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Savings achieved through the adoption of Blockchain technology in the healthcare sector: A Case Study of Estonia

وفورات اعتماد تكنولوجيا سلسلة الكتل (Blockchain) في قطاع الرعاية الصحية: دراسة حالة تجربة إستونيا

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Abstract : This study aimed to analyze the contribution of blockchain technology in efficiently and effectively utilizing resources to increase the value of investments in the healthcare sector, using Estonia as a case study. This was based on a review and analysis of literature and reports that investigated the value of adopting this technology in the healthcare system.

The review revealed that Estonia's adoption of blockchain technology in healthcare can result in annual savings of 2% of the gross domestic product. It contributes to improving communication between healthcare information systems and maintains system security at a reasonable cost. The study also highlighted that it enhances the safety and trust of citizens in the public healthcare sector.

Key words: Healthcare, Blockchain, Value.
JEL classification codes :I1, O3, D4.

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1. Introduction.

One of the prominent challenges facing healthcare organizations is reshaping their operations to maintain a continuous balance between improving quality and reducing costs. The financial sustainability relies on generating revenues from delivering high-quality services. With the global demand for healthcare services surpassing the capacity to afford them, a report by the World Health Organization (WHO) highlighted that the healthcare sector serves as a source of various cost drivers, and a significant increase in the gross domestic product often leads to increased healthcare spending. Therefore, countries with high healthcare expenditures need to explore ways to increase the value they derive from their investments. In 2017, countries such as the United States, Germany, Switzerland, and others spent over 10% of their gross domestic product on healthcare (Bittroff & Sandner, 2020, p. 02). This puts significant pressure on governments and organizations to find innovative approaches to make healthcare delivery more efficient and cost-effective.

Experiments and research have shown that technological advancements can alleviate the burdens of healthcare. The digital transformation characterizing the sector offers opportunities for healthcare systems to transition from paper-based health records to Electronic Medical Records (EMR). Data has been central to this transformation, revolutionizing the economy, society, and health. Through digitization, healthcare institutions can integrate and improve care, enhance quality, and facilitate smoother data flow. This is further enhanced by the adoption of Blockchain technology in healthcare services marketing, which has recently garnered significant attention. Its applications have expanded into various fields, including the healthcare industry. Blockchain technology contributes to the credibility and transparency of healthcare data, with numerous use cases ranging from preserving Electronic Health Records (EHR) assets to streamlining claims processing operations.

Study problem:

Healthcare organizations face the challenge of balancing patient care with information privacy and accessibility while also controlling costs. In this context, Blockchain technology enthusiasts emphasize the capability of this technology to provide maximum privacy. Distributed ledgers can reduce costs and increase access to information without the need for intermediaries, potentially leading

to better outcomes at lower expenses. New projects aim to apply Blockchain technology to solve real-world problems, including efforts in public health tracking, research data aggregation, prescription monitoring and enforcement, administrative streamlining, and patient data organization from an increasing number of inputs. In this field, realistic examples of Blockchain technology application in the healthcare sector are described, addressing both near-term promises and challenges. Estonia, in particular, has already established a comprehensive Blockchain-based ecosystem for healthcare.

The problem of this study can be formulated in the following main question:How does Blockchain technology contribute to efficiently utilizing resources to increase the value of investments in the healthcare sector for Estonia?

The following sub-questions fall under this problem:

- What are the sources of value creation in the Blockchain-based healthcare sector?
- What is the impact of Blockchain technology on the performance of the Estonian healthcare sector?

Research' objectives:

The aim of this study is to determine the achieved added value in the healthcare sector through the use of Blockchain technology.It highlights the motivations for adopting Blockchain technology in marketing healthcare services and clarify the values generated by this technology, whether for the customer or the organization. By establishing its theoretical foundation and analyzing empirical evidence, the study provides an answer to the main research question. There is a growing body of knowledge for the development and adoption of Blockchain that can help all stakeholders make more informed decisions.

Study Approach:

To answer the above, it is necessary to integrate multiple research methodologies by establishing them on theoretical logic and analyzing empirical facts to provide an answer to the main question upon which the research is built. This is based on a review and discussion of the literature that explores the role of Blockchain technology in creating value and improvements in the healthcare sector. To achieve the desired goal of the review, an archival research method was used, which contributes to organizing a reliable knowledge base in this research field. This review utilizes

publications from relevant reference books, scientific articles, edited works, and other research materials to achieve the study's objective. This is done by relying on well-known databases such as Science Direct, Taylor and Francis, Springer link, Emerald, and Wiley Online Library. David Tranfield and others (David, David, & Palminder, 2003) refer to how to conduct a systematic literature review to produce evidence-based content in the field of business management. Considering the objective of this review, the methodology proposed by Tranfield and others is deemed most appropriate.

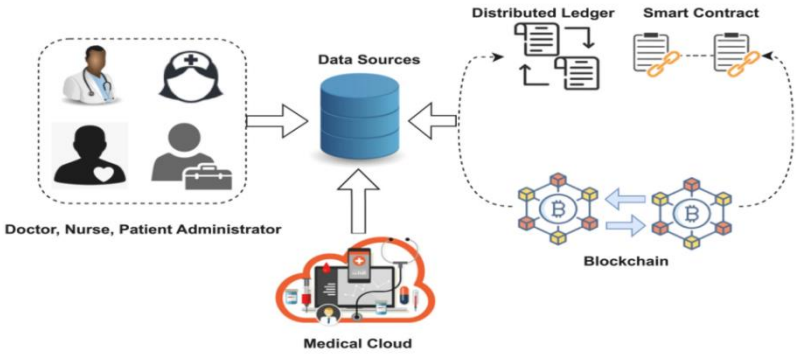
2. The current context of research on the value of Blockchain technology in healthcare

Issues related to the value of Blockchain technology have become increasingly important for all institutions aiming to sustain their operations. Consequently, this topic has been discussed and addressed in numerous research papers in recent years. Historically, concepts of decentralized digital identity have been used to help individuals protect their privacy in the new digital age of computers. Today, data has become a commodity, and the importance of identity ownership has grown amidst the challenges of data breaches. Blockchain technology has provided an opportunity to advance towards enhancing self-sovereign identity (Bittroff & Sandner, 2020, p. 03). This can be realized within the healthcare sector as well.

2.1 The ecosystem of Blockchain-based healthcare

Blockchain technology at its core is a distributed ledger that records transactions in a sequential manner, and identical copies of this ledger are shared among the participating parties. The veracity of the data is declared through consensus among the parties holding that data. As a result, Blockchain is referred to as a decentralized technology that ensures reliable data protection against manipulation, as access to read and write on the Blockchain relies on permissions granted by the specified stakeholders (parties of interest) outlined in smart contracts, which may include patients, pharmacies, healthcare providers, insurers, auditors, and hospitals (Engelhardt, 2017, p. 23).

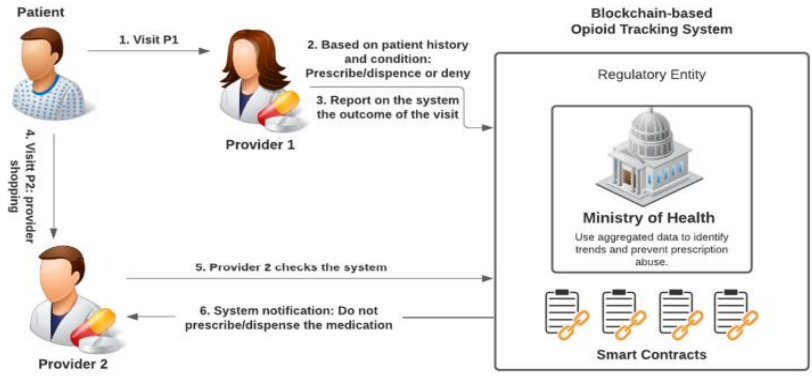
Fig 1. The ecosystem of Blockchain technology in healthcare



Source: (Isravel, et al., 2023)

For example, the manipulation of prescription medications poses a challenge that can benefit from the application of Blockchain technology, especially when it comes to drugs used for addiction purposes. Nuco, a company, has adopted this technology to solve the problem of forgery. When a prescription is issued by a physician, a code is attached as a unique identifier that can be read by a machine. This identifier is then linked to a set of information, including the drug name, quantity, anonymous patient identity, and timestamp. When the prescription is filled by a pharmacist, the code is scanned, and the attempt to comply with the prescription is recorded and compared to the Blockchain. The pharmacist is quickly informed whether the prescription is qualified for dispensing (Engelhardt, 2017, p. 24).

Fig 2. Monitoring system for prohibited drugs using Blockchain technology



Source: (Marbouh, et al., 2022)

Figure 2 illustrates a Blockchain-based system that can control the prescription of regulated substances like opioids. This subsystem

can detect if a patient is doctor shopping to avoid prescription misuse.In general, electronic health records (EHRs), drug supply chain monitoring, organ donation, and clinical trials and pharmaceutical research are among the most common use cases for Blockchain technology. This can be further clarified as follows

2.2 Applications of Blockchain Technology in Healthcare

Blockchain technology holds significant importance in addressing the issue of protecting individually identifiable health information (Ahram, et al., 2017). Statistics indicate that patient data is valued at $7,000 annually (Dimitrov, 2019, p. 53). The technology works to secure shared medical data transparently and efficiently (Mandal, et al., 2014). Data is digitized, recorded, and stored as a means of direct access in the future (Xhafa, 2021, p. 270). In a related field, many companies offer DNA sequencing services. Once users obtain their genome sequencing, they can impose fees for anyone seeking access to it. This prevents genetic information from falling into the wrong hands and allows consumers to sell their genetic data (Dimitrov, 2019, p. 53).

Furthermore, the healthcare sector utilizes Blockchain technology for managing drug supply chains, clinical supply chains, blood products, and medical devices. Blockchain applications in this area include product identification, the use of a distributed ledger that automatically verifies relevant information and verifies product authenticity. Additionally, the technology helps alert stakeholders to incompatible or highly dangerous products (Oderkirk, ilian, & Slawomirski, 2020). It is also used as a tool to monitor the production processes of drugs facing counterfeiting issues (Mettler & Hsg, 2016, p. 03). With the substantial profits generated from counterfeit drugs, drug-related crimes are on the rise (Pham, Tran, & Nakashima, 2019, p. 01). Blockchain technology contributes to tracking medical products from suppliers to consumers (Kalarani, Raghu, & Aakash, 2002, p. 377). Each transaction for a product is recorded through an electronic pharmacy in a tamper-proof and immutable manner, thus reducing fraudulent activity (Kalarani, Raghu, & Aakash, 2002, p. 377).

Within this framework, Blockchain technology provides a reliable platform for storing and exchanging information related to organ availability and matching between donors and recipients, while storing necessary information for the process (Srivastava, Mahara, & Yadav, 2021, p. 173). Managing organ groups is of utmost importance

and requires addressing issues of medical compatibility and personal preferences (Srivastava, Mahara, & Yadav, 2021, p. 173). Blockchain stores donor details, facilitating more efficient matching for organ transplantation (Jat & Grønli, 2022) and utilizes artificial intelligence for verification and matching of donors with patients (Attaran, 2022).

Finally, Blockchain technology enables the reduction of fraud losses in insurance by requiring individuals and service providers to enter personal information for verification before storing and providing the data to health insurance companies. Managing data in a decentralized infrastructure makes it impossible for intruders to leak information or create fake data (Xhafa, 2021, p. 271).

Regarding the adoption of the technology, multiple stages of adoption can be observed worldwide. Estonia has already established a complete Blockchain-based ecosystem for healthcare, while initial steps are being taken in countries like Germany (Bittroff & Sandner, 2020). Other emerging countries are attempting to adopt an effective strategy to integrate this technology into their healthcare systems, similar to the United Arab Emirates.

2.3 Literature Review of Blockchain Technology's Value Creation in Healthcare

Previous research has examined the potential sources of value creation through the adoption of Blockchain technology, using different theoretical lenses. Some studies shed light on the extent to which this technology contributes to value creation in the healthcare sector, focusing on real start-up companies (Spanò, Massaro, & Iacuzzi, 2023). Other studies explored how different institutions can benefit from the created value. However, only a limited number of experimental works have been conducted to measure the potential of Blockchain in value creation. The discussions have remained at a partial level and have not encompassed an entire economic sector of a country, leading to a superficial understanding of the multifaceted potential of Blockchain(Abdollahi, Sadeghvaziri, & Rejeb, 2023, p. 428). The literature mentions a range of research based on multiple use cases across various companies (Abdollahi, Sadeghvaziri, & Rejeb, 2023, p. 428). Based on the analysis of previous data, three main themes emerge, illustrating the channels through which the impact of Blockchain technology in value creation within the healthcare sector occurs. These themes are detailed as follows:

2.3.1 Enhancing Stakeholder Interaction

Stakeholders, including technology providers, physicians, healthcare professionals, researchers, pharmacists, and patients, interact by securely and efficiently exchanging data and resources through transaction tracking, privacy protection, increased compatibility, and transparency. The goal is to improve individuals' health outcomes with minimal sacrifices of time and money, while also developing medical performance that can be enhanced through feedback expressed by other stakeholders in the chain (Russo-Spena, et al., 2023, p. 07). Furthermore, this interaction contributes to expanding access compared to traditional competitors, including access to new resources, both financial and intellectual, that can be continuously maintained. This is particularly important in resource-scarce environments and amidst ongoing competition. On the other hand, technology provides an opportunity to access new stakeholders, such as clients or strategic partners, who may not be available to traditional companies due to technological and financial limitations, even if they are accessible (Abdollahi, Sadeghvaziri, & Rejeb, 2023, pp. 437-439).

Moreover, studies have indicated that the application of Blockchain solutions in healthcare systems will improve communication between health information systems and maintain system security at an affordable cost. These are crucial aspects of managing and securely storing health data (Matlebjane & Ndayizigamiye, 2022, p. 05). The technology not only aids in improving administrative processes but also supports clinical aspects, such as reducing the risk of infections or similar concerns (Spanò, Massaro, & Iacuzzi, 2023, p. 05). On the other hand, smart contracts integrated within Blockchain technology contribute to enabling startups to access new investors, especially small investors, and automating popular resources, facilitating the collection of these resources. This positively affects the cost and efficiency of transactions (Abdollahi, Sadeghvaziri, & Rejeb, 2023, p. 438).

Numerous studies reviewed demonstrate how Blockchain technology can support interactions and enhance stakeholder engagement in the value creation process. This includes involving patients in their healthcare journey and tracking the use of their data, enabling physicians to transform patients' records into digital versions, and scheduling diagnostic tests. It also empowers clinical research organizations to pool their efforts, integrate resources, and participate in advancing scientific research, such as leveraging

patient files available through the platform, including genomic data that aligns with their scientific projects (Russo-Spena, et al., 2023, p. 08).

2.3.2 Cost Reduction

Blockchain technology can contribute to cost reduction, and its impact on value can be transferred to all stakeholders within the Blockchain network. These lower costs result from eliminating the role of intermediaries, enabling transactions to be conducted faster and at lower prices, and redistributing the intermediaries' share among stakeholders (Abdollahi, Sadeghvaziri, & Rejeb, 2023, p. 439). Empowering individuals to choose how they access healthcare contributes to reducing the burden on public healthcare services (Spanò, Massaro, & Iacuzzi, 2023, p. 05). In line with the United Nations' Sustainable Development Goals and achieving universal healthcare coverage, a global healthcare payment system can be established. The technology can manage chronic diseases, one of the world's most significant problems, and improve individuals' health literacy using Blockchain-based smart contracts. This can lead to further cost savings in healthcare services (Oflaz, 2019, p. 441).

Furthermore, studies have shown the potential of Blockchain technology to reduce waste and associated costs, improve resource utilization, and reduce waste costs, especially those resulting from poor transportation practices within supply chains (Abdollahi, Sadeghvaziri, & Rejeb, 2023, p. 439). This is further enhanced through the integration of Blockchain technology with the Internet of Things (IoT) and Artificial Intelligence (AI), allowing for more efficient outputs in the healthcare sector (Oflaz, 2019, p. 440).

Moreover, Blockchain technology reduces errors by detecting repetitive processes and errors that may be related to transactions or medical records (Spanò, Massaro, & Iacuzzi, 2023, p. 05). The costs of monitoring and controlling the authenticity of goods impose a significant burden on the ecosystem. Therefore, reducing surveillance and control costs can be a potential source of cost reduction within Blockchaintechnology (Abdollahi, Sadeghvaziri, & Rejeb, 2023, p. 439). The technology also contributes to lowering risk costs, as individuals and companies can reduce the likelihood of fraud, data tampering, risks of strategic alliances, and collaborations with key stakeholders, while improving customer knowledge. Finally, the impact extends to market data costs, as the new governance mechanisms introduced by the technology consider customers as

contributors or even decision-makers (Abdollahi, Sadeghvaziri, & Rejeb, 2023, p. 440).

2.3.3 Enhancing Environmental System Transparency and Trust

The technology enables secure verification of data by storing tamper-proof information. This feature allows for a comprehensive view of the system as supply chain stations, facilitating the identification of inefficiencies and clarifying responsibilities, thereby activating an effective circle of trust among stakeholders (Russo-Spena, et al., 2023, p. 09). Additionally, Blockchain contributes to enhancing networks and communications, which improve communication capabilities, facilitate collaboration, create shared value, and enhance open trade operations (Abdollahi, Sadeghvaziri, & Rejeb, 2023, p. 441). Moreover, transparency allows for error reduction and quality control of physicians' certifications, enabling patients to receive adequate and specialized medical care. It also prevents unfair practices through effective collaboration among stakeholders, as previously mentioned in anti-counterfeiting applications for medications (Russo-Spena, et al., 2023, p. 09).

In the context of clinical research, the technology has the ability to build trust between active parties, as patients trust in ensuring the necessary protection of their data available for research and development purposes (Spanò, Massaro, & Iacuzzi, 2023, p. 05). Finally, Blockchain technology creates additional value within a broader scope that is not limited to stakeholders' business models in the Blockchain ecosystem but rather focuses on how we collaborate as a society. Value is generated through supporting charitable associations and developing countries. This can contribute to narrowing the health gap between developed and developing nations and improving people's health in developing countries (Spanò, Massaro, & Iacuzzi, 2023, p. 06).

3. The Impact of the Blockchain-Based Environmental System on the Performance of the Healthcare Sector in Estonia

Health is an important social goal worldwide. To promote this goal, Germany spends over 11% of its gross domestic product on healthcare (€374 billion in 2017) (Bittroff & Sandner, 2020, p. 09). There is an urgent need for an efficient structure to identify potential savings. In this regard, Estonia was one of the first countries in the world to introduce innovative Blockchain-based solutions to manage its health databases (Kassen, 2022, p. 03). In 2016, the government

initiated a project that relies on Blockchain technology to secure health records and provide access to the system for 1.3 million citizens (Yaqoob, Salah, Jayaraman, & Al-Hammadi, 2022, p. 11483). This country possesses an ideal platform to experiment with various distributed ledger technologies and undoubtedly offers valuable lessons that can be learned and disseminated globally (Kassen, 2022, p. 03).

3.1 The Digital Healthcare Project in Estonia

Estonia laid strong foundations for technology in 1992, and by 1998, all Estonian schools were connected to the internet. By 2000, internet access was considered a human right (Angraal, Krumholz, & Schulz, 2017a, p. 1169). Estonia is known as an innovative country that has achieved digital milestones, such as establishing a company within hours and paying taxes in a matter of minutes (Lotman & Viigimaa, 2020, p. 22). The country provides digital access to e-services through the national identity card, which includes a legally binding digital signature. It also serves as a legal travel ID for Estonian citizens, facilitates access to bank accounts, and enables electronic voting (Bittroff & Sandner, 2020, p. 07).

Today, Estonia ranks 9th in the Digital Economy and Society Index (DESI) and consistently achieves scores above the European Union average in all sub-indicators except for the connectivity index (Commission, 2022, p. 03). It leads in the highest scores in the Digital Public Services Index, reaching 92/100 for citizens and 98/100 for businesses (Commission E. , 2022, p. 17). Estonia is globally recognized as a leader in e-government and cybersecurity (Lotman & Viigimaa, 2020, p. 22).

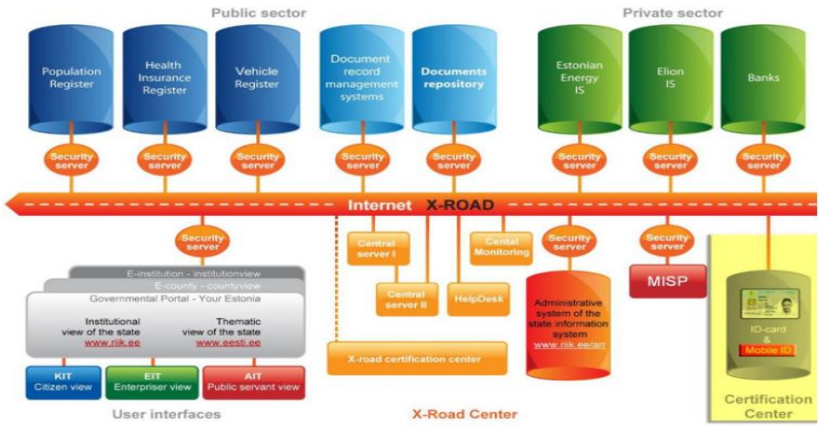
3.2 Development of Blockchain Technology in Estonian Healthcare

Estonia has adopted Blockchain technology and e-Identity cards to ensure the security of healthcare data (Lotman & Viigimaa, 2020, p. 22). Individuals in Estonia have access to an environment that provides electronic healthcare services, their medical records, and doctor visits (Commission, 2022, p. 17). Advanced solutions for the future of healthcare are being implemented, such as using genomics-based analyses to ensure more effective healthcare and facilitate access to individual's information (Lotman & Viigimaa, 2020, p. 22). Estonia has collaborated with the private security company "Guardtime" to secure medical records and develop a framework for patient identity verification through smart cards that include an

identity identifier linked to each citizen's electronic medical record (Angraal, Krumholz, & Schulz, 2017a, p. 1169). The security infrastructure used is the "Keyless Signature Infrastructure" (KSI), built on Blockchain technology to ensure the security of records and grant access to authorized parties (Heston, 2017, p. 02). Each time their healthcare records are updated, a new cryptographic dataset is assigned and recorded in the Blockchain, providing a tamper-proof and permissioned permanent record (Angraal, Krumholz, & Schulz, 2017a, p. 1169).

The implementation of Estonia's e-Health initiative was supported by the Health Information System Act of 2007 and the Governmental Regulation on Health Information Exchange in 2008 (Heston, 2017, p. 02). The national healthcare project based on Blockchain technology was officially launched in 2016. The main goal of the project was to protect records related to the processing of personal health information and ensure the confidentiality and integrity of healthcare data at the national level (Kassen, 2022, p. 03). The X-Road platform serves as the backbone for both private and public services. It has enabled the digital linking of 99% of government services and thousands of databases, with all information stored in a distributed data system that can be instantly exchanged upon request (Hughes, 2018, p. 66).

Fig 3. The Blockchain-based healthcare system in Estonia



Source: (Bittroff & Sandner, 2020, p. 07)

The success of the Blockchain-based healthcare project in Estonia relies on its ability to maintain the privacy of medical records while making them widely accessible to stakeholders (Rashmi, Badal, & Muppalaneni, 2023, p. 149).

3.3 The Added Value of Adopting Blockchain Technology in Estonia's Healthcare Sector

Estonia's electronic solution environment encompasses a complete range of services from both the public and private sectors for the general public, and they all utilize the X-Road platform due to each service having its dedicated information system. To ensure integrity, all data exchanges across the platform are digitally signed, timestamped, and linked in multiple ways (Hughes, 2018, p. 66). Government revenues and mandatory insurance contributions account for 77% of Estonia's total healthcare expenditure, with the vast majority (88%) of these public funds being spent through EHIF (Estonian Health Insurance Fund). Approximately 22% of the expenditure comes from out-of-pocket payments (OOP), mainly in the form of co-payments for medicines and dental care. A very small proportion (1.4%) of the expenditure is through voluntary health insurance programs (Organization, 2023, p. 02).

3.3.1 Cost-saving opportunities in adopting Blockchain technology

The cost-saving potential of the Blockchain-based model in Estonia appears to be significant. According to the Estonian Prime Minister's statement at the 2017 technology conference, Estonia's e-solutions make daily life easier and more efficient for citizens, businesses, and the state, leading to annual savings of 0.2% of the gross domestic product. It is claimed that this has enabled citizens to spend an average of just three minutes to pay their taxes. It is believed that this tax collection efficiency has contributed to the savings in GDP associated with technology (Hughes, 2018, p. 66).

Furthermore, in the context of improving the overall health status of Estonian citizens, the total healthcare expenditure per capita increased from 486.20 euros to 1885.2 euros between 2000 and 2015 (Lotman & Viigimaa, 2020, p. 23). Healthcare expenditures in Estonia accounted for 6.4% of the gross domestic product and 1668 dollars per capita in 2017, compared to 11% in an advanced country like Germany, demonstrating Estonia's efficient management of its system (Bittroff & Sandner, 2020, pp. 08-09).

Reports have indicated the diverse sources of cost savings resulting from the adoption of Blockchain technology in the healthcare sector. Assuming that 5% of the requests made through the X-Road platform are submitted by human users, each request saves 15 minutes (Bittroff & Sandner, 2020, p. 08). With over 900

organizations in Estonia utilizing this platform, over 820 years of working time for the state are saved (Hughes, 2018, p. 66). However, saving 820 years of work in a year is just a small part, not exceeding 5% of the overall picture, as it is challenging to measure the 95% of savings that occur automatically through data exchange between systems. Studies indicate savings of 1407 work years in 2018 (Bittroff & Sandner, 2020, p. 08).

On the other hand, remote consultations provide 8.9 billion euros in savings by addressing structural issues resulting from the shortage of workforce in rural areas, for example. Time savings for professionals and patients through teleconsultation contribute to savings worth 0.5 billion euros. Online appointment scheduling enhances patient convenience and provides an opportunity to save time and cost valued at 0.5 billion euros. Digitizing the care system achieves the highest levels of effectiveness and efficiency, with the creation of patient treatment plan management tools resulting in savings of 5.6 billion euros (OECD, 2021, p. 14). As mentioned above, self-treatment and self-care tools are useful for promoting personal responsibility for health and can eliminate potential cost savings of around 4.3 billion euros (Bittroff & Sandner, 2020, p. 11). In fact, the unmet needs expressed due to high costs decreased from 1.1% in 2016 to 0.4% in 2019 (OECD, 2021, p. 14).

3.3.2 Stakeholder Interactions Benefits

The Estonian healthcare system was highly digitalized even before the onset of the COVID-19 pandemic and continued to provide 99% of medical prescriptions during the pandemic (Commission, 2022, p. 17). The infrastructure of the Keyless Signature Infrastructure (KSI) allows for the expansion of over 1012 data elements per second, enabling access to most government services online 24/7 (Bittroff & Sandner, 2020, p. 08). Furthermore, identity management in Estonia is regulated by unique identifiers under the Digital Signatures Act and the Identity Documents Act (Azogu, et al., 2019, p. 04), confirming the effectiveness of the system. In 2016, over 94% of citizens had an electronic identity that allowed them to use the system, which offers more than 4,000 e-services (Britchenko & Tetiana, 2019).

On the other hand, patients can verify the doctors who have accessed their files (Angraal, Krumholz, & Schulz, 2017b, p. 02). Doctors can also access test results, including image files such as X-rays, even from remote hospitals. Additionally, mobile phone identifiers

enable access to the portal and document signing (Bittroff & Sandner, 2020, p. 09).

A survey conducted by the Estonian Health Insurance Fund in 2020 revealed that 62% of the population considers access to medical services to be good or somewhat acceptable, which is the highest recorded result since 2011. However, 19% of respondents reported unmet needs during the COVID-19 pandemic, but this figure was lower than the European average of 21%. On the other hand, 46% of Estonians stated that they benefited from remote consultations, compared to the European Union average of 39% (OECD, 2021, p. 14).

The digital system enabled the enhancement of primary care, contributing to a reduction in unnecessary hospital visits, which is evident in the importance of this measure in reducing waiting room queues. The recorded rates in Estonia are lower than those in most other European Union countries. Cases related to diabetes decreased by 25% between 2014 and 2018, and heart failure rates decreased by 18%. Asthma-related admissions also significantly decreased from 623 cases in 2010 to 344 cases in 2017 (OECD, 2021, p. 13).

3.3.3 Transparency and Trust Benefits in the Ecosystem

Studies have shown that implementing Blockchain technology in public healthcare institutions can enhance citizens' trust in the sector. The technology is known to reduce the chances of errors and data loss, thereby increasing the security of the patient health information management system (Matlebjane & Ndayizigamiye, 2022, p. 05). The Keyless Signature Infrastructure (KSI) technology developed by Guardtime overcomes the limitations of traditional Blockchain, such as scalability and settlement time. Due to the limited number of participants, settlement time is reduced to a few seconds, enabling real-time data synchronization. This has resulted in increased trust in government institutions. Additionally, the use of modern Blockchain technology aligns with the Estonian Personal Data Protection Act (PDPA) of 2008, ensuring compatibility with the rights and trust of Estonian citizens regarding personal data (Rashmi et al., 2023, p. 149). Centralization remains crucial for customer trust in data security. The electronic health record retrieves data from various healthcare providers using the X-road platform and provides standardized formatting through the patient portal. The insured persons' claims records and the electronic prescription database are included in the Estonian Health Insurance Fund (EHIF)

databases. The key advantages of these implemented structures are efficient resource utilization, interoperability for stakeholders, and data transparency at various levels for patients, physicians, pharmacists, and the EHIF platform. The central issue remains the trust of all citizens in data security and quality (Bittroff & Sandner, 2020, p. 09).

On the other hand, Estonia's adoption of Blockchain technology is based on the principle of exclusive data ownership for the benefit of the patient rather than the party that may retain their data. This enables individuals to access their own records to see which doctors have accessed their data and when. They can also block individuals from viewing their data in a world where the relative importance of personal data as assets is increasing (Hughes, 2018, p. 67). Moreover, this system holds several potential advantages to ensure security and audibility of any modifications to healthcare records, addressing concerns of fraud in appointment scheduling and risks associated with tampering with medical implant devices. Any information update in the healthcare database, such as appointment scheduling, is assigned a timestamp and cryptographically signed within a block (Angraal, Krumholz, & Schulz, 2017b, p. 02).

Estonia has been involved in various collaborative projects with Guardtime, including the establishment of an infrastructure that allows healthcare professionals to access the same health information and eliminates centralized storage restrictions. This can help reduce medical negligence risks due to outdated information and prevent health problems arising from this misinformation (McGhin, Choo, Liu, & He, 2019, p. 68). Guardtime has also created VaccineGuard, a digital network connecting hospitals, vaccine manufacturers, and distributors. The program can identify counterfeit vaccines using Blockchain technology, accelerating and ensuring the secure sharing of data between parties (Abdelhamid, Tharwat, Halim, Ali, & Ibrahim, 2023, p. 508). These projects aim to improve the efficiency and effectiveness of the Estonian healthcare system in a decentralized, secure, transparent, tamper-proof, and auditable manner, mitigating the risks of cyber breaches. The project has the potential to achieve the goal of raising awareness about the safety of stored patient data, enabling officials to identify breaches and take timely action to minimize harm(Yaqoob, Salah, Jayaraman, & Al-Hammadi, 2022, p. 11483).

4. Conclusion:

This study reviewed the previous literature that investigated the sources of value creation in the technology-based Blockchain healthcare sector, with a focus on the Estonian experience. The review yielded several results, which are outlined as follows:

4.1 Results

The healthcare sector in Estonia has achieved valuable outcomes on multiple levels. Blockchain technology has contributed to reducing public spending on healthcare compared to European Union countries. However, this reduction is sometimes associated with clear political plans and projects (Hughes, 2018, p. 66). Additionally, the technology has enhanced the effectiveness of primary care, leading to a decrease in unnecessary hospital visits, which positively impacts waiting times. However, studies have shown significant variations in access to healthcare in Estonia. This is evident through the high level of unmet medical care needs due to waiting times, which are not necessarily correlated with income levels. The nature of most emergency cases cannot be met using Blockchain technology (OECD, 2021, p. 13). The adoption of Blockchain technology in the healthcare sector has resulted in a decrease in the overall workforce in Estonia (Commission, 2022, p. 06). Reports have indicated an increase in vacant positions for primary care physicians, which have quadrupled since 2015, with over half of clinical care physicians being over the age of sixty (OECD, 2021, p. 13).

4.2 Recommendations

Considering the nature of the study's topic and its related concepts, the study recommends conducting investigations to test the proposed research hypotheses and the defined conceptual model of value creation sources in Blockchain technology healthcare, as outlined in the study. This is necessary to obtain stronger and more credible results. Therefore, the required research aims to confirm the relationship between Blockchain technology and added value in the healthcare sector for countries. Moreover, the research assumptions should include an analysis of the impact of stakeholders' readiness levels in adopting the technology on achieving overall savings, in addition to estimating the costs of technology adoption and the impact of technology on improving health levels and meeting individuals' clinical needs. These factors are essential in making a comprehensive judgment on the importance of technology in healthcare in all its dimensions.

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