to earlier detection and better patient outcomes.

### Natural Language Processing

Natural language processing (NLP) includes applications such as speech and handwriting recognition as well as text analysis and other language-related applications. These applications are mainly approached via statistical NLP (although semantic NLP also exists). This type of NLP is based on ML and requires a large language database to learn from. Ultimately, however, AI software can analyze unstructured clinical reports, generate reports, transcribe interactions, or even lead a conversation (Davenport and Kalakota 2019, Eisenstein 2019). These functions can, for example, help to collect information before the appointment, structure it so that it can be presented to the doctor, and speed up and facilitate the treatment process.

Although handwriting recognition technologies exist, they are not yet capable of recognizing physicians' handwriting. Fajardo, et al. (2019) attempted to develop a software that uses a Deep



Convolutional Recurrent Neural Network to recognize text in images of prescriptions, but the model could only achieve a validation accuracy of 35% in a real-world scenario, which is not yet effective enough for practical use.

Nevertheless, speech recognition is a working technology, that mainly uses statistical NLP. Speech recognition can be divided into the back-end, where speech is recorded, converted into a written draft, and then proofread by a medical transcriptionist or physician, and front-end, where the software converts spoken words into text in real time, eliminating the need for transcription. This is a faster process but can lead to small errors (Nikuliak 2020).

There are already around 173 speech recognition focused NLP start-ups operating in the health care sector (StartUs Insights 2020) which suggests that it is a viable option. According to the beforementioned insights, one notable start-up working with NLP is MedInReal, a Dutch start-up that has developed software that uses speech recognition to allow doctors to take notes and automatically fill out electronic medical records, making the data entry process easier. On the other hand there are also experience players, such as Nuance Communications, which has shown positive results in applying the technology in different departments. It reduced not only turnaround and patient visit times, but also transcription costs and physicians workload.

### Real Time Location Services

A common issue healthcare executives face on a regular basis is not only data and facility security, staff satisfaction, and quality of patient care, but also inefficient workflows that can impact the entire organizational structure (Centrak n.d.). While global positioning systems (GPS) are successful as an outdoor solution, they are unable to solve indoor tracking problems, a feature that can bring several benefits in health care. Therefore, one of the latest innovations being integrated to address these shortcomings and support and increase visibility and operational efficiency in the healthcare setting is RTLS (Gholamhosseini, et al. 2019). These

systems can provide information about the whereabouts of staff, patients and equipment at a very precise level, which can then be collected and analyzed to help improve processes. This allows providers to respond quickly or even prevent various problems, such as controlling infections, reducing costs by improving processes, assessing patient throughput and others.

(Boulos and Berry 2012).

Although RTLS is used more on an administrative level, it can help medical professionals such as physicians and nurses improve their workflows by leveraging the various applications of this technology. These applications can be grouped into five main categories - tracking, identification and verification, detection, intervention, and alerts and triggers - which then provide important information and enable better care (Bjorn, et al. 2018).

Centrak is proving successful in the application of such technology, where it is enabling hospitals such as Texas Health to devote more staff time to patient care, increasing patient satisfaction, or The Medical City, which has seen a 48% decrease in infections in one year since installing an RTLS-based handwashing compliance system.

### **Qualitative Findings**

Firstly, it was important to understand health care professionals' perspectives on technology. It was clear from the interviews that physicians are under pressure and face a tremendous workload, with both appointments, procedures, and research. However, the experts believe that this issue can be improved with technology and believe that a key component to success is to reduce the complexity of current systems.

*“It is hard to retrieve data about a patient quickly. There are too many steps, it needs to be more intuitive!”*

Physicians expressed interest in features such as automatically synthesizing large amounts of research data or receiving alerts about abnormal patient values, citing this as an important innovation to current systems. To add on, they were also attracted to the handwriting and speech recognition capabilities and acknowledged that, while not as much needed, these would go a long way toward improving physicians' workflows.

During the interviews with technology experts, it became clear that the technologies addressed are indeed interrelated and mutually dependent to create a successful system.

*“AI encompasses all relevant technologies. NLP cannot exist without ML, and ML would not be useful if it were not able to understand and process what is being said or written”.*

Therefore, most of the content of the interviews was studied as regarding all technologies, with some points focusing more on one or another.

ML and NLP seem to be indispensable for the future of health care systems.

*“The amount of data that is being collected and the need to use it are increasing exponentially, and it is critical to keep up with the surge.”*

As humans we do not have the capacity to deal with such enormous amounts of data, which restrain us from making better decisions. One of the professionals affirmed that we are basing our clinical decisions in only 3% of the population that participated on clinical trials. Moreover, more than half of health care data is unstructured and unused - it is only used when patients go to the doctor, and most of the time the doctor cannot even find the relevant information. The current state of health care technology and data management is clearly inadequate if we want to achieve better outcomes.

The experts were able to explain briefly and clearly how each technology can be developed and applied. In terms of NLP, one of the key takeaways was that the focus should be on speech recognition and that this can be easily implemented. The only problem is the lack of clinical terms in such programs, an important step that needs to be improved to provide physicians with a seamless experience. The possibility of developing handwriting recognition software was also discussed, but unanimously considered an unworthy idea.

*"Many companies are already working on speech recognition, and it's a success; if it catches on, handwriting will just be time consuming."*

In addition, most agreed that working on the software would be too costly, both financially and in terms of time.

It can be concluded that NLP is indispensable to enable physicians to effortlessly collect data and reduce their workload so that they can pay more attention to the patient and work more effectively. However, there needs to be a good ML algorithm behind it.

*"ML can help physicians gain valuable insights into new developments in health care, make informed predictions, and improve their overall performance."*

These algorithms can customize treatment plans based on patient history and enable better health management at a lower cost. It helps to save time on things such as radiology, and by giving faster results with greater accuracy, it can greatly increase care delivery.

Since most health professionals were looking for three main features (measuring outcomes and efficiency, alerts, and automation), respondents were asked about these features. It was found that both NLP and ML are essential for success. NLP can interpret data and understand where

to store it, and ML can identify patterns and improve efficiency. The answers were similar: measuring outcomes and efficiency is a must to improve care, and it is possible. There is NLP software that can standardize data, but it is very time consuming because a lot of data needs to be structured; alerts and notifications should be the easier part of development if it is possible to achieve a functional and effective NLP software; automation is also possible, and there is software capable of doing this that can be implemented once the clinical terms are successfully embedded in the NLP software.

After learning how the experts feel about these technologies and how fascinated they are that they represent the future of health care, it was important to understand whether it is feasible to implement such technologies in an EHR. All respondents agreed, "*It is feasible, but it takes a lot of time, money, and effort. If your goal is having a complete and remarkable EHR, you must implement them (NLP and ML), but it's better to outsource the development*". Although outsourcing can be expensive, it has some advantages. Hiring experts makes development much faster and scaling much easier. Management also becomes easier, as the responsibility for handling patient data falls into the hands of the developers.

Nevertheless, there was one common advice given in most meetings: it is important to work on the implementation as fast as possible. There are many start-ups and especially large organizations already working on full-fledged EHRs with the above features. It is important to work on the implementation as quickly as possible because the more hospitals and providers use one software, the more difficult it will be to dissuade others to use the same.

Overall, the interviewees provided enticing feedback about the feasibility of implementing NLP and ML in EHRs. The technologies are not only desired, but needed, they "*are revolutionizing the health care industry, and are becoming more and more indispensable, especially given medical resources are starting to reach their limits*". However, there is a dilemma. If the software is developed in-house, it is a time-consuming process and there is a risk of missing the

opportunity to capture the market. If the software is outsourced, it may be faster, but the functionality is limited, and it may even injure profitability.

In summary, the implementation of such technologies must begin as soon as possible. The implementation of NLP (including speech recognition) and ML can be a successful project, but it would also be important to explore the possibility of incorporating blockchain technology.

*"One of the main problems of current systems is the inability to share information quickly and securely between providers"* and this software would enable this.

### **Additional Analysis**

After careful analysis of the information collected in the literature and the information from the interviews and the survey, it can be said that the market needs this technology and that its introduction will most likely be successful. Nevertheless, it is also important to perform some additional analysis to understand whether the technology is adopted by the target audience and whether it is worth further consideration.

Since the actual software has not yet been developed, the Technology Acceptance Model (TAM) can be used to determine the characteristics of the software to be developed. The model begins by looking at the external variables, such as the readiness of providers, physicians, and patients for the technology, which in this case is favorable because it is seen as necessary in the marketplace. Consequently, perceived usefulness and ease of use must be considered, keeping in mind that the latter influences the former, and both are attributes that a user will be looking for. In this case, it is important to ensure that the software is easy to use and meets all of the consumer's needs. This leads to an attitude toward the technology and a behavioral intention that, if positive, will lead the consumer to use it. This is also a way to analyze how attractive the product is: first, while the technologies themselves are complex, they make the product user-friendly; second, assuming that it will be possible to implement a fully automated system,

little to no training is required; third, the system will actually be useful and already seen as a need in the market; finally, it will most likely develop a positive attitude as it facilitates the use and access to health data.

### **Final comments on technology**

In the old "heavy industry" economy, when the typical industries were oil and gas, steel and aluminum, and many other physical commodities, the key to competitive advantage was the ability to achieve economies of scale. We now live in a new information economy where industry revolves around hardware and software and the main key to competitive advantage lies in external network effects. The basic idea behind the concept is that the greater the volume, the greater the benefit for new users. However, it is important to note that to increase volume, there must be demand for the system and there must be positive feedback.

It is no different in health care. Let us imagine a system in which all patients' health data is stored and several doctors and hospitals have access to this data. In this scenario, the greater the number of doctors and hospitals, the more attractive the system becomes for patients, as they have more choice, and conversely, the greater the number of patients, the more attractive it becomes for hospitals and doctors, as they can increase their customer base. Furthermore, as the number of health care providers and patients increases, more information is collected, leading to better information and ultimately better care. All in all, both the benefits for the players and the network volume remain stuck in a loop where they increase in parallel.

The literature review makes it clear that implementing NLP and ML in EHRs is feasible and will bring several benefits to the health care industry. It will help reduce the workload of physicians, leading to less fatigue and allowing them to perform better; it will help them make better informed decisions, reducing costs and increasing efficiency; it will securely decentralize

all data and make it easily accessible to all. These technologies will improve health care by making it more accurate and faster, while at the same time reducing costs immensely.

In summary, the workload of doctors will decrease, patients will receive better care, diseases will be treated more effectively, and costs will be reduced. The implementation of this technologies is possible and needed and will contribute to the further development of care delivery and the health care system.



## 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.

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## 8. Appendix

**Table 1: Interview Script**

<b>Interviewee</b>	<b>Questions</b>
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"> <li>a. The ease of accessing information through the System</li> <li>b. Technical support and Education on the System</li> <li>c. Decision making support</li> <li>d. Flexibility in document editing</li> <li>e. Sharing of opinions between the medical staff</li> </ul>
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"> <li>a. Handwriting Recognition</li> <li>b. Voice Recognition</li> <li>c. Increase in Training Programs</li> <li>d. Personalized User Interface</li> <li>e. Pre-defined EHR to draw attention when a patient's values go out of the usual picture</li> </ul>
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**

<b>Country</b>	<b>Region</b>	<b>Facility Type</b>	<b>Professional's Position</b>	<b>Facility</b>	<b>EHR</b>
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**

<b>City</b>	<b>Professional's Position</b>	<b>Facility</b>
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**

<b>City</b>	<b>Professional's Position</b>	<b>Facility</b>
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.