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The Benefits and Challenges of Blockchain Technology and eHealth Implementation in Estonia - A Literature Review

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Abstract
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. 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 written in English. The Scopus database and its integrated search engine presented 74 publications of which 18 filled the selected criteria. Access, efficiency, quality of care, cooperation and data sharing, knowledge, and control were among the most mentioned benefits of eHealth. Disparities, confidentiality lack of trust, financing, the cognitive burden, and the quality of data were the most mentioned challenges of implementing digital technologies in healthcare. 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.

Keywords: Blockchain; eHealth; Estonia; Benefits; Challenges

Introduction

Estonia is one of the most digitally advanced countries in the world, a leader 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 its citizens to these services [1]. 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 eHealth system is the fact that it is implemented at a government level, regulated, and monitored by government entities [2].

The development of 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 in 2008 by Nakamoto initially for the cryptocurrency *bitcoin*, has brought an opportunity to overcome some of the obstacles to greater security and decentralization in the sharing and distribution of data [3]. 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 [4]. 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 technology still presents some challenges, for example, regarding the anonymous but not private aspect of information exchanges; the management of passwords by patients, the immutability aspect of the technology versus the right to be forgotten and the implementation of tight EU data protection regulations. [5]

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").

This paper highlights the benefits and challenges for the adoption of eHealth during a time when the digital transition of healthcare is not only a sign of progression but a necessity, considering the increased demand for access and the scarcity of resources. The experience of a country such as Estonia, with mature digital services, can help governments and managers of healthcare organizations face the challenges that are expected to be encountered during eHealth implementation.

Material and Method

For this research a narrative literature review was conducted subject to the theme of the benefits and challenges of the implementation of eHealth, 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 [6]. These systematic reviews should bring together a large amount of clinical research, discussing the differences between the primary studies dealing with the same object [7]; 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 [6].

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 [7].

Following to Sampaio and Mancini [6], three steps were 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 decision of database to be used for this study, were followed the recommendation of Martín-Martín et al. [8] who compared three options, Google Scholar, Web of Science, and Scopus and demonstrated that in terms of scope, the Scopus had a greater number of unique publications that were not 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, theses, and book chapters. For the context of this article, the selected database was Scopus and its search engine was used to search for 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:

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 the 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.

Results

The applied search string in the Scopus database, in April 2023, revealed 74 documents, published from 2004 to the research date. Of these, 34 were conference papers and 9 were book chapters. Of the remaining articles, only 19 met the requirements previously established for this study and are displayed in Tables 1-3. The analysis has been summarized into topics displayed below, differentiating benefits and challenges.

Table 1. Reported benefits

Author(s) [ref]	Benefits
Bruthans and Jiráková [29]	• Access of healthcare professionals to medical date across European countries
Jogi et al. [19]	• Dispensing of e-prescriptions is safer, more efficient, and more cost-effective • Decreased number of forgeries • Safe for patients, cost-effective for pharmacy • Improved access to medications
Barkas et al. [12]	• Access to notes, lab and test results, diagnoses and prescribed medication • Increased understanding of patient's mental health • Better awareness of side effects and risks of non-adherence to medication • Increased feeling of validation
Van Kessel et al. [14]	• Facilitates distribution and dissemination of public health information • Enhances clinical and laboratory work by supporting administrative tasks • Improves access to life-saving medical care • Augments clinical diagnostic processes • Improves data collection and analysis • Remote monitoring of patients with disabilities • Remote delivery of healthcare during crisis, such as COVID-19 • Remote delivery of healthcare for autistic adults

Author(s) [ref]	Benefits
Tuula et al. [13]	• Enhances pharmacy service • Faster and more accurate consultations • Comprehensive access to health information independent of healthcare facility • Quick and easy access to data by healthcare professionals • Centralized paperless systems saves time for both patients and health workers • Possibility of transferring medical certificates and transactions directly to Social Insurance Board • Tight control of all medicinal products and their packages being sold in Estonia
Luca et al. [15]	• Improves quality and delivery of medical services • Reduces costs, increases revenues • Increases patient safety • Reduces waiting times • Creating patient engagement during its care
Lotman and Viigimaa [21]	• Can help facilitate a more personalized healthcare • Improves quality and participant experience • Reduce consultation time (digital solutions) • Inter-provider e-consultations • Computerized Decision Support Systems can improve clinical outcomes
Yeh and Saltman [20]	• Effective management of medical records • Helps improving patient's health prompting behaviors • Potential to improve operating efficiency and reduce overall administrative costs • Reduce overall rates of disease and associated medical costs
Metsallik et al. [2]	• Time saving for both healthcare professionals and individuals • More effective exchange of data • Security, accountability and transparency of processes • Close monitoring of all actions
Nøhr et al. [17]	• Confidence in the security, privacy and management of data • Potential health outcomes amongst rural and remote patients with chronic disease • Involve patients in own care
Kwiatowska [11]	• Personalized healthcare • Improved access to relevant resources and healthcare providers • Bidirectional flow of information between individuals and healthcare providers • More involved and informed patients can obtain better results • Arranging appointments can be faster and easier • Reduce inefficiencies and fraud, medical errors, duplication of tests, double payments…
Miller [18]	• Improved efficiency and reduced cost • Potential to improve knowledge and intangible value creation
Milani et al. [22]	• Active engagement of individuals in their health management • Biobanks: expected to improve public health • Personalized care in disease prevention and treatment

Author(s) [ref]	Benefits
Parv et al. [10]	• Potential for better access to higher quality health care • Increase efficiencies for health systems • Foster new business opportunities • Better informed physicians, mitigates risks and errors • Saved costs in written paper formas and prescriptions
Lluch [16]	• Supports the development of integrated models, through information sharing • Social care perspective where distances are long
Ross et al. [9]	• Access to patient data and images at any time and any location • Potential for cross-border tele radiology

Table 2. Reported challenges

Author(s) [ref]	Challenges
Bruthans and Jiráková [29]	• Interoperability • Authentication of patients and healthcare professionals
Jogi et al. [19]	• Unavailability of medication • Ambiguities and errors • Technical problems
Barkas et al. [12]	• Lack of policies limiting access to certain data
Van Kessel et al. [14]	• Digital exclusion of underserved population groups threatens equitable access of healthcare • Cognitive burden of frontline staff • Fractured communication and different systems across facilities and departments • Rebalancing of medical education with adequate coverage of digital services
Luca et al. [15]	• Increased support needed amongst countries with a lower quality of life and a poorly functioning public health system • Need for public policies, structural reforms and joint action plans for the adoption of eHealth
Cwiklicki et al. [23]	• Digital divide among the various segments of the population • Privacy and the use of patient data by institutions and companies • National eHealth policies • Funding sources for eHealth • Multilingualism in eHealth • Capacity building • Lack of trust by stakeholders
Lotman and Viigimaa[21]	• Lack of consumer-friendly services that connect the person to the system • Creation of a model of cooperation between the public sector, health care providers, companies and universities • Clinical endorsement by physicians and other healthcare providers due to data overload • Interpretation of data from various sources and different classifications • Data stored in non-compliant structures

Author(s) [ref]	Challenges
Yeh and Saltman [20]	• Initial investment in necessary infrastructure • Trust in the management of personal medical data • Risk of IT system to be degraded into a means of social control • Physicians reluctant to use the standard language • Find the balance between inter-related, but conflicting interests of government, medical professionals and individual citizens regarding access and use of electronic medical information
Metsallik et al. [2]	• Necessary change to the way healthcare professionals fill out medical files towards a more uniform language - standardization of data • Semantic interoperability of medical data • Data quality and secondary usage of data is still challenging • General acceptance of hospital personnel to share medical data • Much attention required to security and electronic authentication of users • User interface development must not be underestimated • Risk of digital divide
Nøhr et al. [17]	• Lack of structured approach to differences in eHealth literacy when using e-portals • Limited user support
Kwiatowska [11]	• Further investments in IT infrastructure • Education of Healthcare providers and patients regarding digital technologies
Miller [18]	• Sensitivity of personal and medical data being made available on integrated systems
Milani et al. [22]	• Lack of evidence of clinical utility and cost effectiveness • Polices and guidelines to regulate before genomic tests are implemented • IT tools that integrate different sources • User-friendly clinical decision tools • Funding schemes for prevention, rather than reactive treatment of disease
Parv et al. [10]	• Complex process, requires joint efforts from a number of different stakeholders • Requires investments, workflow changes and new skills
Lluch [16]	• Interoperability • Liability issues • Polices promoting cooperation • Aligned incentives and funding
Ross et al. [9]	• Trust and legal issues • Language and semantic interoperability • Linguistic barriers • Organizational and technical integration

Table 3. Reports on blockchain

Author(s) [ref]	Blockchain
Semenzin et al. [26]	• Ensures citizen's data ownership • Privacy protection • Increase degree of transparency • Avoid further external intrusions
Tuula et al. [13]	• . Mitigate internal threats to the data • Assure integrity of retrieved electronic medical records
Lotman and Viigimaa [21]	• Ensures health data is secure
Leeming et al. [27]	• Enables greater openness, transparency and trust • Immutable records • Control over supply chain management • Fuller and more public records of research data • Immature technology • Requires intensive digital signing

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 [9-14].

Improved access through remote delivery of quality, cost-effective care was particularly important during a crisis such as the COVID-19 pandemic, allowing patients to interact with healthcare providers at home and limiting exposure to biological 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 [14, 15], and can improve the "potential health outcomes amongst rural and remote patients with chronic disease" [16, 17].

The Benefits: Efficiency

Miller [18], Van Kessel et al. [14] and Tuula et al. [13] 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 [13, 14, 18]. Centralized paperless systems mean patients can fill out medical forms ahead of their appointments, medications can be prescribed without the need for a specific appointment [13], 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 [10, 19]. It has decreased the number of forgeries and it has made "the dispensing of e-prescriptions safer, more efficient and more cost-effective" [15]. Arranging appointments can be done faster and easier and eHealth systems can help "reduce inefficiencies and fraud, medical errors and duplication of tests or payments" [7]. Therefore, eHealth has the potential to reduce administrative costs, increase revenues, and reduce waiting times [15, 20].

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 [2].

Digital solutions, such as wearable devices like smart watches, wristbands, and subcutaneous sensors, can help collect medical history of patients without the need for extra appointments and reduce the consultation time [21].

The Benefits: 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 [14, 15]. In the research of Parv et al. [10], 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 [15] and improves the quality of care, with a more personalized approach [11, 21].

The Benefits: 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" [16]. 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 [21]. The "bidirectional flow of information between individuals and healthcare providers" is regarded as an important benefit of eHealth [11].

There's also the possibility of transferring medical certificates and transactions directly to the Social Insurance Board, in case of claims [13], or the provision of health declarations for driving license applications [2].

This can present a challenge with a risk of fractured communication if healthcare providers need to face different systems across different facilities and departments [14].

It is generally accepted that for eHealth 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 [16, 21].

The Benefits: 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 [11, 12, 14, 17, 22]. This can have a positive impact on patient's "health prompting behaviors", reducing "overall rates of disease and associated medical care costs" [20]. 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 play a more active role in monitoring their health [2]. Involving patients in their own treatment, by allowing them access to their data.

Barkas et al. [12] 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.

The Challenges: Disparities

As society becomes increasingly digital, the risk of worsening existing inequalities should not be ignored. Digital literacy and access to digital infrastructures vary greatly according to age, socio-economic and educational status, place of residence, and degree of disability [2, 14, 23]. There is room

for improvement in consumer-friendly services that connect the person to the system [21], and overall user support [17]. The most vulnerable group is the group of older patients [23]. 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 [24]. 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 equitable access to healthacare [14]. Education is necessary for healthcare providers and patients regarding digital technologies [11].

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 population [23].

The Challenges: Confidentiality and Lack of Trust

According to Ćwiklicki et al. [23], the nonexistence of adequate specific legislation applied at a national level that regulates eHealth is an obstacle to its implementation. The questions raised regarding privacy, confidentiality, and data protection need to be addressed before the adoption of eHealth systems [25]. A national policy of eHealth 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 eHealth is required. The 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 [17]. Estonia is, however, amongst the first countries to introduce specific national policies oriented for eHealth [15].

The issue of trust is perceived as one of the main obstacles for the implementation of eHealth solutions [9, 23]. Miller [18], Metsallik et al. [2], and Yeh and Saltman [20] 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" [20].

Estonia high trust reports are justified by the long-term use of the system without incidents nor misuse of personal data [21]. 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 [2].

The Challenges: Knowledge and Skills "Cognitive Burden"

The area of eHealth that needs more investment is the reinforcement of knowledge and skills of the team of healthcare professionals regarding these digital systems [10, 25].

The dissemination of eHealth 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 [10, 21]. Currently, much attention is required to the security and electronic authentication of users [2], which ensures data protection but requires additional time and training. The need for "workflow changes" is also mentioned by Parv et al. [10].

The need to prepare students and health professionals to operate digital medical technology is essential for the dissemination of eHealth [23] and is defined by van Kessel et al. [14] 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" [2]. 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 [21].

The Challenges: Financing

The lack of financing is amongst one of the most important challenges for the adoption of eHealth [23] and "increased support is needed amongst countries with a lower quality of life and a poorly functioning public health system" [15] particularly for the initial investment in necessary infrastructure [11, 20]. 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" [16].

Healthcare organizations and pharmacies are reluctant to invest additional resources in enabling eHealth services [10]. Public-private partnerships are encouraged [23] and the reorientation of some of the "funding schemes for prevention, rather than reactive treatment of diseases" is proposed [22]. According to Parv et al. [10] setting up a nationwide interoperable eHealth system will require a large initial investment, but if the system works effectively, benefits can surpass costs within three years.

The Challenges: 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 [2]. Some physicians are reluctant to use the standard language, recommended by the system, to describe conditions [20]. The "semantic interoperability of medical data is hard to achieve", according to Metsallik et al. 2018 [2], 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) [2]. Milani et al. [22] 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 [21].

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," "increasing the degree of transparency," and "privacy protection," but also at a government level, to "avoid further external intrusions." [26]. 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 [21, 27]. This technology helps mitigate internal threats to the data and assures the integrity of medical records" [13].

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 [13, 27].

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. 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" [21]. Milani et al. [22] 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 behaviors, 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 [20, 22].

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. With the increasing mobility of populations, we can expect the need for Digital health services available beyond the borders of their country to rise. [28] 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 [29]. 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 [19].

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 by which patients and health professionals are authenticated. The type of mandatory information to be submitted is not the same in all countries [29].

Conclusions

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. 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 but 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 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. 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.

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.

Conflict of Interest

The authors declare that they have no conflict of interest.

References

1. Enterprise Estonia. e-Governance [document on the internet]: E-Estonia; unknown [cited 2023 April]. Available from: https://e-estonia.com/solutions/e-governance/e-services-registries
2. Metsallik J, Ross P, Draheim D, Piho G. Ten years of the e-health system in Estonia. CEUR Workshop Proceedings 2018 Jun; 2336:6-15
3. Nakamoto S. Bitcoin: a peer-to-peer electronic cash system [document on the Internet]: Bitcoin; 2008 [cited 2023 April]. Available from: https://bitcoin.org/bitcoin.pdf
4. Mettler M. Blockchain technology in healthcare: the revolution starts here. IEEE 18th international conference on e-health networking, applications and services (Healthcom). 2016 Sept: 1-3. DOI: 10.1109/HealthCom.2016.7749510
5. Gordon WJ, Catalini C. Blockchain technology for healthcare: facilitating the transition to patient-driven interoperability. Computation and structural biotechnology journal. 2018 Jan 1; 16:224-30. DOI: 10.1016/j.csbj.2018.06.003
6. Sampaio RF, Mancini MC. Estudos de revisão sistemática: um guia para síntese criteriosa da evidência científica. Brazilian Journal of Physical Therapy. 2007; 11:83-9. DOI: 10.1590/S1413-35552007000100013
7. Lopes AL, Fracolli LA. Revisão sistemática de literatura e metassíntese qualitativa: considerações sobre sua aplicação na pesquisa em enfermagem. Texto & Contexto-Enfermagem. 2008;17:771-8. DOI: 10.1590/S0104-07072008000400020
8. Martín-Martín A, Orduna-Malea E, Thelwall M, López-Cózar ED. Google Scholar, Web of Science, and Scopus: A systematic comparison of citations in 252 subject categories. Journal of informetrics. 2018 Nov 1;12(4):1160-77. DOI: 10.1016/j.joi.2018.09.002
9. Ross P, Sepper R, Pohjonen H. Cross-border teleradiology—experience from two international teleradiology projects. European journal of radiology. 2010 Jan 1;73(1):20-5. DOI: 10.1016/j.ejrad.2009.10.016.
10. Parv L, Kruus P, Motte K, Ross P. An evaluation of e-prescribing at a national level. Informatics for health and social care. 2016; 41(1):78-95. DOI: 10.3109/17538157.2014.948170
11. Kwiatkowska EM. IT Solutions for Healthcare System in Poland: In Search of Benchmarks in Various Economic Perspectives. Economics & Sociology. 2016 Jul 1;9(3):210. DOI: 10.14254/2071-789X.2016/9-3/18
12. Bärkås A, Hägglund M, Moll J, Cajander Å, Rexhepi H, Hörhammer I, Blease C, Scandurra I. Patients' Access to Their Psychiatric Records–A Comparison of Four Countries. InChallenges of Trustable AI and Added-Value on Health 2022 (pp. 510-514). IOS Press. DOI: 10.3233/SHTI220511
13. Tuula A, Sepp K, Volmer D. E-solutions in Estonian community pharmacies: A literature review. Digital Health. 2022 Jul;8:20552076221113731. DOI: 10.1177/20552076221113731
14. van Kessel R, Hrzic R, O'Nuallain E, Weir E, Wong BL, Anderson M, Baron-Cohen S, Mossialos E. Digital health paradox: international policy perspectives to address increased health inequalities for people living with disabilities. Journal of medical Internet research. 2022 Feb 22;24(2):e33819. DOI: 10.2196/33819

15. Luca MM, Mustea L, Taran A, Stefea P, Vatavu S. Challenges on radical health redesign to reconfigure the level of e-health adoption in EU countries. Frontiers in public health. 2021 Jul 20;9:728287. DOI: 10.3389/fpubh.2021.728287
16. Lluch M. Incentives for telehealthcare deployment that support integrated care: a comparative analysis across eight European countries. International Journal of Integrated Care. 2013 Oct;13. DOI: 10.5334/ijic.1062
17. Nøhr C, Parv L, Kink P, Cummings E, Almond H, Nørgaard JR, Turner P. Nationwide citizen access to their health data: analysing and comparing experiences in Denmark, Estonia and Australia. BMC health services research. 2017 Dec;17(1):1-1. DOI: 10.1186/s12913-017-2482-y
18. Miller LM. E-health: knowledge generation, value intangibles, and intellectual capital. International Journal of Healthcare Management. 2015 Jun 1;8(2):100-11. DOI: 10.1179/2047971914Y.0000000094
19. Jõgi R, Timonen J, Saastamoinen L, Laius O, Volmer D. Implementation of European Cross-border Electronic Prescription and Electronic Dispensing Service: Cross-sectional Survey. Journal of Medical Internet Research. 2023 Apr 4;25:e42453. DOI: 10.2196/42453
20. Yeh MJ, Saltman RB. Creating online personal medical accounts: Recent experience in two developed countries. Health Policy and Technology. 2019 Jun 1;8(2):171-8. DOI: 10.1016/j.hlpt.2019.05.004
21. Lotman EM, Viigimaa M. Digital health in cardiology: the Estonian perspective. Cardiology. 2020 Dec 4;145(1):21-6. DOI: 10.1159/000504564
22. Milani L, Leitsalu L, Metspalu A. An epidemiological perspective of personalized medicine: the Estonian experience. Journal of internal medicine. 2015 Feb;277(2):188-200. DOI: 10.1111/joim.12320
23. Ćwiklicki M, Schiavone F, Klich J, Pilch K. Antecedents of use of e-health services in Central Eastern Europe: a qualitative comparative analysis. BMC health services research. 2020 Dec;20(1):1-5. DOI: 10.1186/s12913-020-5034-9
24. Paimre M. Do Elderly People Enjoy the Fruits of Estonia's e-Health System?. Proceedings of the 5th International Conference on Information and Communication Technologies for Ageing Well and e-Health. 2019 Dec:230-237. DOI: 10.5220/0007726202300237
25. Stroetmann KA, Artmann J, Stroetmann V. Developing national eHealth infrastructures–results and lessons from Europe. AMIA Annual Symposium Proceedings 2011; 2011: 1347-54.
26. Semenzin S, Rozas D, Hassan S. Blockchain-based application at a governmental level: disruption or illusion? The case of Estonia. Policy and Society. 2022 May 1;41(3):386-401 DOI: 10.1093/polsoc/puac014
27. Leeming G, Ainsworth J, Clifton DA. Blockchain in health care: hype, trust, and digital health. The Lancet. 2019 Jun 22;393(10190):2476-7. DOI: 10.1016/S0140-6736(19)30948-1
28. Palma FN. Interoperability Challenges and Critical Success Factors in the Deployment of Cross-border Digital Medical Prescriptions in Finland and Estonia. In2022 IEEE International Conference on Digital Health (ICDH) 2022 Jul 10: 60-65. IEEE. DOI: 10.1109/ICDH55609.2022.00018
29. Bruthans J, Jiráková K. The Current State and Usage of European Electronic Cross-border Health Services (eHDSI). Journal of Medical Systems. 2023 Feb 11;47(1):21. DOI: 10.1007/s10916-023-01920-9