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Penetration of Blockchain Technology in Healthcare Management Domain: Challenges and Opportunities

Blok-Zincir Teknolojisinin Sağlık Hizmeti Yönetimi Alanına Penetrasyonu: Zorluklar ve Fırsatlar

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ABSTRACT

Blockchain technology (Btech) is one of the new technologies in healthcare management domain. Challenges and opportunities are closely related to the usability of the technology. The study aims to evaluate penetration of the technology in healthcare management domain. Web of Science database was utilized to obtain publications. The publications were subjected to various analyses in the R environment. The parameters were handled within the framework of the values provided with biblioshiny package. The ggplot2 package was used for data exploration and visualization. According to the findings, Btech has been discussed in the context of the management of electronic health records. Prominent key concepts and thematic map revealed that the technology could be a potential tool in the management of health records. While privacy, security, complexity, and sustainability stand out as the main challenges; active patients, management of health records, quality and reliability of clinical trials, and its use in monitoring and procurement processes in the pharmaceutical industry stand out as opportunities. In general, Btech is a brand new paradigm in the management of health data, and in this respect, it can make important contributions to healthcare management from the perspectives of patients, providers, and payers.

Keywords: Blockchain Technology, Healthcare, Healthcare Management

ÖZ

Blok-zincir teknolojisi, sağlık hizmeti yönetimi alanında yeni teknolojilerden biridir. Bu teknoloji ile ilgili sağlık hizmeti yönetimi alanına ilişkin öne çıkan zorluklar ve fırsatlar teknolojinin alanda kullanılabilirliği ile yakından ilişkilidir. Bu çalışmada, blok-zincir teknolojisinin sağlık hizmeti yönetimi alanına ne düzeyde penetrasyon sağladığı değerlendirilmiştir. Web of Science (WoS) veri tabanı kullanılarak yayınlar elde edilmiştir. Elde edilen yayınlar R programı kullanılarak çeşitli analizlere tabi tutulmuştur. Yürütülen analizler için kullanılan parametreler biblioshiny ile sağlanan değerler çerçevesinde ele alınmıştır. Veri keşfi ve görselleştirmede ggplot2 paketi kullanılmıştır. Bulgulara göre, blok-zincir teknolojisi, sağlık hizmeti yönetimi alanı ile en çok elektronik sağlık kayıtlarının yönetimi ile ilişkisi bağlamında ele alınmıştır. Öne çıkan anahtar kavram ve tematik harita bulguları, blok-zincir teknolojisinin sağlık kayıtlarının yönetilmesinde potansiyel bir araç olabileceğini ortaya koymuştur. Gizlilik, güvenlik, karmaşıklık ve sürdürülebilirlik temel zorluklar olarak öne çıkarken; aktif hasta, sağlık kayıtlarının yönetimi, klinik araştırmaların kalitesi ve güvenirliği, ilaç sektöründe izlem ve tedarik süreçlerinde kullanımı ise teknolojinin yarattığı fırsatlar olarak öne çıkmıştır. Genel olarak değerlendirildiğinde, blok-zincir teknolojisinin sağlık verisinin yönetiminde yepyeni bir paradigma olduğu, bu yönüyle sağlık hizmeti yönetimine hasta, sunucu ve ödeyici perspektiflerinden önemli katkılar sağlayabileceği değerlendirilmektedir.

Anahtar Kelimeler: Blok-Zincir Teknolojisi, Sağlık Hizmeti, Sağlık Hizmeti Yönetimi

Since publication data was used in the study, ethical permission was not required.

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INTRODUCTION

Blockchain technology (Btech) has the potential to initiate a new era in healthcare.[1-4] While this technology offers a flexible and reliable network, it has the characteristics of a global account book, a data file, and a database that is open to everyone, transparent, distributed, sequential and time-stamped.[5-7] Today, where data is accepted as a strategic value, these technologies offer important opportunities for better management of the increasing amount of health data.[8-9] Among the opportunities of the technology, we can count the production of drugs in health system and delivery to the patient, ensuring communication and coordination between health providers and payment institutions, recording and managing patient data in a standard way, and increasing the quality of clinical research.[10-12] While this technology was first seen as a distributed and account book open to the public that records Bitcoin transactions in a secure and verifiable way, then it started to be evaluated as a technology with different potentials.[11,13,15,16] Btech does not depend on a center and is not under the control of any authority. There are many computers in the network and every person/institution in the network is equally central. The data entered in a block opened in the technology is immediately saved and the system updates instantly in other blocks.[17] This makes the technology advantageous in ensuring the security of data. The older a block is the more reliable and almost impossible it is to change.[6] Within the Btech, ledger networks are open and participants do not need to trust each other to interact with each other, all transactions are verified and recorded by the nodes of the network through encryption algorithms without a controlling central authority and human intervention.[18] Data can be stored according to their confidentiality criteria in Btech.[19] All technical elements related to the contract made between the parties with the technology are fulfilled with smart contracts produced by computer programs. These contracts can be securely protected in the technology, open to interested parties. In particular, all information regarding contracts such as compensation, insurance, etc. can be managed within the trust environment offered by the technology.[12] In addition, since individuals or institutions in the network have the opportunity to make one-to-one transactions, the technology creates an opportunity to accelerate decision-making processes.[20] Transactions carried out within the Btech are protected by end-to-end cryptographic passwords.[3] Verification made to intervene to people or make control authority unnecessary is performed by a mathematical mechanism.[21-23] Although the technology is seen as a very dynamic, the structure of the technology is described as static. Any data recorded in the Btech cannot be altered later. No person or institution has the opportunity to make any changes to this data.[5-24] It is not possible to attack all blocks, as cryptographic processes are present at each stage of the Btech. Even if the data in the block is damaged when any block is attacked, there is no problem in this regard, since a copy of this data is found in other blocks.[20,25] Since this technology creates important opportunities for the solution of many problems in healthcare, significant gains can be achieved for the health systems with the effective use of it. Managing patient data, sharing it with stakeholders, and using it in clinical, biomedical, and genetic research are among the priorities of the technology.[26-27] To exemplify, the Enigma project aims to securely share patient information among users on a large scale according to privacy and security.[11] In addition, since sharing health data among stakeholders will provide more effective coordination, this can play an important role in eliminating of waste in health system.[24,27,29] In a Btech, healthcare professionals can access the most up-to-date information on patients and have the opportunity to work with other professionals as the data is constantly updated. Smart contracts used in the Btech, on the other hand, protect patient data in a consistent and rule-based manner. In a study, it was revealed that 300 billion dollars can be saved annually as a result of the creative and effective use of

health data.[30] It is quite remarkable that the Btech company Nuco recommended the use of this technology to establish a more effective mechanism between patients and pharmacists. This technology can be used effectively to prevent the sale of different drugs other than the drugs prescribed by the physician to the patient and to warn the doctor and pharmacist for suspicious purchase attempts.[24,31] BurstIQ, Factom, GemOS, HealthCombix, MedRec, Patientory, SimplyVital, and IBM's Watson are involved in various initiatives regarding the application of Btech to the healthcare domain.[32] HealthChainRx and Scalamed, on the other hand, are working on Btech-based solutions to combat corruption related to prescriptions.[24] The potential opportunities of Btech for the healthcare management raise questions about the level of penetration of the technology into the domain. In addition, there are some barriers to the use of this technology in healthcare management. Some opportunities facilitate the usability of technology in the domain, as well as various factors that create a significant challenge for the use of the same technology. Evaluating the penetration of Btech in healthcare within the framework of the challenges and opportunities created by technology shows that it is very important in developing a holistic approach to the usability of technology. In this context, the study aims to examine the penetration of Btech in healthcare management and to draw attention to the challenging factors and opportunities that affect the usability of the technology. While some of the studies in the literature examine the factors related to the difficulties and opportunities of the technology separately, it is understood that the studies evaluating these factors as a whole are insufficient. For this reason, in the study, the penetration of Btech into the healthcare management has been investigated through scientific publications, and the main challenges and opportunities have been attempted to be revealed with a holistic approach.

MATERIAL AND METHOD

The widely known theory of scientific change in the literature is Thomas Kuhn's Theory of Scientific Revolutions. According to the theory, science is an iterative radical process in which scientific paradigms compete and change in a dominant position.[33] Accordingly, it can be said that scientific developments are constantly in the process of change and transformation. The exponential increase in the number of scientific publications, which form the basis of scientific developments, is a compelling factor for researchers working in the field, and the need for studies produced using bibliometric methods that deal with the direction of developments in the field, the dynamics, and structure of the field has increased significantly. Studies (meta-analysis and structured literature research) that deal with the evolutionary process emerging in the field of study with traditional approaches are undoubtedly very powerful methods and make significant contributions to the knowledge in the field. However, since a lot of time is spent on studies produced using these methods, studies produced with such approaches may remain at a very limited level.[34] On the other hand, considering the bias of researchers and the possibility that important studies in the field are not included in the analysis, the need for alternative methods and approaches arises for studies produced with traditional methods and approaches. In this regard, bibliometric methods provide the opportunity to obtain a very different understanding of the change and transformation experienced in the field of study, as well as the opportunity to direct the researcher from micro focus to macro focus. For this reason, the researcher has the opportunity to research and examine the basic structure and dynamics of the field that is interested in with a wider perspective.[35] Bibliometric methods and approaches, undoubtedly, continue to develop day by day due to the accumulation of knowledge in the field. From the historical perspective, it is accepted that the concept of bibliometrics, which is based in the 1920s, was used for the first time by Alan Pritchard.[36] In its most

general definition, bibliometrics is based on the principle of analyzing with various statistical and mathematical methods using data obtained from databases and obtaining an image of the field of interest.[35] Bibliometric studies are generally carried out for two purposes. While performance analysis expresses the scientific publication performance of the institution or country; scientific mapping, on the other hand, refers to revealing the basic structure and dynamics of the scientific field.[37] As a result of the analyzes made using bibliometric methods, some field-specific results are reached with the help of various patterns of authors, documents, and countries.[38] Among the bibliometric methods, the scientific mapping method is quite new. Scientific mapping or bibliometric mapping; refers to a spatial representation that shows the relationship of disciplines, fields, specialties, documents, and authors with each other. The scientific mapping method can be understood as discovering useful information from data.[37] Scientific mapping analysis is done widely through keywords (authors, countries, publications, etc.).[39] The analysis aims to show the structural and dynamic aspects of scientific research. There are 8 basic steps in the analysis and these steps are presented below.[33,38]

- The data can be shared with WoS, Scopus, PubMed, etc. obtaining from databases
- Pre-processing of data
- Network extraction from data
- Normalize data to get the meaningful result from data
- Mapping
- Analysis
- Visualization
- Interpretation

Within the scope of bibliometric research, a detailed literature search was made and the conceptual framework in the field was tried to be understood. In the literature research, besides scientific publications, grey literature was also used. After gaining an understanding of the conceptual framework, a study on the selection of keywords was carried out by the researchers and it was decided what words would be used in obtaining scientific publications. Using the Web of Science (WoS) database, the search process was carried out in two stages. In the first stage, all English journal articles published between 2008-2021 were obtained by using the "health*" keyword using the advanced search feature. In the second stage, all English journal articles published between 2008-2021 were obtained by using the "blockchain*" keyword with the same approach. After this process, publications related to studied area were obtained by combining the findings of both stages. The bibliometric package was activated using R Studio, and then the interface was accessed with the biblioshiny function. After the interface was opened, the data related to the publications were transferred to this environment and prepared for analysis. Data analysis was carried out by adopting a data exploration and visualization approach. After revealing the basic descriptive findings of the publications, analytical findings related to the development dynamics of the field are presented. With this approach, the level of penetration of Btech into the healthcare management domain was evaluated in detail with thematic map findings produced with bibliometric data. The ggplot2 package offered by R was used for data exploration and visualization.

FINDINGS AND DISCUSSION

The main findings regarding the most published sources of the publications examined within the scope of the research are presented in Figure 1 below. Accordingly, IEE Access, Journal of Medical Internet Research, Sensors, Electronics, and Journal of Medical Systems are the cumulative prominent resources on Btech.

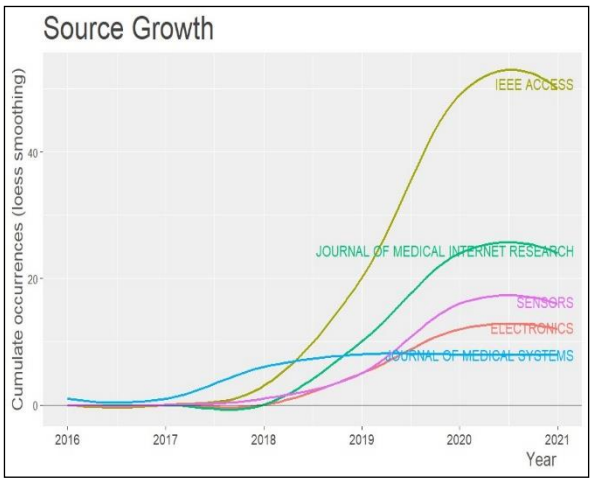

Figure 1. Featured Journals in Publications

The resource called IEE Access comes first, while the Journal of Medical Internet Research comes in second. When other sources are examined, it is understood that they are closely related to the engineering. While IEE Access deals with Btech with an engineering approach, the Journal of Medical Internet Research deals with the subject both with an engineering approach and evaluates the studies produced with internet facilities. Other sources have discussed the engineering aspect of Btech with a similar approach. The main findings regarding the citation networks for authors are presented in Figure 2 below.

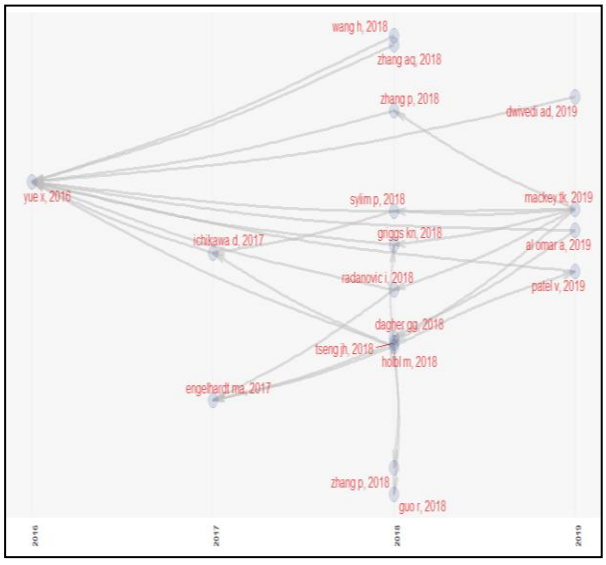

Figure 2. Author Citation Network

According to Figure 2, publications consist of recent studies and have increased especially in the last few years. It is seen that the study published in 2016 on the management of healthcare data is quite central. When the citation network findings are examined closely, it is understood that Btech has been featured more in scientific publications, especially in 2018. The citation network for the aforementioned publications is presented in Figure 3.

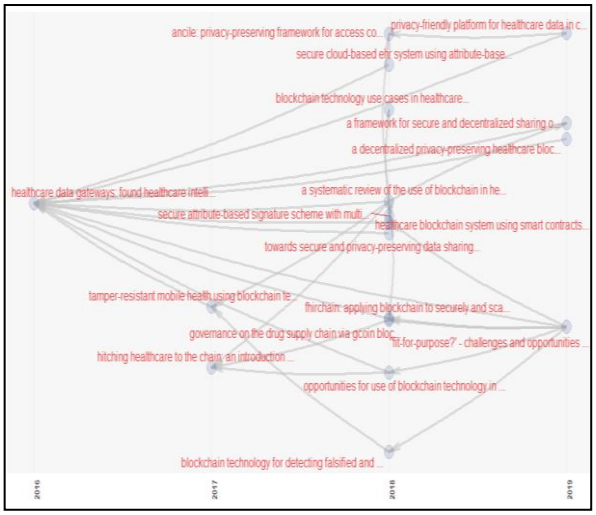

Figure 3. Publication Citation Network

According to Figure 3, the study published in 2016 is quite central. The majority of the studies included in the citation network come from engineering, and they specifically address the technical issues so that the technology in question can be used within the framework of privacy and security principles. This situation can be examined in detail in the centrally located studies published in 2018. When these publications are examined, it can be seen that most of them focus on the privacy and security of the technology. The thematic map created to examine the conceptual development of Btech in healthcare is presented in Figure 4.

Figure 4. Thematic Map

The extent to which Btech converges to the healthcare domain can be evaluated by examining which part of the quadrant the studied concepts are clustered. The fact that the studied concepts are located in the upper right area of the dial, that is, in the area of motor themes, shows that there is little accumulation in healthcare in the context of Btech. The concentration of the concepts in the lower right corner of the quadrant, that is, in the field of basic themes, shows that the technology is new in healthcare, therefore more accumulation is needed. When the concepts in this section are examined, it is understood that they consist of concepts such as electronic health records, supply chain, cloud computing, which are closely related to data management. Although electronic health records have a high level of centrality, it has been included as a theme with a low level of density. The cloud computing theme, on the other hand, is critical to the development and has a high level of centrality and density. This emerging situation shows that Btech mainly has data management potential in healthcare management. The parts on the left side of the dial include niche areas and prominent concepts in relatively less studied areas. The sub-breakdowns of prominent themes in healthcare are presented in the three area charts in Figure 5 below.

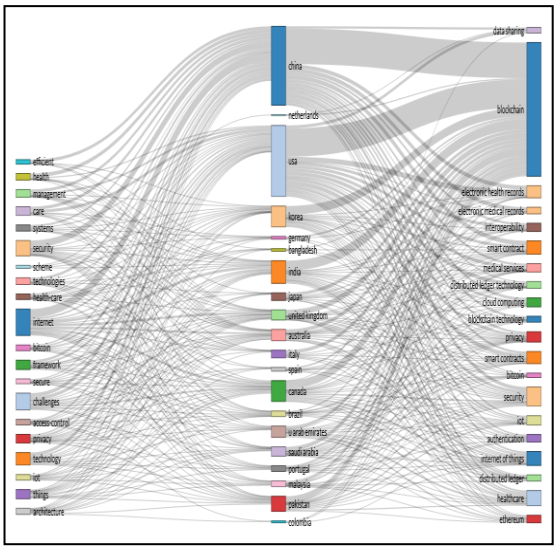

Figure 5. Three Area Graphs

When Figure 5 is examined, it is understood that the publications and thus the prominent keywords mostly come from China and the United States. In addition, it is seen that countries such as India, Canada, and Korea have contributed significantly to the experience. When the prominent concepts in the sub-breakdowns related to the Btech are examined, it is understood that the concepts of electronic health records and security are heavily involved in the publications. In addition, concepts such as smart contracts, cloud computing, and the internet of things are the most frequently used concepts with Btech. The prominence of the concept of healthcare in publications reveals the importance of Btech for healthcare. Internet infrastructure, systems to be installed and their management, security, confidentiality, and privacy of patient data, etc. concepts reveal the reflections of technology in healthcare. In other words, the intense emergence of these concepts not only creates significant challenges for the healthcare but also points to significant opportunities. For example, such a heavy emphasis on privacy and security in publications points to perhaps the most critical challenges regarding the use of the technology in healthcare. On the other hand, the intense handling of concepts such as data sharing and management reveals the opportunities created by the technology in question. The keyword network presents a very comprehensive network regarding the use of Btech in the healthcare. Three concepts have a very

dominant position in the network. The challenges, internet, and security themes demonstrate the extent to which Btech has penetrated the healthcare domain. According to the findings, it is tried to reveal the approaches related to this by drawing attention to the internet infrastructure used to make Btech-based transactions in healthcare. On the other hand, the predominance of the theme of challenges demonstrates the difficulties associated with the use of Btech in healthcare management. These difficulties may be technical difficulties that are closely related to the engineering, as well as various types of privacy and security difficulties in management of patient data. In addition, the concept of security refers to the security risks that may arise with the use of Btech in healthcare. The management of patient data in a distributed structure and in a Btech-based technology that is not connected to any center reveals important problems in terms of security. When the other concepts in the network are examined, it is understood that these concepts are related to the technical infrastructure of Btech. Although Btech has the potential to create value in healthcare, it stands as a technology with various challenges. Since there are various kinds of difficulties related to data management in healthcare, the opportunities that the technology will create in overcoming such a challenging situation are being evaluated by the stakeholders. In the study, the extent of penetration of Btech in healthcare management was evaluated, and the difficulties and opportunities of the use of the technology in healthcare management were revealed. As understood from the literature, Btech has a decentralized structure, has a distributed database feature, it provides one-to-one communication, confidential and secure, transparent and works within the framework of the immutability of records stands out as a technology.[3,5,17,19,20,22,24] The findings of the research point to several types of challenges and opportunities in the penetration of Btech into healthcare management. When evaluated in general, it is understood that the motor themes showing the penetration of Btech in healthcare did not occur, but the majority of the themes came to the fore in the basic themes, which are characterized by the process of change and transformation in the domain. Therefore, it is understood that the developments experienced in the impact of the technology on the healthcare are in a process of change and transformation. As the concepts involved in the change and transformation process find their way in the domain, these concepts can become motor themes with a high level of centrality and intensity. Since the technology is closely related to the management of sensitive patient data, privacy has emerged as a critical factor for the healthcare management. All processes within the technology are carried out openly to everyone in the network. On the other hand, the fact that the information that needs to be kept confidential can be monitored by other people in the system constitutes an important barrier to the use of technology. The ability to view and access sensitive patient information by people unrelated to this information is considered a critical barrier to the usability of the technology. As Benchoufi and Ravaud stated, making patient records accessible to stakeholders can be considered as a practical solution to overcome this challenge.[11] Another emerging challenge with technology stands out as complexity. The technology is undoubtedly not without problems, and some problems may arise with the use of the technology. For example, the technically complex structure of the cryptography on which the technology is based and the network structure that the technology is involved in making it significantly difficult to understand the technology. Therefore, the technology is quite complex, and, as Dos Santos rightly emphasized, it can be considered that it will be difficult for people to accept and use these technologies quickly.[40] The sustainability factor can be considered as another important challenge. The sustainability dimension, which is considered socially, economically, and environmentally, is considered important in terms of the technology. The social aspect of technology, whether it is usable by humans; economic aspect, gains and value to be obtained; finally,

the environmental aspect is closely related to whether the technologies are environmentally friendly. In the context of sustainability, it is possible to talk about some technically disadvantageous features of the technology. For example, the high level of electrical energy consumption remains an important barrier to the use of the technology.[17] Therefore, whether the technology is a cost-effective tool is still debated.[10] On the other hand, while there are opinions that the application of the technology is not effective and environmentally unsustainable, there are also opinions expressing that the technology consumes less energy than today's banking system.[4,35] In addition, one of the main problems regarding the use of the technology emerges as a security problem. Even though the technology is protected by highly secure cryptographic passwords, it is open to malicious attacks. Nowadays, when cyber-attacks are quite common, people's management of their private information on the Btech can cause anxiety. As Kshetri emphasizes, the fact that there has not been a completed cyber-attack attempt on the Btech to date does not mean that these attacks will not occur in the future. Another concern about Btech is the possibility that the technology in question will become a monopoly. The fact that a single institution/organization has control over the majority of the network and the possibility of manipulating the Btech reveals that more scientific research should be done on the security of the technology.[7] Since the use of Btech in healthcare ultimately requires the management of health data in these systems, the acceptance of the technology by society will be very effective in the use of the technology in healthcare. Innovation and complexity pose significant barriers to human adoption of technologies because people generally want to feel safe when it comes to the use of technology.[12] Melanie Swan predicted that there are 3 phases for Btech adoption: Block-chain 1.0, Block-chain 2.0, and Blockchain 3.0. Blockchain 1.0 is the use of cryptocurrencies for transfer purposes, such as currency, money transfer, remittance, and digital payment systems. Blockchain 2.0 is a set of economic, market, and financial applications that use Btech more broadly than simple cash transactions. Stocks, bonds, futures, loans, mortgages, titles, examples include use for smart properties and smart contracts. Blockchain 3.0 is used beyond finance and markets – particularly in government, health, science, literacy, culture, and the arts. According to Swan, the use of Btech in healthcare management will be possible with blockchain 3.0.[23] The usability of the technology in healthcare management stems from the potential opportunities created by the technology. One of the most basic opportunities created by technology is the patient who becomes active for his health. The technology aims to engage patients more with their health. With the development of these technologies, the patient can access their health information, and monitor and control the process as a whole. The role of the patient in this process is to be constantly active instead of the passive patient in the traditional understanding. Of course, these developments have important gains. As highlighted in one study, the patient who accesses the health records feels strong, the communication between the health provider and the patient is strengthened, so that the patient himself can be involved in the management of his health condition and can make decisions about it. On the other hand, one of the most important opportunities created by technology in healthcare management is the effective management of the health records of patients. Patient records are important resources in the delivery, management, and continuity of healthcare. Sharing and monitoring patient records by healthcare providers and payer institutions is an important development in ensuring the continuity of healthcare. Btech has a significant potential to increase the effectiveness, efficiency, and security of the mentioned process. Btech encrypts patient-identifying information, and data on the delivery of healthcare is shared between the healthcare provider and the payer.[10] In this respect, it is understood that smart contracts increase the transparency and traceability of processes. Therefore, it is thought that creating a Btech-based system, in which the

processes related to healthcare, can be monitored transparently between health institutions/organizations and payer institutions and organizations, will make significant contributions to the healthcare management. Another opportunity created by the technology in healthcare stands out as it allows increasing the quality and reliability of clinical trials. Because dealing with data and extracting meaningful patterns from data has become a situation that has been adopted and spread throughout the world. Therefore, keeping reliable patient records managed on a Btech-based basis open to research in a structured way can bring with it extremely important gains in conducting clinical studies, repeating them, and demonstrating their validity and reliability. Monitoring in the pharmaceutical industry can be considered as another opportunity presented by Btech in healthcare. The pharmaceutical industry includes complex processes, and the technology can be considered as a potential opportunity in monitoring the whole process from producing of drugs to patients. That's why, some organizations have already started to use Btech in their procurement processes. This situation shows itself more in the supply chain, and the technology are used to monitor processes in complex supply networks. Since there are many different qualities and quantities of drugs, services, and materials in healthcare, it can be stated that significant gains can be achieved with the use of the technology in the procurement processes.

CONCLUSION AND RECOMMENDATIONS

The health domain is greatly affected by changing and developing technologies. Btech is one of the most important examples of this situation. In the study, the penetration of Btech in healthcare management domain is evaluated within the framework of the challenges and opportunities. It is thought that the management of patient records is significant in terms of enabling interoperability. Although Btech is seen as a potential tool for the healthcare domain, the security problem related to the technology still exists. The fact that Btech is not connected to any center and is outside the control of governments is the main factor that creates the perception of insecurity in people. Therefore, for these technologies to be used effectively, there is a need for an environment of trust that contributes to the possibility of acceptance. Initiatives and legal regulations to be made in this regard may facilitate the adoption of these technologies. As a result, although Btech brings with it some compelling factors, it is thought that the widespread use of the technology in healthcare management will produce significant benefits from the perspectives of patients, providers, and payers by effectively managing of health data.

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