
UNIVERSIDADE CATÓLICA PORTUGUESA

VISEU

**Instituto de Gestão e das Organizações da Saúde**

Mestrado em Gestão Aplicada

# *THE IMPACT OF eHEALTH AND BLOCKCHAIN TECHNOLOGY IMPLEMENTATION IN HEALTHCARE*

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Viseu, October 2023

CATÓLICA
INSTITUTO DE GESTÃO
E DAS ORGANIZAÇÕES DA SAÚDE

VISEU

# *THE IMPACT OF eHEALTH AND BLOCKCHAIN TECHNOLOGY IMPLEMENTATION IN HEALTHCARE*

Dissertação apresentada à Universidade Católica Portuguesa, Centro Regional de Viseu, para obtenção do grau de Mestre em Gestão Aplicada

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Viseu, Outubro de 2023

**“The first wealth is health”**

Ralph Wando Emerson

**ACKNOLWEDGEMENTS:**

I would like to thank the following people, without whom I would not have been able to complete this research project.

The academic team of professors at Universidade Católica Portuguesa in this Master's degree for their willingness to impart their knowledge and for the encouragement and motivation in the numerous research works and articles that allowed me to develop these skills and publish.

To my supervisors, professors António José Ferreira and Pedro Mota Veiga, for their continuous support, rigor and availability, over the last two years.

To all my friends and colleagues who have walked with me through this journey.

And, to my family for the unconditional support.

My sincere thanks!

**ABSTRACT:**

eHealth is viewed as one of the most important revolutions in healthcare and a specific goal of the European Union to improve citizen's accessibility to healthcare across borders. In this field, Estonia stands out as one of the most digitally advanced countries, having had a national eHealth system protected by blockchain since 2008. This research aimed to identify the benefits and challenges of implementing eHealth for society, in general, and for healthcare professionals, in particular; specifically in the country that already has over a decade of experience in adopting eHealth; and analyze the contribution of blockchain technology in the implementation of eHealth. Therefore, in a first phase, a systematic review of the literature was carried out, using the Scopus database, in April 2023, of all the publications, written in English, with the terms "Estoni*" and "eHealth*" or "e-Health*" or "Blockchain". The search engine presented 74 publications, of which 19 met the selected criteria. The improvement in access and quality of the service provided, cooperation and data sharing, efficiency, knowledge and control of one's own data were among the most mentioned benefits. Disparities in access, confidentiality and lack of trust, financing, cognitive load and data quality were the challenges encountered in implementing digital technologies in healthcare. In a second phase, a qualitative research was carried out through a semi-structured interview with eleven participants, selected from among healthcare professionals, such as doctors, nurses and managers of healthcare institutions, on their personal perspective of eHealth. The participants also highlighted easy access to medical data and easier communication with patients and other healthcare providers as major benefits of eHealth. However, data overload, the need to acquire digital skills and disparities in the access to healthcare by specific groups of the population are amongst the biggest challenges in implementing eHealth.

**Keywords:** Estonia, eHealth, Blockchain, Benefits, Challenges

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## INTRODUCTION:

The pandemic crisis caused by COVID19 paralyzed global access to healthcare services due to unprecedented confinements and accelerated the development of digital technologies that could ensure people's continued access to healthcare. The increase in the number of telemedicine consultations, the coordination of large scale operations, such as immunization certificates and COVID contact tracing; and supply chain management for vaccines are some of these examples (Ng *et al.* 2021; Soares and Passos, 2022). With the increase in demand for more access and better healthcare services, it is expected that eHealth will be able to respond to these demands.

The World Health Organization (2006) defines eHealth as the "cost-effective and secure use of information and communications technologies in support of health and health-related fields"; but there isn't a clear and universal definition for the concept that first appeared in the literature in 1999, as an evolution of telehealth (Bruthans and Jiráková 2023; Ćwiklicki *et al.* 2020). We can encompass in eHealth the services of health and information that are provided or improved by the internet and other related digital technologies, such as telehealth, telemedicine, mobile health (mHealth); but may also incorporate emerging areas such as the use of big data and artificial intelligence in healthcare (Lotman and Viigimaa, 2020). The implementation of eHealth is viewed as a positive step towards time and resource efficiency. However, the digital transition is not without challenges and, as in other areas, there are concerns that the general implementation of eHealth may unintentionally worsen disparities in access to healthcare for vulnerable groups (Heinsch *et al.* 2022).

These new digital health systems raise several questions regarding transparency, immutability, trust, privacy and security. Blockchain presents itself as an emerging technology capable of revolutionizing the way information is managed in healthcare (Yakoob *et al.* 2021). Blockchain technology was introduced in 2008 by a person, or group of people, under the pseudonym Satoshi Nakamoto and initially developed for the cryptocurrency bitcoin (Mettler, 2016). This technology is based on a distributed peer-to-peer (p2p) system, originally developed in 1991 by Stuart Haber and Scott Stornetta who intended to create a system where certain documents would have an exact timestamp, which would not be possible to change (Megha *et al.* 2021). Immutability, decentralization and transparency are the three key characteristics of this technology which, applied to cryptocurrencies, has made it

possible to speed up international payments, by eliminating intermediaries, usually, banks; made transactions practically immediate, with fewer costs and bureaucracy; and, without compromising security, continue to be verifiable and auditable (Nakamoto, 2008; Rehman *et al.* 2022). In the healthcare sector, and in eHealth systems, in particular, where the storage and sharing of personal data becomes vital, blockchain can be an important tool to guarantee security and raise the level of trust of all users: patients, healthcare professionals and organizations (Ng *et al.* 2021). The transformative potential of blockchain technology lies in the principle of decentralization which may lead to a paradigm shift, towards more patient-centered healthcare.

The first country to adopt blockchain technology was Estonia, in response to a series of cyberattacks in 2007, against government services, banks and the media (e-Estonia, 2022). Estonia is a small country in the European Union, with around one million inhabitants, which underwent a profound digital transformation at the beginning of the 21st century. Around 92% of Estonian households have access to the internet; and approximately 99% of public services are available online (Eurostat, 2022). In 2008, a national eHealth system was launched that integrates the medical data of all patients, from all healthcare organizations, becoming the first country in the world to implement a nationwide system of this kind. A decade later, Estonia was already among the group of European countries with the highest level of eHealth implementation, ahead of countries such as France, Germany, the United Kingdom and Portugal; registering the greatest growth in this area since 2013 (European Commission, 2018).

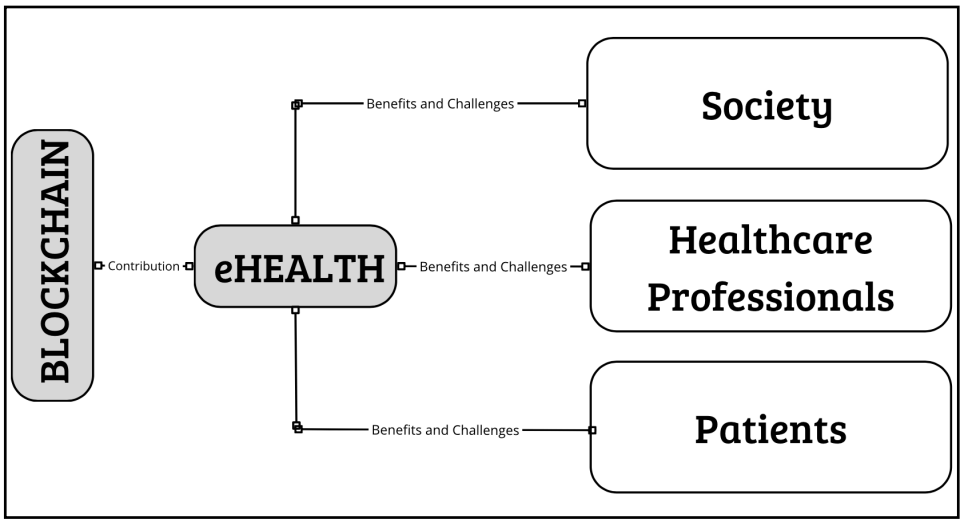
As with Portugal, and many other European countries, Estonia faces a workforce shortage in the healthcare sector caused by ageing professionals, migration and inadequate training volumes in recent years (Habicht *et al.* 2018; OECD 2021). eHealth, in its various applications, is recognized as an important tool to maximize the scarcity of human and material resources; but, the adoption and dissemination of eHealth is only truly possible with the clinical endorsement of healthcare professionals. Therefore, this research aims to, as shown in Figure 1, identify the benefits and challenges in the implementation of eHealth:

a) for society (government entities, healthcare institutions and general population)

b) for healthcare professionals and,

c) analyze the contribution of blockchain in the implementation of eHealth

**Figure 1:** Conceptual Framework




To respond to the first objective, a systematic literature review was carried out through the Scopus database of all the publications, written in the English language, containing the terms “Estoni*” and “eHealth*” or “e-Health*” or “Blockchain”. This investigation resulted in the scientific article, entitled: **“THE BENEFITS AND CHALLENGES OF BLOCKCHAIN TECHNOLOGY AND E-HEALTH IMPLEMENTATION IN ESTONIA - A LITERATURE REVIEW”**.

To answer the second objective, a qualitative investigation was carried out, through a semi-structured, interview with eleven healthcare professionals in Estonia, which includes doctors, nurses and managers of health organizations. This investigation resulted in the article entitled: **“THE IMPACT OF eHEALTH AND BLOCKCHAIN TECHNOLOGY IN HEALTHCARE: A QUALITATIVE RESEARCH OF MEDICAL PROFESSIONALS OF ESTONIA”**.

The analysis of the third objective was carried out through the interpretation of the publications encountered in the first investigation and the results of the semi-structured interview of the second investigation.

The digital maturity of the Estonian population, acquired over more than a decade of eHealth implementation makes this country the ideal subject to evaluate the responses to the objectives defined in this dissertation.

# THE BENEFITS AND CHALLENGES OF BLOCKCHAIN TECHNOLOGY AND E-HEALTH IMPLEMENTATION IN ESTONIA - A LITERATURE REVIEW

*Abstract:*

***Purpose:*** *This study aimed to review the existing literature on the benefits and challenges of the implementation of digital eHealth systems, using the success story of Estonia; and explores the impact of blockchain technology in facilitating eHealth adoption.*

***Design:*** *By using the search query string "Estoni*" and "eHealth" or "e-Health" or "Blockchain" on the Scopus database (on April 2023) a narrative review was conducted over the relevant peer-reviewed publications that were written in English.*

***Findings:*** *The Scopus database and its integrated search engine presented 74 publications of which 19 filled the selected criteria. Access, efficiency, quality of care, cooperation and data sharing, knowledge and control were amongst the most mentioned benefits of eHealth. Disparities, confidentiality and lack of trust, financing, the cognitive burden and the quality of data were the most mentioned challenges of implementing digital technologies in healthcare.*

***Implications:*** *This research provides an extensive up-to-date review of the benefits and challenges of the implementation of eHealth on a nationwide level, whilst analyzing the impact of blockchain technology. The article brings attention to the potential future applications of eHealth developments such as Computerized Decision Support Systems and Cross-border healthcare.*

***Originality/value:*** *This study highlights the lessons taken from a decade of eHealth adoption in Estonia, specifically detailing its benefits and challenges, but also looking at the potential future applications of digital health systems.*

**Keywords**: eHealth, Estonia, Blockchain, Benefits, Challenges.

# 1. INTRODUCTION

Estonia is one of the most digitally advanced countries in the world, leaders in e-governance and cybersecurity. With an impressive 99% of its public services already provided fully online, covering several sectors, from justice to healthcare, Estonia is aiming to improve the quality and access for their citizens to these services.

In 2008, a national system of eHealth was launched that integrates the medical data of every patient, from all healthcare organizations, becoming the first country in the world to fully implement such a system nationwide. Although this is not currently unique, what distinguishes Estonia's particular e-Health system is the fact that it is implemented at a government level, regulated and monitored by government entities.

The development of these digital health systems will naturally raise several security issues regarding confidentiality and data protection. In 2008, in response to one of the largest cyberattacks against an EU country, the Estonian government turned to blockchain technology to ensure the protection of personal data across all its e-services. In 2016, Estonia became the first nation to deploy blockchain technology to enforce the integrity of government data.

Blockchain technology, introduced by Statoshi Nakamoto (2008) initially for the crypto currency *bitcoin*, has brought an opportunity to overcome some of the obstacles to greater security and decentralization in the sharing and distribution of data. In healthcare, and eHealth systems in particular, for which the storage and transfer of sensitive data is vital, blockchain can be an important tool to guarantee the security of information and the level of trust of all users: patients, healthcare professionals and healthcare organizations. Moreso, it can provide the structural foundation for the paradigm shift towards a patient-centered, rather than institution-centered, healthcare delivery.

The impact of eHealth is potentially enormous and the recent global crisis generated by the COVID-19 pandemic has even accelerated the need for a digital transition to improve patients' safe access to healthcare, but there are also challenges and obstacles that can hinder the implementation of ehealth systems and blockchain technology. Thus, this paper intends to explore the literature about this topic and, using Estonia as a reference, whose health system is recognized as a success story in the adoption of eHealth, seek to respond to the following main objectives:

a) Identify the benefits arising from the implementation of eHealth for the various stakeholders

b) Recognize the biggest obstacles and challenges to the implementation of eHealth

c) Analyze the contribution of blockchain technology in the adoption of eHealth in Estonia

In order to respond to these objectives, a systematic review of the literature was carried out through the Scopus database with all the published papers written in English containing the terms “Estoni*” and “eHealth*” or “e-Health*” or “Blockchain”.

According to Palma (2022) there is a clear discrepancy in the literature between expected benefits and the real impact of the implementation of eHealth, that can be justified by the lack of evidence. Therefore, this paper highlights the benefits and challenges for the adoption of eHealth during a time where the digital transition of healthcare is not only a sign of progression but a necessity considering the increase demand for access and the scarcity of resources. Through the experience of a country such as Estonia, with mature digital services, can help governments and managers of healthcare organizations to face the challenges that are expected to encounter during eHealth implementation.

This research begins with a brief analysis of the concept of eHealth, followed by the reality of Estonia in the provision of digital health services and the justification behind the adoption of blockchain. In the second part of this paper the method is characterized as well as the selection criteria. Lastly, this paper presents in different sections the detailed benefits, challenges and potential future applications for eHealth; and the results are analyzed and discussed, assessing the impact of blockchain technology.

## 2. LITERATURE REVIEW

### 2.1. eHealth

The concept of eHealth began to appear in literature in 1999 as an evolution of the term telehealth (Ćwiklicki *et al.* 2020). There is still no universal and standardized definition of eHealth (Ćwiklicki *et al.* 2020), but we can encompass in this concept all health and information services provided or improved by the internet and related technologies such as telehealth, telemedicine and mobile-health (mHealth), but also emerging areas such as the use of advanced computerized sciences in big data, genomics and artificial intelligence (Lotman and Viigimaa, 2020; Oh *et al*, 2005). Another definition of eHealth is the use of information and communication technology and its processes adapted to organizational changes in health systems, and new concepts to improve the health of citizens and, at the same time, increase productivity in the health system (Luca *et al.* 2021).

According to Ćwiklicki *et al.* (2020) eHealth services can be differentiated in terms of technologies, functionalities and areas of implementation:

a) **Education services**, through which institutions use digital technologies to improve consumers' access to health information;

b) **e-Behaviour change services**, through which support groups and online communities promote healthier lifestyles among patients;

c) **Self-monitoring** and disease management, in which chronic patients monitor their health status through devices that can be directly connected to tablets and mobile phones, with or without professional support;

d) **e-Treatment adherence**, through which healthcare professionals can send reminders to their patients to ensure their adherence to the proposed treatment

e) **e-Surveillance services**, in which doctors can establish diagnoses and implement treatment plans through Electronic Medical Records (data collection, analysis, interpretation and sharing of results).

Ideally, eHealth platforms should promote synergy between all stakeholders in the healthcare system: patients, healthcare providers and institutions, researchers, medical and

pharmaceutical technology companies, and mobile application developers (Lotman and Viigimaa, 2020).

The need to do more with less is essential, with the growing demand for healthcare services and the scarcity of human and material resources, and eHealth can bring enormous benefits and contribute to the effective management of health systems in the future. However, the benefits are not automatic, they require control over three conditions: cost, police and utility. There is a wide gap between planning the adoption of new technologies in healthcare and the sustainable implementation of these same technologies to obtain strategic benefits (Luca *et al.* 2021).

### 2.2. The reality of Estonia

Estonia was ranked seventh in the 2022 Digital Economy and Society Index (European Commission, 2022), an index that gathers digital performance indicators and evaluates the evolution of the digital competitiveness of EU members. The country is quite advanced in offering eHealth services and solutions such as electronic health records, digital prescriptions and e-consultations (Habicht *et al.* 2018) with a declared purpose of developing "patient-friendly, efficient and high-quality healthcare services" (Metsallik *et al.* 2018).

Every Estonian citizen has an ID Card that can be used as electronic identification and as a digital signature. This ID card is essential for using all public and private e-services (Nøhr *et al.* 2017). The Electronic Health Record (EHR) is one of the most important components of the eHealth system and works as a centralized database that integrates information from different service providers to create a common medical record. It is an important tool that allows health professionals to easily access specific patient's information from a single electronic file, such as laboratory or imaging test results, such as x-rays (Tuula *et al.* 2022). This information is then presented in a standardized format on a Patient Portal (e-Patient Portal) where it can be accessed by the patient. By logging into the e-Patient Portal, using their own ID cards, patients can also review their appointments, check immunizations, history of medical referrals, electronic prescriptions, statements and certificates; may name representatives or act on behalf of others, if appointed to do so, such as accessing the records of under age patients, on their care, and/or authorizing access to others, such as family members or caregivers; check which healthcare professionals have accessed your data and

hide sensitive information; and even fill mandatory forms before an appointment. In Estonia, patients can restrict access to all or part of their medical data to specific healthcare professionals (Metsallik *et al.* 2018; Nøhr *et al.* 2017; Tuula *et al.* 2022; Yeh and Saltman, 2019).

Since this is an eHealth system implemented at a government level, the information entered by a specific health professional can be accessed by a different provider, in another healthcare organization; and specific patient's data may even be consulted by other entities, such as Social Security, for example, to verify expert opinions on physical disability assessments. This countrywide system makes it also possible to create a national database to be used for statistical studies by government agents (Tuula *et al.* 2022).

The Health Services Organization Act regulates the provision of health services and has a specific chapter for eHealth. It specifies the responsibilities of patients and healthcare providers and defines requirements and standards for document submissions. The same regulation also clarifies that only healthcare professionals, legal representatives or patient trustees can access medical data. Even healthcare professionals, doctors or nurses, must be able to prove their medical relationship with the patient when accessing their data, and patients have the right, at any time, to select information or data they wish to share (Metsallik *et al.* 2018).

The eHealth Foundation was the government entity responsible for the development, financing and management of the system, which at launch was funded partially by the European Union (1,196,206€) and by Estonia (398.735€) (Metsallik *et al.* 2018). Currently, the healthcare system in Estonia is predominantly funded by mandatory health insurance contributions in the form of a tax by employers, which accounts for two thirds of the total healthcare expenditure (Lotman and Viigimaa, 2020). According to Estonia's eHealth strategic development plan, its funding is secured by various parties, including from the budget of the Ministry of Social Affairs and corresponds 6% of the country's GDP (9,5% on OECD average). The majority of hospitals in Estonia are public and most of the general practitioners are private (Metsallik *et al.* 2018).

### 2.3. Blockchain

Estonia was the first country to deploy Blockchain technology on its digital services following several cyber attacks in 2007. Testing begun in 2008 with the objective to mitigate possible threats. Blockchain technology assures system integrity while patients and healthcare professionals can access private medical data, including prescriptions, using Estonia's secure e-ID (e-Estonia, 2022).

Blockchain technology was introduced in 2008 by a person or group, under the pseudonym Satoshi Nakamoto, developed for the cryptocurrency, bitcoin (Mettler, 2016). It is a system for recording and storing transactions, in interconnected blocks with a unique identification code. The underlying principle of immediate, transparent and decentralized access to information represents the essential starting point for many market sectors (Mettler, 2016). Therefore, the potential for blockchain technology has been studied and, as previously mentioned, already applied in several areas to guarantee privacy and security, namely in financial applications, integrity verification, government entities, public services, electronic elections, Internet of Things (IoT), industrial and business applications, supply chain management, energy, education, data management and healthcare management (Casino *et al.* 2019).

Health services have been slow to apply information technologies, but recently the implementation of electronic medical records and other systems of automated tools has led to a faster and more aggressive evolution (El Morr and Subercaze, 2010). The development of these electronic patient records is, according to Casino *et al.* (2019) probably the area with the greatest potential for growth.

The long term view, however, is a paradigm shift that will allow the focus of sharing data and information from different health units to the patient him/herself with quick and easy access to his/her own medical data. Blockchain technology will have a particular role in this development, given its emphasis on sharing, distributing and encrypting information (Gordon and Catalini, 2018). The eHealth system in Estonia is one such example.

According to Metsalik *et al.* (2018) the security of Estonia's eHealth system is ensured by six principles:

. authentication and authorization of all users through an ID card, mobile ID and smart ID;

. digital signature (by individuals) or digital stamp (in the case of institutions) of all medical documents;

. accountability and transparency provided by an immutable and unalterable trace, containing detailed description of all the actions;

. personal data is separated from medical data;

. encrypted database, with less risk of breach of confidentiality by technicians and system administrators;

. monitoring of all actions to identify and quickly act in situations of fraud.

This technology still presents some challenges, for example, regarding the anonymous, but not private, aspect of information exchanges; the management of passwords by patients, and the implementation of tight EU data protection regulations that need greater clarity and up to date policies (Gordon and Catalini, 2018). The immutability aspect of the technology versus the right to be forgotten, for example.

The cost associated with the implementation of advanced computer systems, as well as the difficult usability of these systems are other obstacles generally pointed out to the adoption of blockchain technology in healthcare (Aguiar *et al.* 2020).

## 3. METHOD

For this research a narrative literature review was conducted subject to the theme of the benefits and challenges of the implementation of e-Health, using the success story of Estonia as the reference, and the contribution of blockchain to the adoption of digital healthcare systems.

A systematic review is a form of research that uses the literature on a given topic as a source of data (Sampaio and Mancini, 2007). These systematic reviews should bring together a large amount of clinical research, discussing the differences between the primary studies dealing with the same object (Lopes and Fracolli, 2008); and they are particularly useful for integrating information from a set of studies carried out separately. It is, however, a retrospective and secondary type of study, which depends on the quality of the primary source (Sampaio and Mancini, 2007).

The analysis of qualitative results obtained in a systematic review can be presented in narrative form, topics, or thematic summaries, as the sum of the parts of the results on a given topic (Lopes and Fracolli, 2008).

According to Sampaio and Mancini (2007), three steps should be taken into consideration before starting a systematic review: defining the objective of the review, identifying the literature and selecting the studies that can be included.

Regarding the database used for this study, Martín-Martín *et al.* (2018) compared three options, Google Scholar, Web of Science and Scopus and demonstrated that in terms of scope, the former had a greater number of unique publications that weren't found in the other two databases. However, the same study found that the scientific impact of the citations in Google Scholar was, on average, much lower than the citations found in Web of Science and Scopus. It was also demonstrated that it is the database that presents the highest probability of errors, since among these unique publications, many can refer to articles not published in scientific journals, but rather dissertations, thesis and book chapters.

Jacso (2005) also referred to the difficulty in implementing the most basic Boolean operations, AND or OR, correctly in Google Scholar.

For the context of this article, the selected database was Scopus and its search engine was used to research all the publications that included in the Title, Abstract or Keywords, the terms "Estoni*" and "eHealth*" or "e-Health*", to ensure the widest coverage of the various presentations of these terms.

*Search String used on Scopus:*

***TITLE-ABS-KEY(Estoni*) AND TITLE ABS-KEY (e-health*) OR TITLE-ABS-KEY (eHealth*) OR TITLE ABS-KEY (Blockchain)***

The selection criteria for inclusion in this research were relevance of the article in relation to eHealth, type of publication and written in the english language. No time frame was imposed as a restriction; book chapters and conference papers were not included.

## 4. RESULTS: presentation and analysis

The research in the Scopus database revealed seventy four (74) documents with "Estoni*" and "eHealth*" or "e-Health*" and "Blockchain" in the title, abstract or keywords, ranging

from 2004 to the current date. Of these, thirty four (34) were conference papers and nine (9) were book chapters. Of the remaining articles, only nineteen (19) met the requirements previously established for this study and are displayed in **Table A1** (see Appendix A). The analysis has been summarized into topics displayed below, differentiating benefits and challenges.

### 4.1. The Benefits

**. Access**

The quick and easy access to patient's medical history, laboratory and imaging test results, diagnoses and prescribed medication by customer's themselves, but also attending doctors and other healthcare professionals, at any time and at any location, is perceived as one of the greatest advantages of eHealth (Barkas *et al.* 2022; Kwiatowska, 2016; Ross *et al.* 2010; Parv *et al.* 2014; Tuula *et al.* 2022, van Kessel *et al.* 2022).

Improved access through remote delivery of quality, cost-effective, care was particularly important during a crisis such as the covid-19 pandemic, allowing for patients to interact with healthcare providers at home, limiting exposure to biologic risk. This benefit goes beyond such periods of crisis, it is also an important advantage for remote monitoring of people with disabilities, or autistic adults who seek alternative forms of communication "whilst not subjecting these patients to overwhelming and unknown sensory environments". eHealth allows for patients to interact with their healthcare providers at home, creating close patient engagement during their care (Luca *et al.* 2021; van Kessel *et al.* 2022), and can improve the "potential health outcomes amongst rural and remote patients with chronic disease" (Lluch 2013; Nøhr *et al.* 2017).

The group of over 65 year olds, represents 20% of the population structure in Estonia, which is very close to the European average (Eurostat, 2023). eHealth systems can play a vital role, in allowing this segment of the population to book appointments online, renew medical prescriptions, and access health information such as referrals and test results.

**. Efficiency**

Miller (2015), Tuula *et al.* (2022) and van Kessel *et al.* (2022) bring attention to the benefits of increased efficiency and reduced cost of eHealth to healthcare and pharmacy services. It can "facilitate distribution and dissemination of public health information"

reaching the target audience more easily with widespread announcements and warnings, such as reminders for future appointments); it can enhance clinical and laboratory work, by supporting administrative tasks and therefore leaving more time for healthcare providers to spend more time with their patients. Centralized paperless systems means patients can fill medical forms ahead of their appointments, medications can be prescribed without the need for a specific appointment (Tuula *et al.* 2022), and physicians can effectively manage medical records. The process alone has saved costs by vastly reducing the number of written paper forms and medical prescriptions (Jogi *et al.* 2023; Parv *et al.* 2014) It has decreased the number of forgeries and it has made "the dispensing of e-prescriptions safer, more efficient and more cost-effective" (Jogi *et al.* 2023). Arranging appointments can be done faster and easier and according to Kwiatowska, 2016, e-Health systems can help "reduce inefficiencies and fraud, medical errors and duplication of tests or payments. Therefore, eHealth has the potential to reduce administrative costs, increase revenues and reduce waiting times (Luca *et al.* 2021, Ye and Saltman 2019).

eHealth has proven to save time for both healthcare professionals and individuals when it comes to the exchange of data across institutions and/or sectoral borders (Metsallik *et al.* 2018).

Digital solutions, such as wearable devices like smart watches, wristbands and subcutaneous sensors, can help collect medical history of patients without the need of extra appointments and reduce the consultation time (Lotmand and Viigimmaa, 2020).

**. Quality of Care**

eHealth improves data collection and analysis and through aggregated information and insights, an online record of healthcare appointments (past and future), exams, test results, and prescriptions improves the quality of diagnosis (Luca et al. 2021; van Kessel *et al.* 2022). Parv *et al.* (2014) claim that e-Health has the potential for better access to higher quality healthcare.

In the research of Parv *et al.* (2014), by accessing all of pharmaceuticals prescribed to a patient "67% of primary care physicians believed that they would make fewer mistakes": better informed physicians can help mitigate risks of errors.

Increases patient safety (Luca *et al.* 2021) and improves the quality of care, with a more personalized approach (Kwiatowska, 2016; Lotman and Viigimaa, 2020).

**. Cooperation and Data Sharing:**

The cooperation between healthcare providers is crucial to ensure quality medical services. eHealth can "support the development of integrated models of care" through sharing of information across multiple professional teams and institutions, thus "enhancing service coordination" (Lluch, 2013) .

In order to improve this cooperation services such as e-consultation, e-referral and e-prescription have been available in Estonia since 2013. These services allow for family doctors to refer to a specialist quickly and conveniently. Patients can, then, review these consultations in the Patient Portal (Lotman and Viigimaa, 2020). The "bidirectional flow of information between individuals and healthcare providers" is regarded as an important benefit of e-Health (Kwiatowska, 2016).

There's also the possibility of transferring medical certificates and transactions directly to the Social Insurance Board, in case of claims (Tuula *et al.* 2022), or the provision of health declarations for driving license applications (Metsallik *et al.* 2018).

This can present a challenge with a risk of fractured communication if healthcare providers need to face different systems across different facilities and departments (van Kessel *et al.* 2022).

It is generally accepted that for e-Health to reach its full potential it is necessary to find a model, or policy, of cooperation between the public sector, healthcare providers, businesses and universities (Lluch, 2013; Lotman and Viigimaa, 2020).

**. Knowledge and Control**

With easier and better access comes more knowledge and control over patient's own health; which in turn improves their understanding over their medical condition (health literacy) and provides an increased feeling of validation (Barkas *et al.* 2022; Kwiatowska, 2016; Milani *et al.* 2015; Nøhr *et al.* 2017; van Kessel *et al.* 2022). This can have a positive impact on patient's "health prompting behaviors", reducing "overall rates of disease and associated medical care costs" (Ye and Saltman, 2019). Healthcare providers and IT

technicians (contacted when there are difficulties in accessing the e-Patient Portal) report that with more accessible data, patients are encouraged to take a more active role in monitoring their health (Metsallik, 2018). Involving patients in their own treatment, by allowing them access to their data

Barkas *et al.* (2022) brings attention to the risk of too much access to their own clinical information. Some patients "can become confused, anxious or offended" by some of the data they read, and this can lead to "increased threats and violence" from patients.

### 4.2. The Challenges

**. Disparities:**

As society becomes increasingly digital, the risk of worsening existing inequalities should not be ignored. Digital literacy and access to digital infraestructures varies greatly according to age, socio-economic and educational status, place of residence and degree of disability (Cwiklicki *et al.* 2020, Metsallik *et al.* 2018; van Kessel *et al.* 2022). There is room for improvement in consumer-friendly services that connect the person to the system (Lotman and Viigimaa, 2020), and overall user support (Nøhr *et al.* 2017). The most vulnerable group is the group of older patients (Ćwiklicki *et al.* 2020). Estonia registers one of the worst results in the EU in terms of poverty in this age group. Acquiring a computer or accessing the internet can present a major financial challenge (Paimre, 2019). The same study indicates that the elderly use computers as a means of communication with some reluctance. Digital exclusion of underserved specific population groups threatens the equitable access of healthacare (van Kessel *et al.* 2002). Education is necessary for healthcare providers and patients regarding digital technologies (Kwiatowska, 2016)

Ensuring eHealth's multilingualism promotes linguistic diversity and cultural identity, and demonstrates, the government's commitment to the inclusion of the country's linguistic minorities; especially in countries that receive immigrant populations (Ćwiklicki *et al.* 2020).

**. Confidentiality and Lack of Trust**

According to Ćwiklicki *et al.* 2020 the non existence of adequate specific legislation applied at a national level that regulates e-Health is an obstacle for its implementation. The questions raised regarding privacy, confidenciality and data protection need to be addressed

before the adoption of e-Health systems (Stroemman *et al.* 2011). A national policy of e-Health with well defined objectives, clearly stating the tasks, rights and duties of all the stakeholders and which areas of services are expected to be substantially improved with e-Health is required. EU must provide the strategic guidance to ensure the adoption of a common framework which would in turn improve the confidence in the security, privacy and management of their data (Nøhr *et al.* 2017). Estonia is, however, amongst the first countries to introduce specific national policies oriented for e-Health (Luca *et al.* 2021)

The issue of trust is perceived as one of the main obstacles for the implementation of e-Health solutions (Ćwiklicki *et al.* 2020; Ross *et al.* 2010). Metsallik *et al.* (2018), Miller (2015) and Yeh and Saltman (2019) claim that there is a concern of trust by patients in the management of personal medical data, but also physicians who are initially reluctant to provide full accounts, or share medical data on integrated systems. Users, patients and physicians, were slow to begin accessing and utilizing their health information accounts. There is, according to Yeh and Saltman (2019) a need to "find the balance between the tightly inter-related but conflicting interests of government, medical professionals, patients and individual citizens concerning access and the use of electronic medical information".

Estonia high trust reports are justified by the long-term use of the system without incidents nor misuse of personal data (Lotman and Viigimaa, 2020). Blockchain technology ensures "security, accountability and transparency of processes"; and the close monitoring of all actions allows for quick and definite identification of fraud and misuse (Metsallik *et al.* 2018).

**. Knowledge and Skills: "Cognitive Burden"**

The area of e-Health that needs more investment is the reinforcement of knowledge and skills of the team of healthcare professionals regarding these digital systems (Parv *et al.* 2014; Stroemman *et al.* 2011).

The dissemination of e-Health amongst the public is only possible with the "clinical endorsement by physicians and other healthcare providers" but the concern over data overload which will require of them more time to check, review and provide feedback for their patients, the need for general "workflow changes" can become a real challenge (Lotman and Viigimaa, 2020; Parv *et al.* 2014). Currently, much attention is required to the security and electronic authentication of users (Metsallik *et al.* 2018), which ensures data protection but requires

additional time and training. The need for “workflow changes” is also mentioned by Parv *et al.* (2014). The need to prepare students and health professionals to operate digital medical technology is essential for the dissemination of eHealth (Ćwiklicki *et al.* 2020) and is defined by van Kessel *et al.* (2022) as the “cognitive burden” of frontline staff who need to use digital technologies and platforms efficiently. There is a definite need for “medical education to be rebalanced with adequate coverage of digital services” and continuous “user interface development should not be underestimated (Metsallik *et al.* 2018).

In Estonia, after two decades of digital development, it is now expected that new generations of healthcare professionals will have the qualifications to work with eHealth and they have high expectations, themselves, regarding the services they will encounter in their workplace (Lotman and Viigimaa, 2020).

**. Financing**

The lack of financing is amongst one of the most important challenges for the adoption of e-Health (Cwiklicki *et al.* 2020) and “increased support is needed amongst countries with a lower quality of life and a poorly functioning public health system” (Luca *et al.* 2021) particularly for the initial investment in necessary infrastructure (Kwiatowska, 2016; Yeh and Saltman, 2019). The implementation of digital health services is initially influenced by the availability of funding, not only as a “driver to test or scale it up, but also as an incentive to promote integrated care and the sustainability of the initiative” (Lluch, 2013).

Healthcare organizations and pharmacies are reluctant to invest additional resources in enabling e-Health services (Parv *et al.* 2014). Public-private partnerships are encouraged (Ćwiklicki *et al.* 2020) and the reorientation of some of the "funding schemes for prevention, rather than reactive treatment of diseases” is proposed (Milani *et al.* 2015). According to Parv *et al.* (2012) setting up a nationwide interoperable e-Health system will require a large initial investment, but if the system works effectively, benefits can surpass costs within three years.

**. Quality of data**

The exchange of information and digital documents between institutions demands great emphasis on the need for medical professionals to enter data with quality (Metsallik *et al.* 2018). Some physicians are reluctant to use the standard language, recommended by the

system, to describe conditions (Yeh and Saltman, 2019). The "semantic interoperability of medical data is hard to achieve", according to Metsallik *et al.* 2018, who also claim that data quality and secondary usage of data is still challenging. This is a particular obstacle during the first phase of the implementation of eHealth systems, when looking for a certain standardization of data (summary notes, inpatient discharge letters, demographic, reports). Milani *et al.* (2015) claim that when dealing with large amounts of data there is a need for IT tools that can integrate different sources and "user-friendly clinical decision tools".

The "interpretation of data from various sources and different classifications" and "data stored in non-compliant structures" can become a challenge in large data studies (Lotman e Viigimaa, 2020).

### 4.3. Future Applications:

**. Computerized Decision Support Systems and Genomics**

The amount of data that is available across the Estonian Health Information System and Estonian Genome Center helps healthcare professionals to support their decisions, take into consideration case-specific recommendations to improve clinical outcomes, avoid adverse effects and improve efficiency (Lotman and Viigimaa 2020). These large databases, also referred to as Biobank, allow for the deployment of Computerized Decision Support Systems with demonstrated results on the "improvement of treatment monitoring, safe prescription of medical products and utilization of health care resources, decrease rates of rehospitalizations" (Lotman and Viigimaa 2020). Milani *et al.* (2015) claim that the introduction of genomics together with current medical practices organized by user-friendly IT systems will lead to "better screening programs, earlier detection of disease and better opportunities for treatment of patients", thereby reducing the burden on the healthcare system.

Through personalized medicine healthcare professionals can go a step further and may be able to utilize personal medical information, health behaviours, traditional test results, symptoms, family history, environmental factors and genomic information to implement new routines for diagnosing and treating disease. The intention is to focus on preventive health care, instead of reactive treatment to disease (Milani *et al.* 2015; Yeh and Saltman, 2019).

**. Cross-border healthcare:**

eHealth systems have the potential to break down borders within the EU space and recent studies are focusing on the development of Cross-border Healthcare. This system would allow a European citizen access to healthcare even if he/she is not in his/her country of origin. The European Commission (2019) reported more than 2 million occasions in which a citizen residing in a given member state sought health services in another. With the increasing mobility of populations, we can expect the need for Digital health services available beyond the borders of their country to rise (Palma, 2022). Therefore, the EU has launched a program called "*MyHealth@EU*" and the first of these services should be guaranteed through the interconnection of electronic prescription systems; followed by a summary record of medical data for each European citizen (Bruthans and Jiráková, 2023). As far as e-prescriptions are concerned, there have been substantial developments. By the end of 2022, there were already six countries in the European Union with a digital prescription service without borders (CBeP - Cross-Border ePrescriptions): Croatia, Estonia, Finland, Poland, Portugal and Spain (Jogi *et al.* 2023).

The implementation of a cross-border system also poses challenges in terms of interoperability of the various systems, the capacity to interpret the data, which must be available to the receiving country, and the process in which patients and health professionals are authenticated. The type of mandatory information to be submitted is not the same in all countries (Bruthans and Jiraková 2023).

### 4.4. Blockchain

Blockchain has gained growing attention from several different sectors, including governments and international organizations looking to avoid power centralization problems on the internet, tackle corruption, facilitate and scale up governance processes and increase governmental transparency. In more data dependent digital systems such as eHealth, blockchain has been advocated as the solution to several user's issues such as "ensuring citizen's data ownership", "increase the degree of transparency" and "privacy protection" but also at a government level, to "avoid further external intrusions" (Semenzin *et al.* 2022). In Estonia, every patient's health record is secured with blockchain technology, and they can be assured as to who has had access to their records (Leeming *et al.* 2019, Lotman and Viigimaa

2020). This technology helps mitigate internal threats to the data and assures the integrity of medical records" (Tuula *et al.* 2022).

Besides eHealth there has been implementation of blockchain technology in the control of medicinal products being sold in Estonia, through immutable tracking of the supply chain for medicines and packages (Leeming *et al.* 2019, Tuula *et al.* 2022)

## 5. CONCLUDING DISCUSSION

The healthcare system in Estonia has undergone an impressive digital transformation since the introduction of electronic health records, the implementation of digital prescriptions (e-prescriptions) and the creation of a Patient Portal that collects, in one single database, all of the patient's medical data submitted by any healthcare provider. It is a success story that has been studied for implementation in other European countries, as is also the desire of the EU in their strategic plan for cross-border healthcare development.

A centralized and technically competent government agency and the political willingness of its citizens to allow for data collection, storage and management seem to be essential elements for the successful implementation of these digital systems. As stated also by Yeh and Saltman (2019) it appears that in order to grant citizens the power over their own medical data it is first necessary to empower a bureaucratic governmental entity. These ensure integrity and provide legitimacy and accountability to the eHealth system which in turn grants confidence to its users.

The results of this study, which focus specifically on the example of Estonia, corroborates the existing literature. Advantages and benefits such as an improvement in access, demonstrated widely during the period of COVID19 pandemic; and the decrease in waiting times, in the management of consultations by healthcare professionals, facilitated by the possibility of all having all the medical data easily accessible at any time, at any location have been mentioned in most publications. Information and communication technologies make it possible to increase the fluidity in the transfer and sharing of data in both directions, between patients and healthcare providers, but also between these users and other entities or departments.

This research also points out the potential benefits, not yet verified, of more knowledge and control by patients of their own health information. Increasing medical literacy and involving patients in their own treatment by allowing them access to their medical data and respective monitoring can prompt healthier behaviors and reduce hospitalizations.

Amongst the challenges to the implementation of eHealth services, the risk of digital exclusion of specific population groups is the biggest threat to the equitable access of healthcare. Digital transition must be accompanied by campaigns and education opportunities for its members to raise awareness and reduce digital impairment. Questions regarding confidentiality, data protection and lack of trust are raised equally by patients and healthcare providers. Blockchain technology is proving to be a viable solution since there hasn't been any incidents or reports of data misuse, over a decade of adoption of eHealth services in Estonia. The cognitive burden for healthcare professionals, not only in acquiring the necessary digital knowledge and skills to operate eHealth services, but also in the attempt to standardize all of the medical language and information that is collected and inserted in the system, to guarantee the semantic interoperability of medical data. It is a particular challenge during the first phase of implementation of eHealth systems when previous records need to be updated, but a critical step in guaranteeing the cross-border healthcare.

It is overall understood that the implementation of such eHealth services will require a substantial initial investment in necessary infrastructures, which is presented a challenge, but the European Commission does offer some support in co-financing of such projects. Regarding the day to day costs, the study points out the potential to reduce administrative costs, by adopting paperless systems, reducing errors and becoming more efficient in the management of appointments and consultations, but falls short in presenting more precise data over maintenance costs and benefits.

The majority of the member states of the EU are facing a scenario of an ageing population, with a higher prevalence of chronic diseases, and scarcer financial and human resources for the provision of healthcare. This research points out the clear benefits and challenges for countries and healthcare providers looking into the introduction of digital eHealth systems. Cross-border European healthcare is already a strategic foundation for the future of healthcare provision in EU. Estonia's decade old example has shown that there is room for improvement and potential long term benefits in overcoming the initial challenges, that are only now being

researched, such as computerized decision support systems, enabled by blockchain technology.

Unfortunately, due to the low number of publications that linked blockchain and healthcare, we were not able to thoroughly analyze the contribution of this technology in the adoption of eHealth in Estonia, but security, privacy and transparency are common trends.

There is an urgent need to ensure better management and provision of healthcare services and given the potential benefits of eHealth, governments should at least consider its implementation. The new eHealth services should not replace existing health services but rather complement them to make processes more efficient and accessible to society.

### 5.1. Limitations

This study has some limitations, namely in the choice of database which, despite being quite reliable, with its own search engine, was restricted to Scopus. The search resulted in a very low number of publications and of the 74 initial findings only 19 publications were included in this study. It is expected that with the increasing interest in the subject of eHealth and blockchain technology in healthcare, that the number of publications will increase and strengthen the results of this paper.

### 5.2. Future Investigations

There is limited insight into the ultimate impact at both individual and population health levels, highlighting the need for more investigation on how investments in eHealth systems and e-portals providing patient's access to personal health data are actually contributing to patient empowerment and in doing so, improving individual and population health outcomes.

There's definite opportunity, and the most recent studies are pointing in that direction, to study the benefits and challenges of cross-border healthcare, following the success of Cross Border e-prescriptions.

The concern with data privacy versus the benefit of personalized medicine and the privatization of data by companies, versus the accessibility of medical information for research are conflicts and dilemmas that should be addressed by future regulators, policy makers and researchers (Ibrus and Tafel-Viia, 2019).

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# THE IMPACT OF eHEALTH AND BLOCKCHAIN TECHNOLOGY IN HEALTHCARE: A QUALITATIVE RESEARCH OF MEDICAL PROFESSIONALS OF ESTONIA

*Abstract:*

***Purpose:*** *This study aimed to analyze the perception of healthcare workers of Estonia on the impact of eHealth and blockchain technology in healthcare, after over a decade of its nationwide adoption, and their perceived benefits and challenges of its implementation.*

***Design:*** *A qualitative research was conducted involving a semi-structured interview of eleven participants, selected amongst healthcare professionals such as doctors, nurses and managers of healthcare institutions.*

***Findings:*** *The eleven participants referred to eHealth as a great tool which facilitates access to patient's medical data, saving time and improving communication with other healthcare providers and patients. Data overload, insufficient computer skills and the disparities on access by particular groups of the population are amongst the challenges on the implementation of eHealth.*

***Implications:*** *This research provides a personal insight of frontline health workers, with over six years of experience, on the impact of eHealth after a decade of its implementation in Estonia, particularly the benefits and challenges.*

***Originality/value:*** *This study highlights the perceptions of healthcare workers, on the impact of eHealth and blockchain technology, specifically detailing its benefits and challenges, after a decade of its adoption in Estonia.*

**Keywords**: eHealth, Blockchain, Estonia, Benefits, Challenges

## 1. INTRODUCTION

eHealth is viewed by some as one of the most important revolutions in healthcare, comparable to modern medicines and vaccines (Silber, 2003) and has become an integral part of healthcare systems across Europe.

The broader objective of eHealth is to support healthcare professionals in their work and continuous, lifelong learning, as well as to assist all citizens in their own healthcare management, across organizational boundaries and health systems (Moen *et al.* 2012). In recent years Estonia has ranked highly in various international comparisons measuring e-readiness amongst EU countries. Its eHealth service has been established since 2008 becoming the first country in the world to fully implement such a system nationwide. The Estonian ehealth information system incorporates health data from all of Estonia's healthcare providers, which can then be safely exchanged between patients and medical staff.

The introduction of blockchain technology was the response of the Estonian government to a series of cyber attacks which plagued the country in 2007. Initially developed for the crypto currency bitcoin, its properties of anonymity, transparency and auditability has sparked the interest of several market sectors. In healthcare the application of blockchain aims to improve the interoperability of patient health information between different healthcare organizations while maintaining the privacy and security of data. The technology ensures accountability and much needed transparency of processes through close monitoring of all actions. The principle of decentralization can provide the structural foundation for the paradigm shift towards a patient-centered, rather than institution-centered, healthcare delivery.

As with many European countries, Estonia is facing a health workforce shortage caused by ageing healthcare workers, professional migration and inadequate training volumes of recent years but eHealth, and its many applications, is viewed as one of the responses to maximize the scarcity of human and material resources. By eliminating unnecessary face-to-face medical appointments, improve the cooperation between healthcare providers and involving patients in their own care by allowing them access to their data the implementation of eHealth is seen as a positive move towards time and resource efficiency. The digital transition is not without its challenges, however, as concerns have been raised that general implementation of

eHealth may unintentionally aggravate healthcare disparities for vulnerable and under-resourced groups.

After over a decade of implementation in Estonia, we are bound to ask, has eHealth lived up to its potential for those working with its many applications? What benefits and challenges have healthcare professionals encountered in their day-to-day experience with eHealth? The aim of this study is to attempt and answer these questions, with the following primary objectives:

a) Analyze the perception of medical professionals regarding eHealth and Blockchain

b) Recognize the benefits of the implementation of eHealth for medical professionals

c) Identify the biggest challenges of the implementation of eHealth for medical professionals

In order to respond to these objectives a qualitative study was carried out with a written interview of eleven participants working in healthcare, including doctors, nurses and managers of healthcare institutions.

This research begins with a brief analysis of the concept of eHealth, followed by a description of its several applications in Estonia and the justification behind the adoption of blockchain. In the second part of this paper the method is characterized as well as the presentation of the participants in the interview. Lastly we reveal the questions of this interview and answers of the participants; the results are analyzed and discussed, assessing the perception and impact of eHealth and blockchain technology on the day-to-day life of medical professionals and in their interaction with other colleagues and their patients.

## 2. LITERATURE REVIEW

### 2.1. eHealth

There is no general agreement on a single definition of eHealth (Bruthans and Jiráková, 2023). The WHO (2006) defines eHealth simply as "the use of information and communication technologies for health". Despite the difficulty in defining eHealth, there is a common view that it is a rapidly expanding area, that has the potential to encourage the adoption of healthy behaviors, enable improvement of healthcare services and communication between healthcare professionals, at relatively low cost, time efficiency, and customized for individual patients (Ahern *et al.* 2006; Kim *et al.* 2023; Maramba *et al.* 2019; Schreiweis *et al.* 2019; WHO, 2006)

eHealth should not be viewed as just the use of information and communications technology, but should be considered in relation to the multitude of needs within the health care system (Moen *et al.* 2012). eHealth is not the solution to all of the current healthcare problems, but it can significantly contribute to its improvement (Silber, 2018)

The quick and easy access to patient's medical history, laboratory tests and other medical data, at any time and at any location is perceived as one of the greatest advantages of eHealth for healthcare providers (Parv *et al*. 2014, Tuula *et al.* 2022, van Kessel *et al.* 2022). Booking appointments, as well as managing consultations, sharing data and referring to other specialists has been made easier and more efficiently by eHealth, saving time for both patients and medical professionals (Lluch, 2013; Lotman and Viigimaa, 2020).

There are several obstacles for eHealth, including limited investment and limited availability of skilled ICT personnel. Despite that, the use of electronic health records is well accepted and widely used by patients and healthcare professionals. (Bert *et al.* 2023). Evidence suggests, that many people who already experience poor health outcomes are also more likely to face digital exclusion (Heinsch *et al.* 2022).

### 2.2. e-Health in Estonia

Estonia has developed a number of e-services since 2008, including the Estonian digital health platform (DHP), called the Estonian nationwide health information system (EHIS) which allows secure and trusted access to medical data, prescriptions and medical images.

The Estonian e-Health system is unique because it is nationwide, integrating healthcare data of all healthcare providers (Metsallik *et al*. 2018)

The most widely used applications are the Electronic Health Record, the Patient Portal, the digital prescription, the drug interaction decision support, e-consultation and e-ambulance (Bertl *et al.* 2023).

**. Electronic Health Record**

The electronic health record (e-Health Record) is a "nationwide system that integrates data from Estonia's different healthcare providers to create a common record that every patient can access online" (e-Estonia, n.d.). The system functions as a national database that retrieves data from various providers, which may be using different programs, and presents the data in a standardized format via the e-Patient Portal. In a single electronic file, doctors can access patient's records and read test results as they are entered (Tuula *et al.,* 2022).

The electronic health record is a fundamental building block to all of the eHealth applications. It allows the sharing of medical records between healthcare providers, across many disciplines, institutions and, potentially, geographic boundaries (Silber, 2018).

. **e-Patient Portal**

The e-Patient Portal allows for patients to access their medical records, as well as the records of their underage children, or authorize others such as caregivers or family members. By logging in, using an electronic ID (eID), the patient can review doctor visits, check and renew prescriptions, assess which health providers have had access to their files, book appointments and ask for sick-leave notices, which are issued digitally and automatically sent to the patient's employer (e-Estonia, 2020; Tuula *et al.*, 2022). The e-Patient Portal includes a self-reported Health Declaration which is used towards specific requests such as driver licence's renewal; and includes reminders for vaccines and mandatory regular check ups (Nøhr *et al*. 2017).

. **e-Prescription**

Estonian e-prescription system was first introduced in 2010 and currently over 99,9% of prescriptions are handled online (Tuula *et al.* 2022). e-Prescription is a centralized paperless system for issuing and handling medical prescriptions. Medicines are prescribed, by doctors, electronically, using an online form which can be accessed at the pharmacy with the information retrieved by the patient's ID-card. The centralized aspect of the system allows for

any medical cost assisting benefits, that the patient might be entitled to, will also appear and the medicine is discounted automatically. The system allows automatic billing from pharmacies to the Estonian Health Insurance Fund. Doctors can issue repeated prescriptions without the need for an appointment. A patient can contact the doctor by e-mail, Skype or phone and with just a few clicks doctors can issue a refill; which can be collected from the nearest pharmacy (e-Estonia, n.d.). This system saves time for both patients and health workers, but most importantly, it allows healthcare workers and authorities to keep track of prescribing patterns, patient's medicine use and monitor compliance (Tuula *et al.* 2022).

. **e-Consultation**

The e-consultation service is an opportunity for family doctors to consult with medical specialists in order to clarify their patient's health problem. This service is carried out electronically and through a proper digital referral document the physician describes the patient's complaints and condition in detail, including any tests, analyses and studies carried out. The medical specialist prepares a proper response to the referral, which may be some advice regarding further treatment, further tests or analysis and/or if the patient requires specialist treatment.

The service improves the communication between family doctors and medical specialists; as well as it saves patient's time, avoiding unnecessary appointments (Tervisekassa, 2019).

. **e-Ambulance**

e-Ambulance is a digital service that can detect and position an emergency phone call for the responding ambulance. It also allows for the attending emergency crew and the doctor at the hospital to read time-critical information, such as blood type, allergies, medication and recent treatment, through the patient's ID code (e-Estonia, n.d.). Emergency crews can access patients medical history and condition en-route to the victim and, through live health monitoring devices, record and deliver status information to receiving hospitals, for preparation and increased readiness, thus saving time and effort (Matsumoto *et al.* 2015).

. **Clinic Decision Support**

The clinic Decision Support system was first introduced in Estonia in 2020. It is an important tool used by doctors and nurses that brings patient-based recommendations in order to help make better decisions, faster. It collects and analyses human data, such as diagnoses, medications, tests from the last five years, blood pressure readings and lifestyle factors (e-

Estonia, 2020). The amount of data that is available across the Estonian Health Information System helps healthcare professionals to support their decisions, take into consideration case-specific recommendations to improve clinical outcomes, avoid adverse effects and improve efficiency (Lotman and Viigimaa 2020). The intention is to focus on preventive health care, instead of reactive treatment to disease (Yeh and Saltman, 2019).

### 2.3. Blockchain Technology in Healthcare

Blockchain technology was introduced in 2008 by a person or group, under the pseudonym Satoshi Nakamoto, developed for the cryptocurrency, bitcoin (Mettler, 2016). This technology is based on a distributed peer-to-peer system which applied to crypto currencies has made it possible to speed up international payments, eliminating intermediaries, normally banks; transactions happen practically immediately, with less costs and bureaucracy; and, without compromising security, continues to be verifiable and auditable (Nakamoto, 2008).

Since then, the technology has been used in various other industries such as business, data management, education, finance, public services and more recently, healthcare. The underlying principle of immediate, transparent and decentralized access to information represents an essential starting point for many market sectors (Abu-Elezze *et al.* 2020; Casino *et al.* 2019). The healthcare sector, for which the storage and transfer of sensitive data is vital, could not remain indifferent to the evolution of this technology and the association of blockchain and healthcare has been the subject of particular interest (Ambrósio and Soares, 2022). “The quality management of information is indispensable to the quality of healthcare” (Silber, 2018).

Estonia became the first country to deploy blockchain technology on its digital services following several cyber attacks in 2007. Testing begun in 2008 with the objective to reduce the risk of possible threats (e-Estonia, 2022). Blockchain technology is used to ensure the integrity of the electronic medical data as well as the system access logs (e-Estonia, n.d.). “Blocks” of information are connected to each other and make up a chain that reflect all the changes; so that every attempt to change the data leaves a trace in the pattern that can be instantly detected. The “chain of blocks” reaches a great number of computers all over the world, and can, therefore, be controlled and verified by a great number of parties. The information isn’t stored in a single, specific, location and no centralized version exists for a

hacker to corrupt, making it safe to use. (e-Estonia, n.d.). Blockchain technology ensures "security, accountability and transparency of processes"; and the close monitoring of all actions allows for quick and definite identification of fraud and misuse (Metsallik *et al.* 2018).

The issue of trust is perceived as one of the main obstacles for the implementation of eHealth solutions (Ćwiklicki *et al.* 2020). Yet, Estonia's eHealth system ranks highly in trust reports due its long-term use of the system without incidents nor misuse of personal data (Lotman and Viigimaa, 2020).

## 3. METHOD

The research in this study is classed as qualitative, regarding the analysis and treatment of data. The method for collection of data was a written semi-structured interview with fourteen questions divided in four groups and submitted to the participants through google forms.

An interview is considered as the interaction between two or more people and is applied to the study of history, relationships, representations, beliefs, perceptions and opinions of individuals (Batista *et al.*, 2017, Spencer *et al.*, 2004). As a data collection instrument, written interviews help to provide personal depth to overall numbers and statistics.

The e-interview saves time and financial resources and, in this particular case, opened up the possibility for interviewing research subjects who lie beyond the geographical social reach of the researchers. This type of interview however, provides a limited register for communication and is dependent on competent access to reliable technology by researchers and subjects (Bampton and Cowton, 2002).

The selection of participants was intentional and was centered in healthcare professionals, mainly doctors and nurses, working actively, with eHealth applications, on patients or acting in management positions. The aim of the interview is to obtain a personal insight of those healthcare professionals that are in close contact with eHealth and therefore are able share their experience and opinions on the subject as well as their own perception of the impact of blockchain in their work.

The group of eleven (11) interviewed participants included oncologists, surgeons, physicians; nurse team leaders and advanced nurse practitioners; and a chief medical officer and government official.

The presentation of the results adopted the method proposed by Miles & Huberman (1994) cited by Batista *et al.* (2017) of data reduction (focusing, simplification and transformation of original data into organized summaries), followed by presentation and conclusion/verification. The analysis of the interviews follows the coding presente in table 1.

**Table 1**
Coding of Participants by Role

| | |
|---|---|
| Doctor, Oncologist, Surgeon, Physician | DOC1, DOC2, DOC3, DOC4, |
| Nurse, Team Leader, Advanced Nurse Practitioner | NUR1, NUR2, NUR3, NUR4, NUR5 |
| Chief Medical Officer / Government Healthcare Official | MAN1, MAN2 |

## 4. RESULTS: Presentation and Analysis

The interview was divided in four parts in order to answer the objectives of this study. In the **table 2** is presented the sociodemographic profile of the participants.

**Table 2**
Sociodemographic profile of participants

| **Age (Years)** | **Gender** | **Role** | **Professional Experience** (Years) |
|---|---|---|---|
| 21 to 33 (18%) | Female (73%) | Medical Doctor (36%) | < 5 years (0%) |
| 34 to 49 (64%) | Male (27%) | Nurse / Advanced Nurse Practicioner / Team Leader (46%) | 6 to 10 years (55%) |
| 50 to 65 (18%) | | Chief Medical Officer/Government Official (18%) | > 10 anos (45%) |

The majority of the participants is between 34 and 49 years old (64%). Regarding their role, 36% are medical doctors, which includes oncologists, surgeons and physicians; 46% are

nurses, which includes team leaders and advanced nurse practitioners; and 18% refer to management positions in the medical field such as chief medical officer and government official. All of the participants were working at their role for over five years.

The second group of questions, presented in **table 3**, aim to assess the perception of the participants regarding eHealth and the relevance of eHealth for medical professionals, evaluating two of its main characteristics: access to patient's medical data; and the sharing of medical information and referral process between healthcare providers. The participants refer to eHealth as a "great tool", "simple and easy to use", that helps to access, manage and share relevant information. Also, believed to ensure better quality of service and improve health outcomes by involving the patient in the process.

The literature does support that patients are encouraged to take a more active role monitoring their own health, and through a better understanding of their medical conditions, adopt healthier behaviors which can potentially reduce overall rates of disease (Metsallik, 2018; Ye and Saltman, 2019)

When it comes to access, there is an overall agreement between the participants that eHealth is very useful and access is made simple and transparent, "with guaranteed privacy"; even when you change physicians. There is a concern expressed by one of the participants regarding the amount of available data which may make it difficult to access the relevant information. This has already been suggested by Lotman and Viigimaa (2020), and Parv *et. al* (2012) who have mentioned the risk of data overload which may require more time of medical professionals to check, review and provide feedback for their patients. The necessary security checks and electronic authentication of users require additional time and training (Metsalik *et al.* 2018).

In respect to sharing of medical information, once again the overwhelming opinion is that eHealth has made the referral process between healthcare providers, easy, with only one participant claiming it could still be made a lot easier.

Services such as e-Consultation and e-prescription have been shown to improve the cooperation between multiple professionals (such as family doctors and specialists) teams and institutions (Lluch, 2013, Tervisekassa, 2019).

**Table 3**
eHealth for Medical Professionals

| Questions | Answer Threads |
|---|---|
| **What are your perceptions of eHealth?** | "Any electronic and digital process of healthcare data and access to it" "(…) helps to get and share relevant data" (NUR2, NUR4, DOC4) |
| | "It is a great tool, when used right" (DOC2, DOC3) |
| | "Its a good tool to exchange information between different specialists and to ensure better quality/service information for the patient" (NUR5) |
| | "Better management of data. Improved access. Bigger role of patients in the process, thus better health outcomes" (MAN1) |
| | "We need it" (NUR1) |
| | "Simple and easy to use" (NUR3) |
| **What are your perceptions of eHealth in the access to relevant medical data?** | "That makes communication, cataloguing, diagnostics and treatment to be done quicker and without unnecessary bureaucracy" (NUR2) |
| | "It is a good way to access data, but the problem is finding the relevant data fast" (DOC3) |
| | "It's good. You can change physicians and clinics when necessary and no data gets lost" (NUR4) |
| | "Better management of data in all aspects" (MAN1) |
| | "Everything that has been logged and not restricted by the patient becomes easily accessible; (…) access is simple, transparent and guaranteed privacy" (DOC4, NUR5, MAN2) |
| | "Absolutely positive"; "Useful"; "Great" (DOC1, DOC2 NUR1) |
| **Has the process of sharing relevant medical data between professionals and referrals process become easier, thanks to eHealth?** | "Yes" (DOC1, DOC2, DOC3, NUR1, NUR2, NUR5, MAN1, MAN2) |
| | "(Sharing data) has become a lot easier" (DOC4, NUR4) |
| | "It could be much better" (NUR3) |

The third group of questions, presented in **table 4**, aim to assess the opinion of professionals in the medical field about the relevance of eHealth in the communication with patients; and the perceived impact of eHealth in patient's compliance to their treatment.

The majority of the participants agree that it is "faster" and "easier" to communicate with their patients and issue prescriptions which they can, then, access electronically. This leads to saved time and reduced "unnecessary face-to-face" visits. From the point of view of the interviewed medical professionals, it is a great tool for patients to book their appointments and access their own medical data, mainly information discussed at previous appointments, referral letters and test results. A concern, however, is brought up by one of the participants regarding elderly patients. There is a need for mentoring on eHealth, and basic knowledge of computer skills in order to guarantee access to patients.

The risk of digital exclusion of specific population groups has been identified and threatens the equitable access of healthcare. The most vulnerable group is indeed the group of older patients who use computers as a mean of communication with some reluctance (Ćwiklicki *et al.* 2020, van Kessel *et al.* 2022).

The literature has suggested that eHealth can lead to higher compliance by patients regarding medical advice, treatments and prescriptions regimes. The interview shows some divide in this subject with a group of participants complementing the concerns raised in the previous question regarding the difficulty of older generations in accessing their own electronic records and therefore all the information regarding their treatment plans and prescriptions.

Finally, considering the possibilities of eHealth, and e-Consultations in particular, and the reduced need for face-to-face visits, a follow up question was asked regarding the reduction of waiting lists for hospital and emergency appointments. Two participants concurred but a majority of the participants did not agree with the assessment but pinpointed the lack of human resources as the main reason.

**Table 4**
eHealth for Patients

| Questions | Answer Threads |
|---|---|
| **What are your perceptions of eHealth regarding communication with patients?** | "Communication is easier, unnecessary face-to-face visits have been reduced" (DOC1) |
| | "Patients can access their health information and look up details they might have missed at previous appointments; (…) it is easy to forget what was told during the appointment" (DOC3, NUR4) |
| | "Communication is less time consuming and easier to commit. Patients can see all prescribed medications and get them from pharmacy without paper prescriptions. They can also see referral letters, test results, medical examinations and book appointments." (DOC4) |
| | "If patient is mentored, understands eHealth and is fine with basic PC skills; but with many elderly patients, it becomes a huge problem" (NUR2) |
| | "Good access to patient's health data enables a faster and more effective treatment plan" (NUR3) |
| | "Improved relationships, faster access, (…) useful" (DOC2, MAN1) |
| | "Information should be of high quality" (MAN2) |
| **In your opinion has eHealth led to higher compliance by your patients to medical advice and therapy prescriptions?** | "No, older generations show difficulties accessing their electronic records"(DOC1, MAN1, MAN2) |
| | "Yes" (DOC2, DOC3, DOC4, NUR1, NUR3, NUR4) |
| | "It's good. You can change physicians and clinics when necessary and no data gets lost" (NUR4) |
| | "Yes, but sometimes people get prescriptions too easily" (NUR5) |
| **In your opinion, has there been an improvement on the overall access to non-urgent care and consequent reduction of waiting lists?** | "Yes" (DOC1, NUR5) |
| | "No"; "No, but the problems lays elsewhere (…) lack of professionals, medical resources" (DOC2, DOC4, NUR1, NUR2, NUR4, MAN1, MAN2) |
| | "No significant reduction, but the treatment decision can be made faster using e-Consultation option with a specialist in the field" (DOC3, NUR3) |

The **table 5** presents the medical professionals perspectives on the benefits and challenges of eHealth.

**Table 5**
Benefits and Challenges of eHealth

| Questions | Answer Threads |
|---|---|
| **In your opinion, what were the observed benefits of eHealth for you and your patients?** | "Easy access to medical data by all interested parties. Easier doctor appointment system. Possibility of getting advice, without leaving home. Time saving, efficient" (DOC1, DOC3, NUR5) |
| | "Better understanding of the current status of my patients" (NUR2) |
| | "Faster access to patient's health data; medication, tests and episodes of crisis - better care" (NUR1, NUR3, NUR5, MAN1) |
| | "Booking appointments is faster and easier. Patients can look up information about previous procedures and recall what was told and advised" (NUR4) |
| | "Faster to reach the right diagnosis and treatment prescription. Administration and handling in emergencies. No repetition of investigations. Transparency! (DOC2) |
| | "Sharing of data with other professionals" (MAN2) |
| **What have been the biggest challenges/ difficulties working with eHealth?** | "Insufficient computer skills"; "Lack of training" (DOC1, NUR1) |
| | "Technical issues and having to go through a lot of data to find what you need (…) higher demand for secretaries/non medical personnel" (DOC3, NUR2, NUR4, NUR5, MAN1, MAN2) |
| | "Restricted access for medical professionals" (NUR4) |
| | "Data didn't use to be systemized" (DOC4) |
| | "None" (DOC2) |

Fast and easy access, for medical professionals and patients, to medical information and eHealth services is the main advantage. This leads to another mentioned advantage: time efficiency and convenience. As stated before, eConsultations and ePrescriptions allows for patients to get advice without leaving home and since everything is recorded in the patient's medical record, it avoids the risk of repeating investigations. Some participants state "better

understanding" of patient status, quicker diagnosis and handling of emergencies which is also supported by the literature.

The amount of aggregated information accessible online, record history of healthcare appointments, exams, test results and prescriptions improves the quality of diagnosis, and mitigates the risk of errors, increasing patient safety (Luca *et al.* 2021, van Kessel *et al.* 2022). The quality of care is improved, with a more personalized approach thanks to eHealth (Kwiatowska, 2016; Lotman and Viigimaa, 2020).

Finally the possibility of sharing data with other medical professionals is also mentioned as one of the advantages of eHealth. According to Lluch (2013) the cooperation between healthcare providers is crucial to ensure quality medical services and eHealth can support the development of cross-border integrated models of care, through sharing of information across multiple professionals and institutions.

Regarding the disadvantages, technical issues and the overwhelming amount of available data are amongst the most mentioned. The need for training and basic computer skills is also a concern for medical professionals.

Patients have the ultimate say on who accesses their medical information and that is viewed as a disadvantage by one participant.

**Table 6**
Blockchain technology in healthcare

| Questions | Answer Threads |
|---|---|
| **What is your perception of the use of Blockchain technology in Healthcare?** | "Don't know" (DOC1, DOC3, DOC4, MAN2) |
| | "Might be useful, easy to use, safe" (NUR2, NUR3, MAN1, MAN2) |
| | "Faster to reach the right diagnosis and treatment prescription. Administration and handling in emergencies. No repetition of investigations. Transparency! (DOC2) |
| **Do you feel your medical data is safe and secure?** | "Yes" (DOC2, DOC4, NUR1, NUR3, NUR4, NUR5, MAN1) |
| | "No" (DOC3, MAN2) |
| | "Maybe" (DOC1, NUR2) |

The last group of questions relate specifically to the subject of blockchain technology. Analyzing the responses there is a general affirmation of unfamiliarity with the subject, with

four of the participants clearly stating not knowing and the other participants suggesting a confusion between the blockchain technology and the broader subject of eHealth.

When the particular question of safety and security, attributed to as the major benefit of blockchain technology in healthcare, the majority of the participants feel their medical data is safe and secure; with only three expressing a concern regarding this matter.

## 5. CONCLUSION:

As demand for more and better healthcare services increases, it is believed that a significant part of that demand can be satisfied with eHealth. The dissemination of eHealth and its many applications amongst the public is only possible with the clinical endorsement of healthcare providers. Therefore, medical professionals need to be an integral part of the plan for its implementation, development and constant evaluation.

With at least six years of experience working with eHealth the participants of this study were able to offer their perception of the subject as well as their personal insight into the advantages and challenges of the implementation of such digital solutions.

Easy access to medical data by medical professionals is the most highlighted trait of eHealth, with improved communication with patients and other healthcare providers also being mentioned as a time saving solution.

More divisive is the subject of the amount of data available for consultation. For one side it can lead to faster diagnosis and treatment decisions, reducing also repeated investigations and prescription errors; but it can also lead to data overload and difficulty in reaching the necessary information, which is time consuming for frontline staff who need to use digital technologies efficiently.

In the opinion of the participants, although eHealth applications can help reduce waiting lists, through e-Consultation and e-Prescription, for example, it is not sufficient to solve the current problem, considering the lack of medical professionals.

The need for training is mentioned as one of the biggest challenges of eHealth, along with technical difficulties. This is corroborated by the literature and brings attention for the need to prepare students and health professionals to operate digital medical technology services and continuous development should not be underestimated (Metsallik *et al*. 2018).

There is positive correlation between eHealth literacy and health-related behaviors for health promotion in the future (Bertl *et al.* 2023) and the majority of the participants are of the opinion that being able to access their own medical data, prescriptions, information about their condition, may increase patient's compliance to advice and treatment regimes proposed by healthcare providers. However, a common concern was also brought forward regarding elderly patients and their difficult accessing that same medical information and using the full potential of eHealth applications. The risk of worsening existing inequalities in the access to healthcare services should not be ignored.

Regarding the subject of blockchain, the technology behind the guaranteed security and transparency, it does not fall under the direct scope of action of the medical professionals and therefore its impact on their day-to-day work goes very much un-noticed. The issue of trust, when managing private, sensitive data, is however perceived as one of the main obstacles for the implementation of eHealth solutions and a general concern for patients and medical professionals (Ćwiklicki *et al.* 2020; Ross *et al.* 2010; Yeh and Saltman, 2019). Time and the lack of events that raise suspicion over ill use of personal data have worked in favor of Estonia's eHealth system and the majority of the participants feel their private information is safe and secure, which is in itself a mark of blockchain's success.

### 5.1. Limitations

The limitations of the study include the subjectivity of the interviews, which may reflect the interviewer's disposition; and the fact that the interviews were conducted online, which removes spontaneity and does not allow for the interpretation of reactions.

The representativeness of the sample, which despite having a reasonable number of participants, does not identify the origin of the responses regarding the health service they represent and that may face different challenges.

### 5.2. Future investigations

Future research should examine the impact of more specific eHealth applications for healthcare professionals. Finally assessing the perception of the impact of eHealth, and blockchain technology, by other stakeholders such as patients and healthcare institutions.

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**CONCLUSION:**

The healthcare system in Estonia has undergone a profound digital transformation since the introduction of electronic medical records, the implementation of digital prescriptions and the creation of the Patient Portal; that integrates all individual medical information into a single database. It is a success story, with more than a decade of implementation, which other countries seek to replicate as is also the intention of the European Union through the program "*MyHealth@EU*" (European Commission, 2019).

The majority of European countries is facing a scenario of ageing population with an increase in the prevalence of chronic diseases and a shortage of human and material resources, making it more difficult to provide healthcare services capable of meeting the demands. This research, in its two components, clearly demonstrates the benefits and challenges for organizations, and healthcare professionals, in the implementation of eHealth. These should not, however, replace existing healthcare systems, but rather complement them, in order to make processes more efficient and accessible to society.

Improved access and easier communication with patients and other healthcare professionals are benefits found in the literature and confirmed in this research. Electronic medical records and the ePortal allows for any duly authorized healthcare professional to consult their patient's medical data, including exames, prescriptions and laboratory results, anywhere, at any time. In this aspect, eHealth contributed to reducing the number of unnecessary face-to-face consultations, saving time for patients and healthcare professionals. The reduction in waiting lists, however, was not significant due to a shortage of human resources, according to the participants of this research.

With better and easier access, comes greater control and knowledge for patients over their own data and their health condition. Literature and health professionals agree that improving medical literacy can contribute to the adoption of healthier behaviors, greater compliance to proposed treatments and prescription regimens, and thus reduce disease levels, the number of consultations and hospitalizations.

The quality of service provided was also highlighted by the literature and health professionals as one of the benefits resulting from the implementation of eHealth. According to this research it becomes easier to monitor the patient, book appointments, prescribe medication, answer any questions and ask for advice or refer to specialists. The availability of

all the patient's medical information in a single database helps to reduce the likelihood of errors, repeated tests and exams; and contributes to faster and more effective diagnoses. Navigating through an excessive amount of data and information, which may not always be of standardized quality is, however, pointed out in the literature and confirmed by the participants on this research as a tedious and time-consuming process. The need for specific digital skills and adequate training on digital eHealth systems also adds on to the pressure of continuous professional development.

The risk of aggravating inequalities in accessing an increasingly digital healthcare system is an inherent challenge in the implementation of eHealth, and should not be ignored. Both the literature and healthcare professionals point out the elderly as the population group that is facing the greatest difficulties in benefiting from the potential of eHealth.

The issue of trust is perceived as one of the main obstacles to implementing eHealth solutions and a concern for patients and healthcare professionals. Estonia, however, registers the highest levels of trust in its healthcare system, which is justified by several years without records of cyber attacks or misuse of personal data. It is in the context of security, transparency and privacy that the researched literature associates eHealth with blockchain. Other contributions or potential uses of this technology in healthcare were not observed in this investigation.

The full transition to nationwide digital health systems will naturally require a substantial initial investment in infrastructure and human resources. Even though the European Union is prepared to help with funds for this type of projects, this is undoubtedly one of the biggest challenges to the implementation of eHealth, especially for countries that are facing greater economic difficulties and present less efficient healthcare systems.

**Limitations:**

This research is not without its limitations, which have already been mentioned in the respective articles. The selection of just one database, which being quite reliable, was restricted to Scopus, and resulted in a reduced number of publications for a systematic literature review; especially regarding the topic of blockchain.

The participants in the qualitative research may not be representative of all types of organizations and health units, whose professionals may find other benefits and face different challenges.

The results obtained in this research, despite being supported by existing literature, are restricted to the context of Estonia and may not be applicable to other European countries.

**Future investigations:**

The most recent studies are pinpointing eHealth in a more global perspective, which makes it necessary to evaluate benefits and challenges for a cross-border healthcare system. This research, carried out from the Estonian experience, highlights some of the future applications of eHealth, benefiting from the integration of all medical the medical data. Namely, decision support systems, which may lead to better clinical results, avoid adverse effects and improve the effectiveness of treatments; or the association between genomics and Information and Communication Technologies, which can contribute to more accurate screenings and early detection of hereditary diseases.

The contribution of blockchain to healthcare is still in its early stages and more research is required to prove its benefits for eHealth, beyond security and transparency.

Finally, following a research into the impact of eHealth and blockchain technology for society in general, and healthcare professionals in particular, it remains to evaluate the impact, benefits and challenges, from the point of view of one of the most important stakeholders: the patient.

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# APPENDIX

**Table A1 -** List of Publications on Scopus Database and highlighted Benefits, Challenges and Blockchain mentions

| Document Title | Author(s) | Year | Journal | Benefits | Challenges | Blockchain |
|---|---|---|---|---|---|---|
| **The current State and Usage of European Electronic Cross-border Health Services (eHDSI)** | Bruthans, J., Jiráková, K. | 2023 | Journal of Medical Systems | . Access of healthcare professionals to medical date across European countries | . Interoperability<br>. Authentication of patients and healthcare professionals | |
| **Implementation of European Cross-border Electronic Prescription and Electronic Dispensing Service: Cross-sectional Survey** | Jogi, R., Timonen, J., Saastmoinen, L., Laius, O., Volmer D. | 2023 | Journal of Medical Internet Research | . Dispensing of e-prescriptions is safer, more efficient, and more cost-effective<br>. Decreased number of forgeries<br>. Safe for patients, cost-effective for pharmacy<br>. Improved access to medications | . Unavailability of medication<br>. Ambiguities and errors<br>. Technical problems | |
| **Blockchain-based application at a government level: disruption or illusion? The case of Estonia** | Semenzin, S., Rozas, D., Hassan S. | 2022 | Policy and Society | | | . Ensures citizen's data ownership<br>. Privacy protection<br>. Increase degree of transparency<br>. Avoid further external intrusions |
| **Patient's Access to Their Psychiatric Records - A Comparison of Four Countries** | Barkas, A., Hagglund, M., Moll, J., Cajander, A., Rexhepi, H., Hormhammer, I., Blease, C., Scandurra, I. | 2022 | Studies in Health Technology and Informatics | . Access to notes, lab and test results, diagnoses and prescribed medication<br>. Increased understanding of patient's mental health<br>. Better awareness of side effects and risks of non-adherence to medication<br>. Increased feeling of validation | . Lack of policies limiting access to certain data | |

| Document Title | Author(s) | Year | Journal | Benefits | Challenges | Blockchain |
|---|---|---|---|---|---|---|
| **Digital Health Paradox: International Policy Perspectives to Address Increased Health Inequalities for People Living with Disabilities** | Van Kessel, R., Hrzic, R., O'Nuallain, E., Weir, E., Wong, B.L.H., Anderson, M., Baron-Cohen, S., Mossialos, E., | 2022 | Journal of Medical Internet Research | . Facilitates distribution and dissemination of public health information<br>. Enhances clinical and laboratory work by supporting administrative tasks<br>. Improves access to life-saving medical care<br>. Augments clinical diagnostic processes<br>. Improves data collection and analysis<br>. Remote monitoring of patients with disabilities<br>. Remote delivery of healthcare during crisis, such as covid-19<br>. Remote delivery of healthcare for autistic adults | . Digital exclusion of underserved population groups threatens equitable access of healthcare<br>. Cognitive burden of frontline staff<br>. Fractured communication and different systems across facilities and departments<br>. Rebalancing of medical education with adequate coverage of digital services | |

| Document Title | Author(s) | Year | Journal | Benefits | Challenges | Blockchain |
|---|---|---|---|---|---|---|
| **E-solutions in Estonian community pharmacies: a literature review** | Tuula, A., Sepp, K., Volmer D. | 2022 | Digital Health | . Enhances pharmacy service<br>. Faster and more accurate consultations<br>. Comprehensive access to health information independente of healthcare facility<br>. Quick and easy access to data by healthcare professionals<br>. Centralized paperless systems saves time for both patients and health workers<br>. Possibility of transferring medical certificates and transactions directly to Social Insurance Board<br>. Tight control of all medicinal products and their packages being sold in Estonia | | . Mitigate internal threats to the data<br>. Assure integrity of retrieved electronic medical records |
| **Challenges on Radical Health Redesign to reconfigure the Level of e-Health Adoption in EU Countries** | Luca, M. Mustea, L., Țăran, A., Ștefea, P., Vatavu S. | 2021 | Frontiers in Public Health | . Improves quality and delivery of medical services<br>. Reduces costs, increases revenues<br>. Increases patient safety<br>. Reduces waiting times<br>. Creating patient engagement during its care | . Increased support needed amongst countries with a lower quality of life and a poorly functioning public health system.<br>. Need for public policies, structural reforms and joint action plans for the adoption of eHealth | |

| Document Title | Author(s) | Year | Journal | Benefits | Challenges | Blockchain |
|---|---|---|---|---|---|---|
| **Antecedents of use of e-Health services in Central Eastern Europe: A qualitative comparative analysis** | Cwiklicki, M., Schiavone, F., Kilch, J., Pilch, K. | 2020 | BMC Health Services Research | | . Digital divide among the various segments of the population<br>. Privacy and the use of patient data by institutions and companies<br>. National e-Health policies<br>. Funding sources for e-Health<br>. Multilingualism in e-Health<br>. Capacity building<br>. Lack of trust by stakeholders | |
| **Digital Health in Cardiology: The Estonian Perspective** | Lotman, E.-M., Viigimaa, M. | 2020 | Cardiology (Switzerland) | . Can help facilitate a more personalized healthcare<br>. Improves quality and participant experience<br>. Reduce consultation time (digital solutions)<br>. Inter-provider e-consultations<br>. Computerized Decision Support Systems can improve clinical outcomes | . Lack of consumer-friendly services that connect the person to the system<br>. Creation of a model of cooperation between the public sector, health care providers, companies and universities<br>. Clinical endorsement by physicians and other healthcare providers due to data overload<br>. Interpretation of data from various sources and different classifications<br>. Data stored in non-compliant structures | . Ensures health data is secure |

| Document Title | Author(s) | Year | Journal | Benefits | Challenges | Blockchain |
|---|---|---|---|---|---|---|
| **Blockchain in health care: hype, trust and digital health** | Leeming, G., Ainsworth, J., Clifton D.A. | 2019 | The Lancet | | | . Enables greater openness, transparency and trust<br>. Immutable records<br>. Control over supply chain management<br>. Fuller and more public records of research data<br><br>. Immature technology<br>. Requires intensive digital signing |
| **Creating online personal medical accounts: recent experience in two developed countries** | Yeh, M.-J., Saltman, R.B. | 2019 | Health Policy and Technology | . effective management of medical records<br>. Helps improving patient's health prompting behaviors<br>. Potential to improve operating efficiency and reduce overall administrative costs<br>. Reduce overall rates of disease and associated medical costs | . Initial investment in necessary infrastructure<br>. Trust in the management of personal medical data<br>. Risk of IT system to be degraded into a means of social control<br>. Physicians reluctant to use the standard language<br>. Find the balance between inter-related, but conflicting interests of government, medical professionals and individual citizens regarding access and use of electronic medical | |

| Document Title | Author(s) | Year | Journal | Benefits | Challenges | Blockchain |
|---|---|---|---|---|---|---|
| **Ten Years of the e-Health System in Estonia** | Metsallik, J., Ross, P., Draheim, D., Piho, G. | 2018 | CEUR Workshop Proceedings | . Time saving for both healthcare professionals and individuals<br>. More effective exchange of data<br>. Security, accountability and transparency of processes<br>. Close monitoring of all actions | . Necessary change to the way healthcare professionals fill out medical files towards a more uniform language - standardization of data<br>. Semantic interoperability of medical data<br>. Data quality and secondary usage of data is still challenging<br>. General acceptance of hospital personnel to share medical data<br>. Much attention required to security and electronic authentication of users<br>. User interface development must not be underestimated<br>. Risk of digital divide | |
| **Nationwide citizen access to their health data: analyzing and comparing experiences in Denmark, Estonia and Australia** | Nøhr, C., Parv, L., Kink, P., Cummings, E., Almond, H., Nørgaard, J.R., Turner, P. | 2017 | BMC Health Services Research | . Confidence in the security, privacy and management of data<br>. Potential health outcomes amongst rural and remote patients with chronic disease<br>. Involve patients in own care | . Lack of structured approach to differences in e-Health literacy when using e-portals<br>. Limited user support | |

| Document Title | Author(s) | Year | Journal | Benefits | Challenges | Blockchain |
|---|---|---|---|---|---|---|
| **IT Solutions for healthcare system in Poland: in search of benchmarks in various economics perspectives** | Kwiatowska, E.M. | 2016 | Economics and Sociology | . Personalized healthcare<br>. Improved access to relevant resources and healthcare providers<br>. Bidirectional flow of information between individuals and healthcare providers<br>. "More involved and informed patients can obtain better results<br>. Arranging appointments can be faster and easier<br>. Reduce inefficiencies and fraud, medical errors, duplication of tests, double payments | . Further investments in IT infrastructure<br>. Education of Healthcare providers and patients regarding digital technologies | |
| **E-health: knowledge generation, value intangibles and intellectual capital** | Miller, L.M. | 2015 | International Journal of Healthcare Management | . Improved efficiency and reduced cost<br>. Potential to improve knowledge and intangible value creation | . Sensitivity of personal and medical data being made available on integrated systems | |

| Document Title | Author(s) | Year | Journal | Benefits | Challenges | Blockchain |
|---|---|---|---|---|---|---|
| **An epidemiological perspective of personalized medicine: The Estonian Experience** | Milani, L, Leitsalu, L., Metspalu, A. | 2015 | Journal of Internal Medicine | . Active engagement of individuals in their health management<br>. Biobanks: expected to improve public health<br>. Personalized care in disease prevention and treatment | . lack of evidence of clinical utility and cost effectiveness<br>. Polices and guidelines to regulate before genomic tests are implemented<br>. IT tools that integrate different sources<br>. User-friendly clinical decision tools<br>. Funding schemes for prevention, rather than reactive treatment of disease | |
| **An evaluation of e-prescribing at a national level** | Parv, L., Kruus, P., Motte, K., Ross, P. | 2014 | Informatics for Health and Social Care | . Potential for better access to higher quality health care<br>. Increase efficiencies for health systems<br>. Foster new business opportunities<br>. Better informed physicians, mitigates risks and errors<br>. Saved costs in written paper formas and prescriptions | . Complex process, requires joint efforts from a number of different stakeholders<br>. Requires investments, workflow changes and new skills | |
| **Incentives for tele healthcare deployment that support integrated care: a comparative analysis across eight European countries** | Lluch, M. | 2013 | International Journal of Integrated Care | . Supports the development of integrated models, through information sharing<br>. Social care perspective where distances are long | . Interoperability<br>. Liability issues<br>. Polices promoting cooperation<br>. Aligned incentives and funding | |

| Document Title | Author(s) | Year | Journal | Benefits | Challenges | Blockchain |
|---|---|---|---|---|---|---|
| **Cross-border tele radiology - Experience from two international tele radiology projects** | Ross, P., Sepper, R., Pohjonen, H. | 2010 | European Journal of Radiology | . Access to patient data and images at any time and any location<br>. Potential for cross-border tele radiology | . Trust and legal issues<br>. Language and semantic interoperability<br>. Linguistic barriers<br>. Organizational and technical integration | |

**Table A1 -** List of Publications on Scopus Database and highlighted Benefits, Challenges and Blockchain mentions