Kaunas University of Technology

School of Economics and Business

Implication of Blockchain Technology on Health Care Innovation Areas: A Multi-Case Study

Master's Final Degree Project

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Declaration of Academic Integrity

I confirm that the final project of mine, Tugce Yerlitas, on the topic „Implication of Blockchain Technology on Health Care Innovation Areas: A Multi-Case Study "is written completely by myself; all the provided data and research results are correct and have been obtained honestly. None of the parts of this thesis have been plagiarised from any printed, Internet-based or otherwise recorded sources. All direct and indirect quotations from external resources are indicated in the list of references. No monetary funds (unless required by Law) have been paid to anyone for any contribution to this project.

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Summary

The health care environment shift to the precision medicine approach, which is dependent on data analysis, the importance of data is increased. Since precision medicine aims developing drugs and treatment that takes into account individuals' demographic, genetic, and environmental differences. As a result of that, blockchain technology is offered as a solution for data management in health care. Together with these approaches and blockchain technology, not only products and treatment changes in health care but also business models are affected. In the literature, there are many studies exist that are related to applications of blockchain technology for electronic health records, genomic studies, supply chains, wearable devices, clinical trials. However, there are so limited studies that explain how these applications affect the business models and value chains in health care. In this research, it was aimed to demonstrate the effects of blockchain technology on health care business models and the effect of these new business models on health care innovation environment. Therefore, multi-case study method was performed as one of qualitative research methods. Three different health information technology companies that used blockchain technology were chosen and these companies blockchain structures were analyzed by focusing on features and values that are generated in accordance with features while their business models were analyzed by using business model canvas that is offered by Osterwalder & Pigneur (2010). As a result of this analysis, the values that are generated by these companies using blockchain was taken into consideration, and blockchain's effects as a trigger of business model innovation were shown on business model canvas for all health care business. Also, these new information companies' business models and their effect on other health care businesses how enhanced the innovation environment by their key activities, key partnerships, and resources was explained. As a result of research, a business model canvas is generated to be used by companies which want to adapt blockchain technology in their business model. The business model canvas shows the blockchain's effects on each business building blocks. Also, it was seen that blockchain-based information companies can have a role in creating an innovation network by providing brokerage service and being the main provider of this technology. Additionally, blockchain's current limitations and challenges during the adaptation of blockchain were explained and expectations on future of blockchain were mentioned according to interviewees' explanations.

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Santrauka

Sveikatos apsaugos aplinkos pasikeitimas į tiksliosios medicinos požiūrį, kuris yra priklausomas nuo duomenų analizės, ir duomenų svarba yra pakilę. Kadangi tiksliosios medicinos tikslas yra vystyti vaistus ir gydymą, remiantis asmenų demografiniais, genetiniais ir aplinkos skirtumais, dėl to, kaip sprendimas duomenų valdymui sveikatos apsaugoje yra siūloma „blockchain“ technologija. Kartu su šiais požiūriais ir „blockchain“ technologija, keičiasi ne tik produktai ir gydymas, bet paveikiami yra ir verslo modeliai. Literatūroje egzistuoja daug tyrimų, susijusių su „blockchain“ technologijos pritaikymu elektroniniams sveikatos įrašams, genomo tyrimams, tiekimo grandinėms, nešiojamiesiems prietaisams, klinikiniams tyrimams. Tačiau, yra ne itin daug tyrimų, kurie paaiškintų, kaip šie pritaikymai paveikia verslo modelius ir vertės grandines sveikatos apsaugoje. Šio tyrimo tikslas buvo parodyti „blockchain“ technologijos poveikį sveikatos apsaugos verslo modeliams ir šių naujų verslo modelių poveikį sveikatos apsaugos inovacijų aplinkai. Todėl, kaip vienas iš kokybinio tyrimo metodų - buvo taikytas kelių atvejų metodas. Buvo pasirinktos trys skirtingos sveikatos informacijos technologijos įmonės, kurios naudojosi „blockchain“ technologija, buvo analizuojamos šitų įmonių „blockchain“ struktūros, fokusuojantis į bruožus ir vertybes, kurios sugeneruotos pagal bruožus, kol jų verslo modeliai buvo analizuojami naudojant verslo modelių drobes, pasiūlytas Osterwalder ir Pigneur (2010). Kaip šios analizės rezultatas, atsižvelgiant į vertybes, kurios yra sugeneruotos šitų įmonių naudojant „blockchain“, „blockchain“ poveikis buvo parodytas ant verslo modelių drobių kaip verslo modelių inovacijų trigeris visam sveikatos apsaugos verslui. Taip pat, buvo paaiškinti naujų informacijos kompanijų verslo modeliai ir jų poveikis sveikatos apsaugos verslui, kaip sustiprina inovacijų aplinką pagal jų pagrindines veiklas, pagrindines partnerystes bei išteklius. Kaip šios analizės rezultatas, verslo modelio drobės yra sugeneruotos naudojimui įmonių, kurios nori pritaikyti „blockchain“ technologiją savo verslo modeliuose. Verslo modelio drobė parodo „blockchain“ poveikį kiekvienam verslo kūrimo blokui. Taip pat, buvo pastebėta, kad „blockchain“ paremtos informacijos įmonės gali turėti vaidmenį kuriant inovacijų tinklą, suteikdamos tarpininkavimo paslaugas ir būdamos pagrindiniu šios technologijos tiekėju. Beje, buvo paaiškinti dabartiniai „blockchain“ apsiribojimai ir iššūkiai „blockchain“ pritaikymo metu, taip pat buvo paminėta ir „blockchain“ ateitis, pagal apklaustųjų paaiškinimus.

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Introduction

At the last point where the cumulative knowledge of technology and humanity brought us, people's lifespan has been prolonged, and the variety of known diseases has increased. This change has led to an increase in the need for new treatment methods and new drug formulations. Also, the speed of changes has brought about the necessity of collaborative innovation work.

Today, when the business environment and literature are searched, it can be realized easily that especially the pharmaceutical industry uses an open innovation environment to respond to the needs of the health industry. In order to reduce the cost of R&D, reduce the time of launching new products, and use external information many collaborative projects are practiced. Using open innovation tools is not a new trend for the health industry, however, during this research, it is realized that there is a new actor, which is blockchain, that has emerged in the health environment through data collecting, storing, and sharing.

Although blockchain technology, a twenty-first-century innovation, has emerged with digital currency exchange platforms, it can be seen that its functionality is more than this with new developments in information and software technology. Blockchain technology can be defined as a new technological infrastructure of sharing knowledge among individuals and institutions.

When the existing usage of blockchain in the health industry is analyzed, it is noticed that some steps of health service and development of drugs or medical devices are changed. Some steps and intermediates have been eliminated in these processes. These changes affect the cost of both product development and service improvement. Also, it affects the capability of reaching correct and trusted information in a secure way.

The relevance of thesis research. Knowledge integrity is very important from the perspective of health providers, producers to provide effective and decent treatment and producing effective medicine. However, old information technology has limited capacity. Because of security, transparency, lack of merging ability of data, the used technology is not sufficient. However, blockchain technology looks promising with its architecture to fix these issues. Also, many pharmaceutical companies have already invested blockchain-based structure and companies, in order to use in their supply chain process, clinical trials, and collecting genomic data. Also, some new businesses have emerged, especially in the USA, which is related to storing personal health records. These companies basically provide an opportunity for individuals to manage their data. All these new things based on blockchain show that dynamics and trends in health led to be changed.

Thesis research problem. Today, communities' approach to the management of data's ownership, method of diseases' treatments, and innovation process in health face to change. In Literature, there are some research in this field base on the applied case and also many blockchain application's prototypes that propose to use in health. Also, some experts' predictions and visions exist. All these new things based on blockchain show that dynamics and trends in health led to be changed. This dissertation aims to answer the following question.

Research question: how the blockchain technology can increase innovation in health care?

Object of research: prediction of new business models in health.

Tasks implementing the research objective:

1. Defining the blockchain technology in health care
2. Analysis of blockchain technology application in health care innovation.
3. Developing case study methodology for investigation of health care innovation driven by blockchain.
4. Collecting empirical evidence in cases and providing comparative analysis of innovation.
5. Producing recommendation for implementation of blockchain technology in health care.

1. The importance of blockchain technology's impact on the changes of the health care industry

Innovation is one of the key drivers in order to gain leadership in the market for countries and institutions. In this age, the owner of knowledge and in parallel with this the owner of state-of-the-art technology gains a big advantage over competitors. Having this knowledge or competence is not only important to be a leader, but also important to increase the welfare of the community. Especially the innovation in health industry is essential for whole humanity. It affects directly to people's life span and quality.

In accordance with World Health Organization reports (2020), worldwide health expending raised each year in the period of 2000-2016. While the rate of growth of the global economy is 2.8%, growing in real terms at an average annual rate of 4.0%, faster than the global economy. Also, it can be seen on world bank data, the world population increased consistently from 1960 to 2018. (data.worldbank.org, 2019). The world's population is expected to increase by 2 billion persons in the next 30 years, from 7.7 billion currently to 9.7 billion in 2050, according to a new United Nations report -2019 (United Nations, 2020). One of the reasons for this population increase is prolonged life of people. Overall life expectancy is projected to increase from an estimated 73.7 years in 2018 to 74.7 years by 2023 (Allen, 2019). Therefore, it is observed that the number of diseases based on senility increases. Such as dementia currently impacts over 50 million people aged 60 and above globally. The number is expected to reach 82 million by 2030 and 152 million by 2050 (Allen, 2019). Moreover, people's changed lifestyle leads to diversity of illness and disease's frequency of incidence. These increases show that all innovation in the health industry which helps to minimize cost and increase efficiency in health care is essential to community welfare.

The benefits of health innovation are more than prolong people's life or improving life quality. For instance, the research on AIDS treatment in Africa indicates that new medicine brought along social and economic development in addition to health improvement. Together with this treatment, while the rate of going to school and the labor force participation rate increased, people's life quality was also increased. Some medicine like contraceptive pills has changed the rate of women's employment. Moreover, after the discovery of poliomyelitis' vaccine, extensive vaccination studies have been conducted worldwide against poliomyelitis, a childhood infectious disease, and the disease has been brought to the stage of destruction. (Sampat, 2019).

Health technology is very essential for society to provide the treatment of many diseases and preventive treatment. It is not just for individual health but also important for public health. However, a substantial part of society does not access to decent and affordable health care (Winter et al., 2019). Even in settled markets, after medicines are accepted for human health, getting a license for new medicines can take many years. Companies respond to collaboration all over the world in order to remove obstacles for healthcare availability. Many of them create programs in order to meet local

needs by providing illness education or make products affordable (Franz, 2017). Improved traditional models and new paradigms are very important to create a new product, reduce uncertainty, and create a sustainable initiative between the public and private sectors for health technologies. (Kaslow, 2019)

Especially the governments of developed countries are aware of the problems and it is seen that they started to change strategies. The USA started "***the precision medicine initiative***" in 2015. Also, The Council of European Union recognized the concepts in the same years, although the scientific and research activities started in 2010. However, in European Commission's website and some scientific documents, the same approach is called "***personalized medicine"*** (Nimmesgern et al., 2017). Precision medicine aims to correct treatment to people by taking account of differences which are emerged because of genes, environment, and lifestyles. Moreover, the aim is not limited to the cure of disease but also includes activities of taking precautions (The White House, 2020; European Commission, 2020).

Change in health care in order to solve today's and tomorrow's issues are not limited to precision medicine. New approaches are being shaped around patients and patients' data through digitalization.

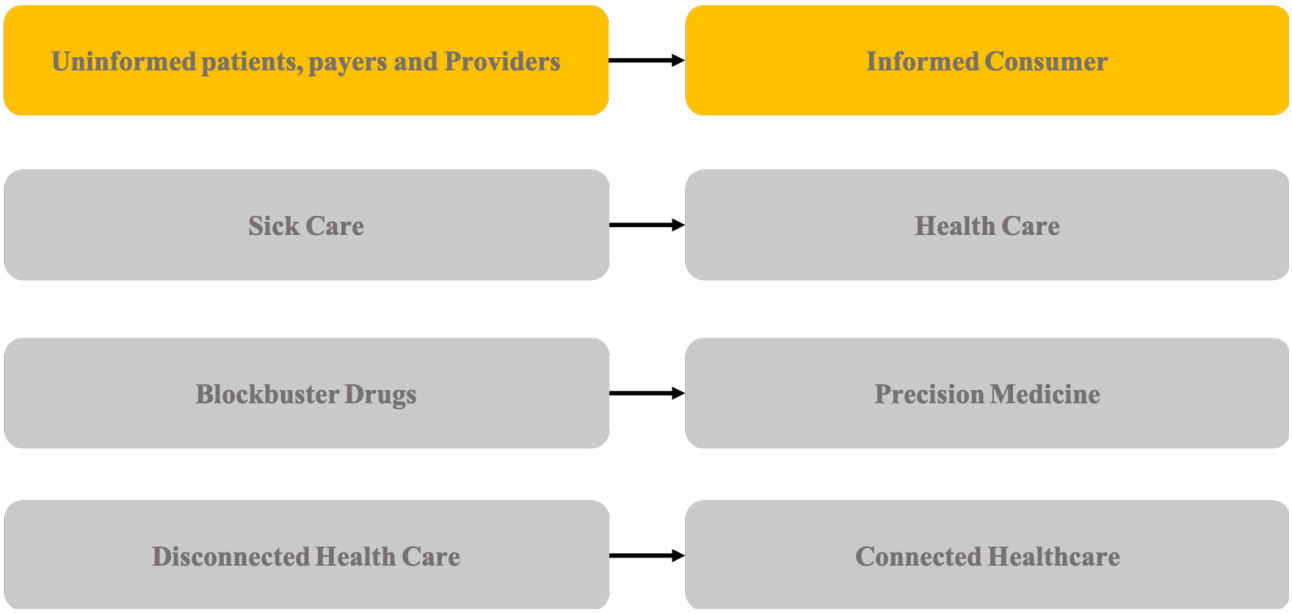

Figure 1. Shifts in health care in the effect of data power. Retrieved from EY (2018)

Together with all these changes, cumulative information in health care shifts the treatment from the focus of healing the disease because now It is known that preventive treatment can be developed by using phenotype' and genotype' information. Moreover, creating a connected environment in healthcare is targeted by enabling data exchanges among health care stakeholders. Thus, efficiency can be increased while the cost-minimizing (EY, 2018). As it can be seen that the very sensitive data is in the center of all this changing. It is hard to manage this kind of data in a very complex environment because of multi-stakeholders. Data should move among different stakeholders in order to gain connected health care. But also, these data should be protected from cyber-attacks, information manipulation, and information loss. In this sense, blockchain technology has started to

use in health care as information technology, especially in the USA. Blockchain technology has passed through development process until it is started to use in health care.

1.1.Definition of blockchain technology

Blockchain is a system that records and collect data. All transaction information among parties is recorded in a digital ledger as immutable data by using blocks. (Krawiec et al., 2016). Also, data is recorded as a tamper-proof. This data can be any assets such as bank account number, any written documents or musical note of a new song. Any item can be matched with a unique digital fingerprint and can be traced. Blockchain is created transaction rules and generates a protocol. Moreover, all computers in networks witness on transactions. Thus, if any computer loses the transaction's information, records never lost because other computers have the same information. (Waldman, 2018). A blockchain network can be configured as public, private or hybrid network. While public blockchain are open to any one, private blockchain require some invitation or security check. In order to understand how engine of blockchain works, cryptographic hashes should be analyzed. In simply terms, different cryptography is used in blockchain networks. While in normal symmetric key encryption only one private key is used to both encrypt and then decrypt a message, in blockchain unsymmetric key encryption,public key cryptography, is used.

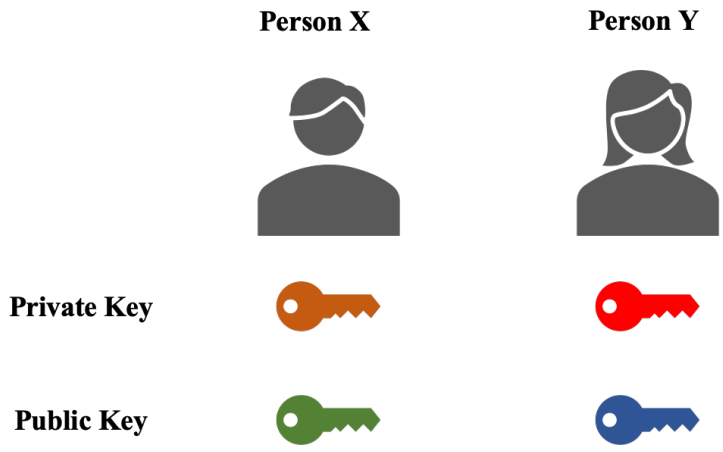

Figure 2. Key types of public key cryptography based on blockchain and healthcare, Udemy (2020)

Public key cryptography uses a pair of keys that are public and private keys. The public keys that can be broadly shared and the private key is that should be kept secret by the owner. The data is locked with the public key but can't be unlocked with the public key. Only the private key can unlock the data. The reason for this situation is Public key cryptographic systems rely on mathematical problems that are not easy to solve as discrete logarithms factorization or elliptical curves. Therefore the security provided by these systems depends on how hard it is to calculate the private key given. So, the security increase in parallel with the length and complexity of the private key's hash. The public key cryptography has two main uses encryption and authentication. So unlike Hasharon which is one-way transformation decryption is used for transforming data so that it can be restored later to its original form.. (Kuzmeskas, 2020) To clarify this process, the data transfer process can be explained with an example.

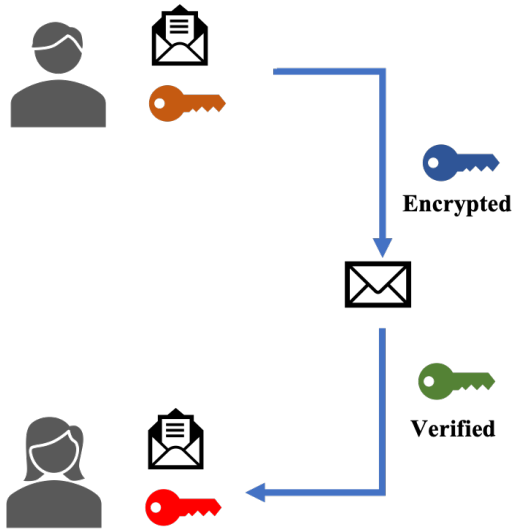

Figure 3. Process of sending message on blockchain based on Blockchain and Healthcare, Udemy (2020)

Person X can create a special digital signature by using own private key for sending a message to Person Y. After that, they used Person Y's public key to encrypt the message so that only Person Y can open this message. After that, Person Y uses Person X's public key to verify its digital signature. As the last step, Person Y then uses its private key to open the message and read the message. Thus, the message can be sent securely from Person X to Person Y.

1.2.Evolution of blockchain technology

Although the invention of blockchain technology is older, this technology made its mark with Bitcoin. After the publication of Satoshi Nakamoto's paper entitled "Bitcoin: A Peer-To-Peer Electronic Cash System" in 2008, an open-source program implementing the new protocol was released with the first blockchain, beginning with the Genesis block of 50 coins (Crosby et al., 2016). After Bitcoin, many alternative cryptocurrencies have been created. According to Coinmarketcap (2020), there are now 5.007 cryptocurrencies exchangeable on the market. However, cryptocurrency was just the beginning to understand the capacity of blockchain. In order to understanding improvements on blockchain technology, Swan (2015) break down into three categories blockchain technology revolutions: Blockchain 1.0, 2.0, and 3.0.

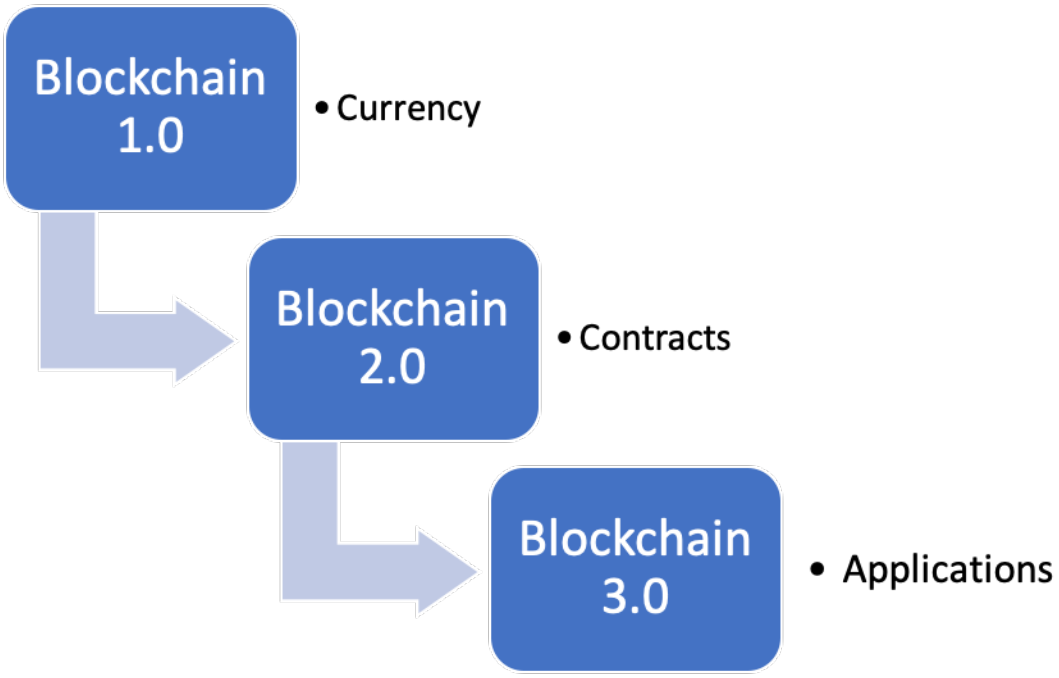

Figure 4. Revolution of blockchain, based on Swan (2015)

The first stage of blockchain technology is a payment system. Blockchain 1.0 applications are related to actions like money transfer, currency exchange, or money order. Blockchain 2.0 is more extensive. Applications of this stage include all financial activities that are selling and buying stocks, loans, bonds, and other negotiable instruments. Blockchain 3.0 is also related to other industries like health, science, music, etc. (Swan, 2015).

The journey of blockchain which is started with currency exchanges and transfers is evaluated to smart contracts steps in Blockchain 2.0. Basically, it was realized that by using blockchain, other assets can also be transferred with a decentralized system. Blockchain 2.0 emerged with Ethereum and smart contracts on blockchain in 2014. Differences between the two-stage of Blockchain are their consensus. While in the first stage is used Proof of Work, in the second stage is used Proof of Stake (Padmavathi & Rajagopalan, 2019). Differently from PoW, the PoS algorithms cause no waste of energy, because the algorithm demands no high computational effort. Importantly, a validator risks losing their deposit if the block they staked it on is rejected by the majority of validators. Conversely, validators earn a small reward, proportional to their deposit stake, for every proposed block that is accepted by the majority. Thus, PoS induces validators to act honestly and follow the consensus rules by a system of reward and punishment. (De Angelis et al., 2019) However, these previous versions have some limitations that are related to scalability, interoperability, sustainability, privacy, and governance. Therefore, these problems are addressed in the next generation, Blockchain 3.0 which is under development. Blockchain 3.0, whose underlying technology Directed Acyclic Graph (DAG) works according to a horizontal scheme whereas the previous on the vertical scheme. (Padmavathi & Rajagopalan, 2019).

Smart contracts

A smart contract is similar to a physical contract however it is on a digital platform and it applies automatically by computer. However, sometimes human interference can be necessary. It can be

implemented through legal execution of rights and necessities or executing computer code against tampering. (Clack et al., 2016)

Directed acyclic graph (DAG)

The key idea behind is that the previous transaction validates the succeeding transaction to achieve the consensus. The core innovation behind using a DAG is its ability to have zero-fee transactions. The Tangle, in particular, removes miners by making validation of transactions an intrinsic part of the ledger - making miners (nodes confirming transactions) and people sending transactions one and the same. The self-regulating Tangle Network only requires two confirmations per transaction. In doing so, much less computing power is needed, and thus, much less electricity. DAG doesn't need to link large blocks one after another in a long chain. Rather, it is building a graph of transactions. (Kairys, 2020)

It was seen that applications of blockchain in the health sector can cause changes in both newly developed products and business models because of blockchain's features. In the literature, although there are studies on the use of blockchain in health, studies on its impact on business models and innovation are limited. For this reason, in this thesis, it is aimed to observe how blockchain affects business models and innovation in the health sector through case studies and to produce a business model canvas that is shown the blockchain technology's effect on each business building blocks. Thus, the companies in health care can see what kind of value they can create in case that they adapt blockchain to their business. Also, as a result of these new business models, it was aimed to demonstrate how the blockchain can change or impact innovation environment.

2. Definition and dimensions of innovation and health care innovation ecosystem

There are several definitions of innovation in literature. Some researcher associates the definition of innovation with the process, the others associate with a new product or service. While Drucker (2015) defines innovation as "*the act that endows resources with a new capacity to create wealth*", Bessant and Tidd define as "*the process of translating ideas into useful new products, processes or services*". Kahn (2018) emphasizes that it should be well understood the innovation in order to make a better definition. According to the researcher, innovation is related to outcome, process and mindset because outcomes emerge from a process that is managed by a supportive mindset. All of these different perspectives emerge from different categorizations. More clearly, researchers define the innovation in accordance with the outcomes of the process or novelty level of outcomes. Innovation is categorized by Bessant and Tidd (2015) as product, process, paradigm and position innovation.

Product Innovation: it is any new improvement or new design which change the value, quality or performance of product or service.

Process Innovation: it can be any changes in producing or delivery process of the product. All improvement in managerial, business and organizational levels is assessed as process innovation.

Paradigm Innovation (Business Model Innovation): it is defined as improvement in mental models of business that can create social or commercial value. It can be thought as reshaping business model by simplifying or adding processes. The outcome of the process can lead to rooted changes in the sector.

Position Innovation (Marketing Innovation): it can be any action to change customer segments or customer perception of the existing products or services. This can be any change in the marketing process but also the creation of any channel to reach new customer segments. (Bessant & Tidd (2015); Kahn (2018); Rowley (2011)).

Many innovations are not referred to only one category of innovation, they are overlapped and integrated processes. Any changes are made in a product that is created value for consumers can change a specific business process or it can lead to changes in the value chain. In the literature, it is seen that these four innovation types are called in different names. Even though all these innovation types are slightly different from each other, it can be collected under these four main categories. Therefore, these different names can be shown by using Rowley et al. (2011)'s research.

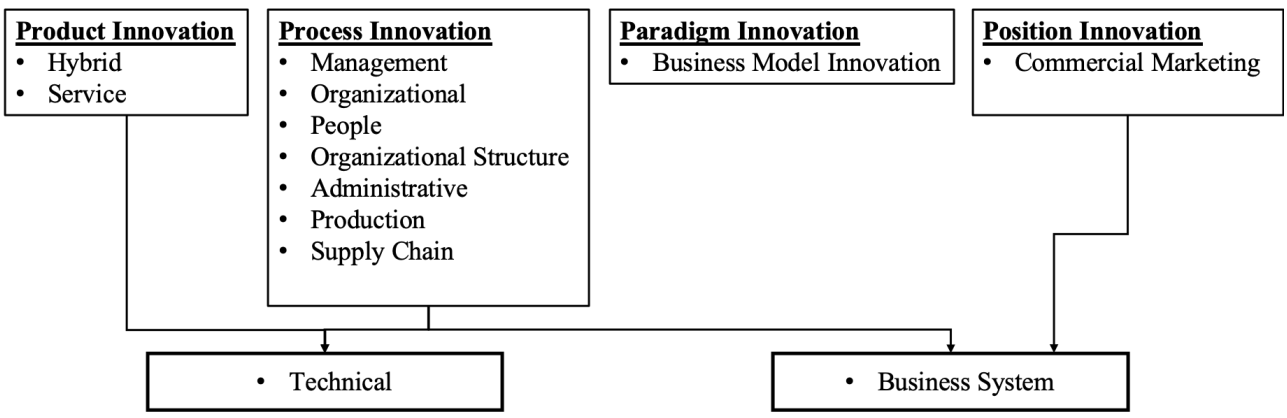

Figure 5. Types of innovation. Retrived from Rowley et al. (2011) and Kahn (2018)

As it is mentioned before, innovation is also categorized according to novelty level. While some innovation includes little changes to improve quality, speed of the process, the others can include changes in the total system, approaches, or design. As a result of that, two different innovation types have emerged from this categorization.

Radical Innovation is major and discontinuous change that is different from existing performed. It can be led to uncertainty in the market. Although it is mostly referred to as technological improvement, also can be shown as a new product, service, and process (Domínguez-Escrig et al., 2019; Popadiuka & Wei Choo 2006).

Incremental Innovation can be defined as a minor amendment in existing products or processes. It is a more common innovation because it is performed in order to fulfill the more distinct needs of consumers or organizations while radical innovation fulfills the partly hidden needs. (Domínguez-Escrig et al., 2019; Popadiuka & Wei Choo 2006).

Health care innovation

Health care innovation is not completely different from innovation in other industries. However, it differentiates in terms of core aim. In a health care innovation, it is addressed to improving the treatment process, increasing diagnosis accuracy, enhance social welfare, education and research in the short-term period while it is addressed to improving safety, efficiency and quality issues and reducing cost in long-term period. (Omachou & Einspruch, 2010). All investment in sustainable health care innovations makes possible to cope with the various disease by using cutting edge technologies and therapies. (Christensen et al., 2006). Today technology and innovation are shown as key drivers of the health care industry. However, health care innovation is beside of commercial issues, it is also essential for social welfare. When it is looked at from a broad perspective, any medical device which helps disabled people by providing easiness to moving enables these people's participation in employment and invigorates the economy. Moreover, even though health care innovation is not the only factor, it is in a relationship with the lifespan of people. It can affect the demographics of any country by increasing the lifespan of citizens, reducing infant mortality. Therefore, World Health Organization Health Innovation Group, which are composed of volunteers who want to promote innovation in health care, following the integrated innovation approaches. They consider social innovation applications as much as any other business and scientific innovations (WHO, 2020). In this study, it will be focused on business innovations part of health care.

Varkey et al. (2008) claim that three types of innovation are mostly seen in health care. They are product, process, and structural innovation. Although this statement is correct, it should be known that all types of innovation can be performed in health care industry. Some examples of health care innovation are provided.

Product Innovation: Needle-free injection technology is developed as a substitution for hypodermic syringes. This technology eliminates the risk of a wrong application by automatic inactivation system in order to protect patients and health providers. Another example is minimal invasive surgery. It can be also considered as a process innovation from medical perspective. However, this surgery is made possible by modern robotics technology. It reduces the recovery period and makes it possible also ambulatory surgery. (PharmaJet, 2020)

Process Innovation: Electronic health records are a digitalization process of patients' health data. It is not only changing the keeping health record process by moving data to the digital platform but also affect the hospitals' financial process. It helps the lean management process of hospitals by eliminating unnecessary workload. Telemedicine is also an example of process innovation. It enables to online consultation for patients and physicians inside of a physical conversation. (Varkey et al., 2008)

Paradigm Innovation: Subscription-based pop-up clinics models. It is an example of business model innovation (paradigm innovation). These types of models have emerged in the USA. Such as "Heartbeat", and "Kindbody" are clinics that are focused on the cardiology and on fertility, respectively. Clinics keep records of patients'(subscribers) health records on digital platforms. Models differentiate from hospitals in sense of fix-price strategy, subscription method and personalized service. (Shah , 2020)

Position Innovation: Contraceptive methods are one the good example of this innovation. When it is talked about contraceptive drugs, the target market is always considered as women. However, there are some studies it can be seen on the market. Indian Council of Medical Research claims that contraceptive injection for male is found and prepared for production (Lothian-McLean, 2020). Another example is adrenergic beta-blocking drugs that are produced in order to cure only two cardiovascular symptoms. They were started to use for more than twenty different symptoms as a result of clinical research. Thus, the target market for these drugs was extended. (Gelijns & Rosenberg, 1994)

In order to understand health care innovation's dynamics, this system's actors and their roles should be understood.

Healthcare innovation ecosystem

Healthcare ecosystems comprise multifarious players with a wide variety of interests, conflicting needs, priorities and influence. They were classified by Bessant et al., (2012) as follows:

- **Regulators:** Ministry of Health and other regulations' setter;
- **Providers:** doctors, nurses and other health professionals who provide care in different places;
- **Payers**: public and private insurance institutions, government agencies;
- **Suppliers:** pharmaceutical, and medical technology companies, scientific institutions, universities, pharmacies, and wholesalers, and
- **Patients:** beneficiaries of care and source of valuable knowledge.

All of these actors have different reasons and motivation to be part of these ecosystem. When it is talked about innovation in this ecosystem, Secundo et al. (2019) exemplified the motivation of each player as follow:

- **Regulators**: supply efficient services, costs reduction, guidelines monitoring;
- **Providers**: improving patient life conditions, reducing time of hospitalization, improving working conditions and efficiency;

- **Payers**: reducing costs, monitoring hospital efficiency;
- **Suppliers**: improve research activities, increase profits; and
- **Patients**: improving life conditions, reducing the time of hospitalization, finding new and more effective treatments.

Although all players have a direct or indirect role in the innovation process, in this study it will be focused on the suppliers' part. The main reason for this choice is that suppliers are the main innovation provider of this ecosystem. Suppliers part can also divide the three categories as producers, researchers and distributors.

Table 1. Categories of health care innovation's suppliers

Producers	**Researchers**	**Distributors**
Pharma Industry	Universities	Pharmacies
Biotechnology Industry	Scientific Intuitions	Wholesalers
Pharmacogenetics & Pharmacogenomics Industry		Purchasing Organization
Medical Device Industry		
IT Industry		

Even though all these industries have different dynamics in sense of trigger of innovation, the structure of business, level of internationalization, size of companies in the industry, risk level and length of the product development process, newness of the industry, they survive for common aim that is enhancing health care and gaining profit. In order to achieve these two basic main aims, they have made the innovation their focus point. Today, because of technology, unmet customer needs, and the necessity of a faster innovation process, these industries become more of a significance for each other. Collaboration and interaction are inevitable (Burns, 2012). The newly developed soft millirobot that delivers a sufficient amount of drug to directly the target cells in human-body can be a decent example of the necessity of this kind of collaboration among industries. (Lu et al., 2018) Because this kind of innovation corresponds to the nature of precision medicine, the number of these kinds of study will be increased in the future. Therefore, the collaboration between industries will increase or it will be seen some merging between them.

Moreover, it can be seen that other actors from different industries that are technology-based started to be part of this environment. Such as Apple, Google, Amazon, and Microsoft have got involved with health care industries by keeping and sharing consumer's health records with wearable device technologies. Recent developments show that they will not remain limited only wearable devices. Currently, Apple has started to sell diabetes products that connect with smartphones and some health applications in order to track glucose levels in the blood. According to the explanation of company's CEO, they will continue to develop more user-centric health products to take place in the medical device industry (Farr, 2020).

2.1. Relationships Among health innovation ecosystem industries in the sense of innovation and prevalent business models

Pharma and biotechnology industry

Pharma industry is a mature and chemistry-based industry while biotechnology industry is younger and based on protein chemistry, genetics, and cell biology. The collaboration between these two industries starts in parallel with launching the first biotechnology product in 1983, as a result of emerging genetic engineering (Gassmann et al., 2018;Burns, 2012). In order to understand this collaboration how effect each industry, history of them can be analyzed shortly. Before the second world war, the pharma industry did not have enough sources. All drugs were developed mostly based on natural and organic components. Moreover, the tests about the efficiency and safety of drugs were very limited. This lack of product and knowledge's gap was perceived after the war because many different diseases of which cure was not known emerged. As a result of that, pharma companies started to apply random screening method to find curative effects of natural chemical compounds. At the end of this research period, they gained huge data about the chemical compounds and their possible effects. Even though random screening is not an efficient method for today, it was played a significant role for laying the foundation of the pharma industry by filling the product and knowledge gap (Petrova, 2014). However, the lack of products, that are drugs and vaccines, was not solved. Therefore, innovation became key success factor in industry. Because there were a few effective drugs and many undiscovered treatments and disease, drug discovery was a very profitable market, especially after the patent protection. This period innovation drivers were high demand and unmet medical needs. An innovative drug was emerged very rarely; however, it was able reached very high sales record. Therefore, these blockbuster drugs that belong to major firms dominated market. Big Pharma companies gained significant amount profits during these processes. However, after patent expires “generic drugs”, that are imitation of blockbuster drugs, started producing by other companies. These companies used the price advantage as a marketing strategy. This price-cutting was not a problem for them because they did not spend for R&D investment. Novel drug decreased in the market. In the beginning of 1970s, "guided search" and "rational drug design" techniques that help monitoring and design compounds according to therapeutic effects emerged. Birth of biotechnology industry lead to some changes in the market. Biotechnology industry’s business model was based on three things which are commercializing of scientific discovery, venture capital and intellectual property right regime (Malerba & Orsenigo, 2015). Biotechnology firms became an opportunity for pharma companies in order to remove blockage in R&D pipeline. Today, biotechnology firms are considered as an innovation resource by pharma companies. Petrova (2014) formulated the relationship of pharma and biotech companies with “*the trifecta model of innovation”*.

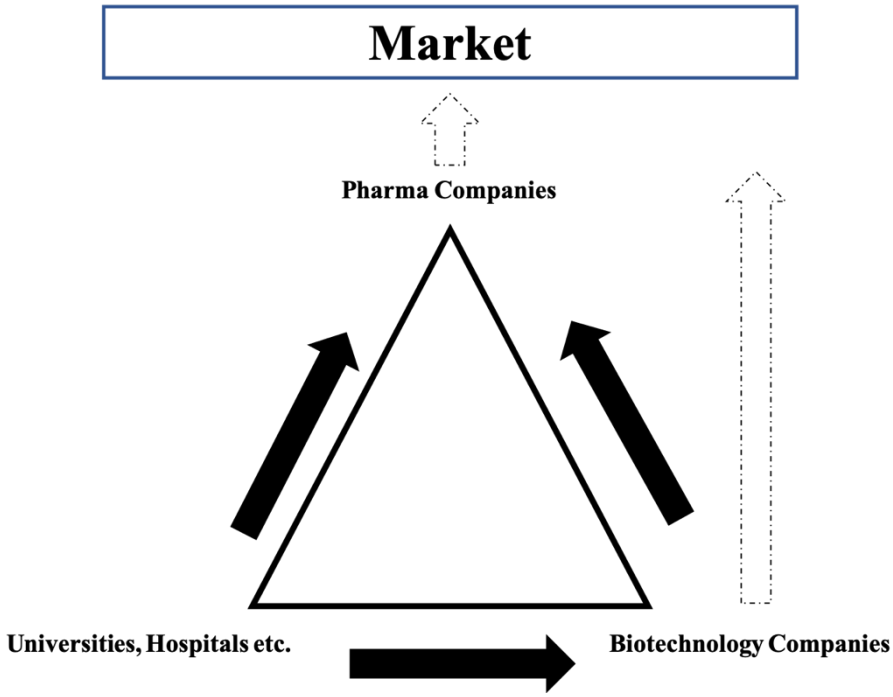

Figure 6. Innovation's trifecta model in pharma industry. Retrieved from Petrova (2014)

According to this model, the tasks are portioned out in accordance with institutions' capability and specialty. All parts can gain some benefits and contribute to the process. Universities, hospitals, etc. provide fundamental knowledge and regulate the maps of the development process in order to use in future innovation and research. Also, after product launch by collecting the information from the market they can contribute to the drug improvement process. While small biotechnology companies lead the development process by providing novel biomolecules and modern technology, big pharma companies bring their own experience to this collaboration in order to lead the commercialization process. This collaboration is defined as a "drug-centered" new business model by the author.

Pfeffer (2005) shows the importance of biotechnology companies in the innovation process for pharma companies by emphasizing the evolution of biotechnology companies' business models. Biotechnology companies' business models are categories as four different types based on intellectual property right management and dependency level to pharma companies. The first one is ***"fully integrated biopharmaceutical company"*** that is adopted by frontier biotechnology companies. In this model, companies prefer to build own value chain by themselves like any pharma company to develop blockbuster drug independently. Therefore, they need to huge investment. However, managing this investment and building a strong value chain was not easy and it was required experience. So, some of them achieved to be successful while others failed or became less successful. The Therefore, they need to huge investment. However, managing this investment and building a strong value chain was not easy and it was required experience. So, some of them achieved to be successful while others failed or became less successful. The second one is ***"technology platform model".*** The companies which are adopted this business model was built on different type technologies. Some genomics companies can be an example of this business model. In early times, these companies built their strategy based on selling their own technology. However, they could not be taken enough investment because technology oneself alone is not considered valuable and investors did not believe that it can be successful enough. However, some investors were discerned that these technologies can provide enough capability to small biotechnology companies to develop their own drugs. Therefore, today

many pharma companies or investors make an investment by choosing a biotechnology company according to companies' capability of developing drugs by using this technology. As a result of that, the companies who have the patent-protected drug are considered more promising. Another one is ***"royalty income pharmaceutical companies"***. These companies develop the drug until the preclinical or early clinical development stage. After that, they license the drug to big pharma companies in order to launch to the market. In return for the license, they take the royalty on the sales. The last one is ***"no research development only"***. This model can be considered as the opposite of the previous model because of the backward license selling. Small companies buy the license of big pharma companies' products that potential peak sales are expected no more than three hundred million dollars and completed the preclinical and clinical testing stages.

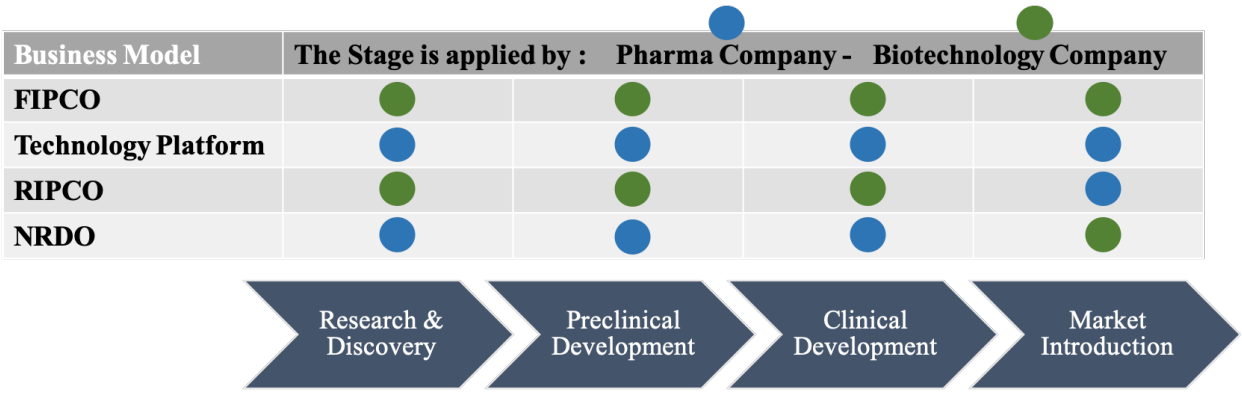

Figure 7. Innovation process of biotechnology industry's business models

Also, Segers (2017) collects the biotechnology companies' business models under two main categories as closed and open business models. All business models which are mentioned before are defined as close business models. According to the study on Biotechnology companies in Belgium, companies evolved their closed business models by using tools of open innovation that are strategic alliance on R&D development, joint venture, license exchange, open access and knowledge sharing. This evolution is based on the ground of three core activities of firms that are collaboration, knowledge management and process optimization. Making collaboration on the innovation process helps to share the risk, reducing to launching time of the product, open a way to reach knowledge. In order to knowledge management, there are three different basic models are defined that are the virtual R&D model, the repurposing and the technology brokering model. ***The virtual R&D model*** is based on network management, all value chain is emerged from outsourcing. Every member of the network brings the activity which is the best in order to drug development and reach the market. The success depends on alliances for access to knowledge, equipment, and market. In ***the repurposing model,*** a molecule that has already discovered for one therapeutic domain is used. Therefore, the discovery phase of drug is skipped, and the innovation process is started from the development process. Success depends on making a decent alliance in order to reach the market. ***The technology brokering model*** creates a connection between two firms, which are interested in a molecule in other firm's pipelines, and it manages this interaction. The core aim is not drug development, the aim is bringing together the two firms in order to drug development. When it is talked about process optimization, collaboration becomes again focused point however the aim of collaboration is the optimization of the value chain process from development to launch of the market (Sabatier et al. , 2010). The

companies usually merge these business models in accordance with the needs of their business process and in order to fulfill the gap in the market. The main aim is reducing the time and the cost of research and production by increasing the effectiveness of core activities. Accordingly, new business models that enable gain useful knowledge and technology in the market are created.

Medical device industry

Medical devices are defined by U.S Food and Drug Administration as any device (include components and accessory) which use in order to diagnose, treat, prevent disease or mitigate disease symptoms that in human or animal (FDA, 2020). Medical device industry is one of the essential actors of health care in sense of providing accessibility and affordability of health care. Different from other life science industries, the medical device sector is affected more from other industries. Innovation in this industry is related also, electronic, mechatronics and engineering solutions in the production industry. When the key success points are considered in this industry, it can be seen that knowledge transmission and collaboration are a source of innovation. The gold developments in the sector are shown in the figure below.

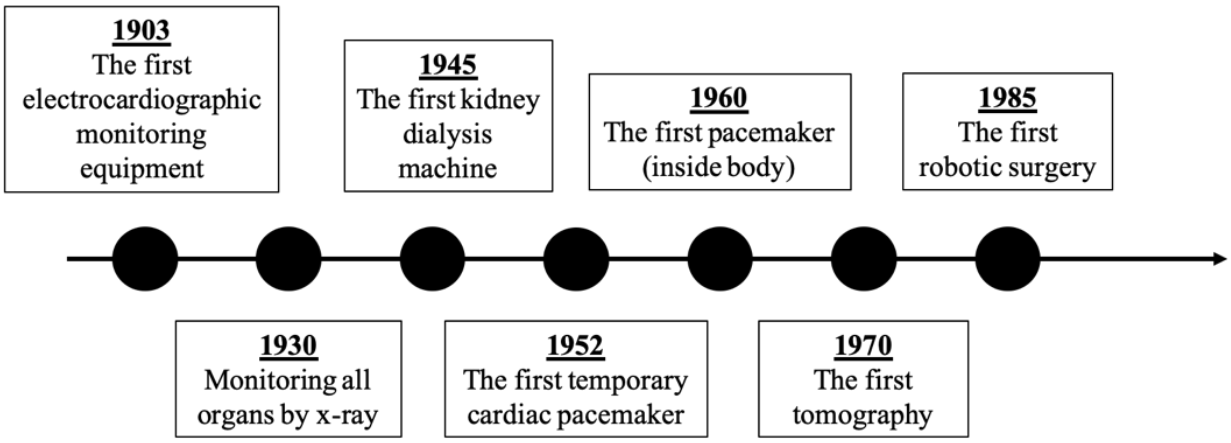

Figure 8. The golden innovations in medical device industry. Retrieved from Kiper (2018).

It can be seen that, while medical advances started to depend more on technologies in the forties, after the sixties, interdisciplinary period on device development started (Ed. Kiper, 2018). Technology has been always the key driver of this industry. When it comes to 2000s, many products are developed by using imported technology from other industries. When medical devices are analyzed that it can be said that, technology improvement in electronics, nanotechnology, robotics, software and material science are affected the medical device technology. This interaction is so strong that the recession in one of these sectors from time to time directly affects innovations in medical devices. For instance, the problem in morphogenetic proteins which is used for bone healing led to reducing in innovation rate through the orthopedic industry. Because of the nonexistence of alternative protein, in this period medical device companies plunged into a quest in order to gain novel biomaterials in spare of developing new products (Bayon et al., 2016). The triggers or barriers of medical device innovation are not only technology but also this industry's users (hospital, healthcare professionals, patients, etc), managers, financiers, and regulators. Users want to use modern and innovative devices because of prestige and a more effective cure. While Regulators want to protect public health by keeping standards, financiers of the system want to reduce the price. Consequently, producers should consider all these desires. Generally, a new product development process starts with discovery and identification step, and it finishes with product launched. After that, the product is monitored in the

market (Holmes et al., 2016). This process differentiates from other industries in sense of high standard requirements because of safety issues. All devices must fulfill some standards which are determined by the FDA and similar regulators. Therefore, the products pass many tests and produce from the most sensitive and quality materials. Moreover, some components of products in the development process should protect by patent to make possible work with the multi-sided environment. All of these procedures increase the cost of development while it also prolongs the time of development. Besides of this pecuniary fatigue for end-users, reimbursers, it also causes manufacturers to resist new technology because of uncertainty on success. After all effort, cost and time, producers cannot be sure whether the product will fulfill the clinical needs until the clinical trial (Bayon et al, 2016). Therefore, preclinical studies, needs analysis and clinical trials are important for medical device producers as much as pharma industries. All of the R&D processes should be managed strategically in order to be successful in the clinic.

In summary, the payment policy, which is common in the health sector, is also seen in the medical industry. In other words, the innovation users and financiers in the system are different actors. Therefore, while users expect modern, effective, and quality devices in order to increase effectiveness of treatment, financiers want to pay less. Due to this situation, innovation providers (medical device manufacturers) focus on cost and quality while they leave the tracking of patients' treatment process and effectiveness of cure to health providers (physicians, hospitals, etc.). Therefore, the business models are shaped around these focal points. When the dominant business models in this industry are considered, it is possible to divide the models into two main categories according to target users (customers) group. One group is health professionals and hospitals, the other is patients. In the business models which end users are patients, progress on products depend on patients' insight. According to patients' feedback, product is redesigned or developed. However, when the users become physicians, in order to develop products or determination of unmet needs, professionals'' insights gets importance (Yock et al., 2015). Today, health care environment start to become more connected with developments in health information technology. As a result of this, health providers are strengthed with clinical information. They can track the device or drug effectiveness, and they can use this information against financier and medical device companies to demand better products. For instance, they can prove that although using a lower quality implant solve the patients' problem in the short-term, additional medical intervention will be emerged in long-term because it is not fulfilled the patients' need. Thus, Insurance companies can be convinced to pay innovative devices, and medical device companies can find the motivation to develop new products. (Reh et al., 2016)

Developments in information technology, robotics and new competitors from other sectors push the medical device sector to expand its product portfolio. When the last trends are analyzed, more patient-centric products, smart devices, wearable and embedded devices which are connected with IoT are getting importance.

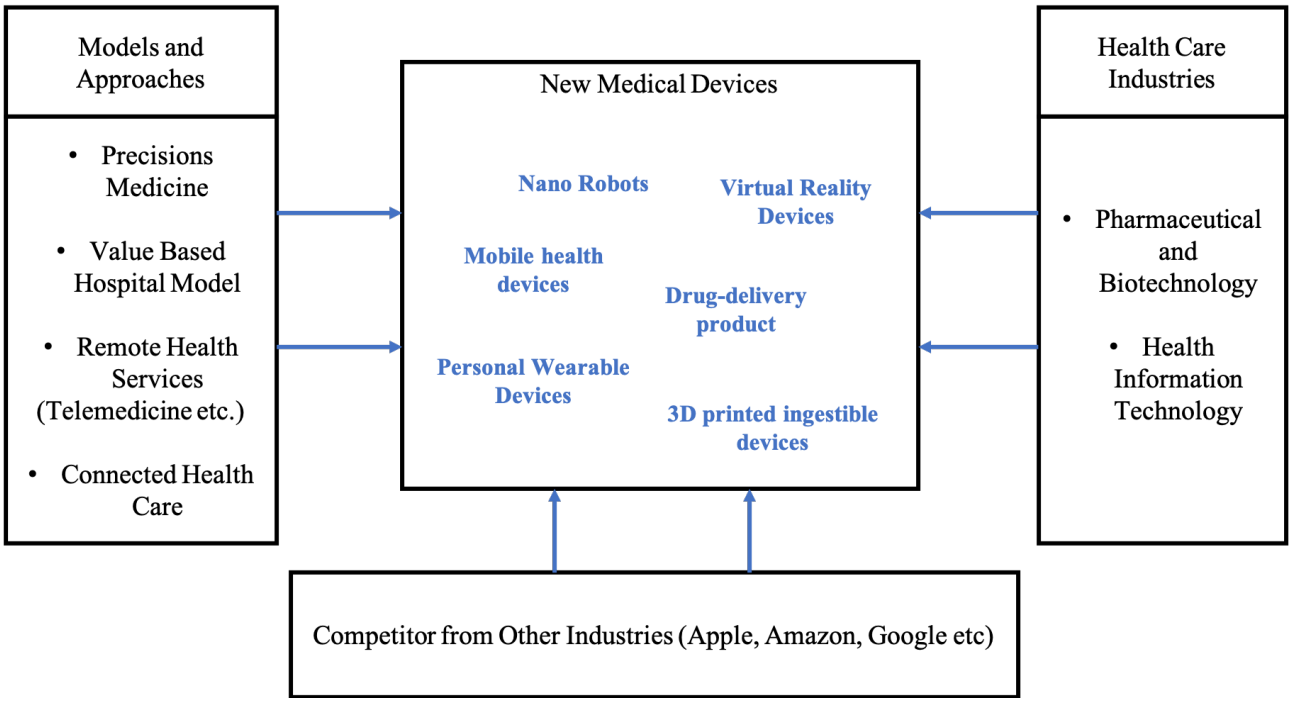

Figure 9. Tendencies of new medical device and the causers of this tendency

Companies use strategic partnerships, collaboration on R&D, or mergers and acquisitions to expand their portfolio. There are some examples are listed below.

Table 2. Medical device companies and other industries collaboration in new product development

Company	Industries	Product	Description	Tools
Enable Injections & GenenTech (Member of Roche Group)	Medical Device & Biotechnology	Wearable drug delivery	Aim: to develop a product which enables to inject subcutaneously drugs developed by Genentech without.	Strategic Partnership
Abbott & BigFoot	Health Care & Medical Device	Insulin delivery without manual intervention	Aim: to create a product which optimize insulin level and deliver to human body by using IoT connection and machine learning as a result of merging both companies' technology.	Strategic Partnership
Smith & Nephew & Tusker Medical	Medical Device & Medical Device	Ear tube delivery systems	Aim: Acquisitions company and its technology in order to expand portfolio	Mergers and Acquisitions
Omron Corporation & AliveCore	Medical Device & Health Information Technology	Remote patient monitoring Products	Aim: Create more accessible products for cardiac patients	Strategic Alliance

Even though R&D investment champion in health care is pharma industry and medical device industry looks less promising about the future in the sense of R&D spending, medical device industry

is considered more valuable for investing by investors. While in the last three years medical device industry shows a slight increase, also at the beginning of 2018 it shows bigger market capitalization growth more than other life science sectors. Professionals in medical device industries' have an optimistic perspective about growing and expanding portfolios by collaborations and investments (EY, 2019).

Healthcare information technology industry

Information Technology took part in health care like other industries. Health records that are kept on paper in the twenties were computerized in the sixties. Between the eighties and nineties, special software programs for health care was started to use in hospitals. However, these software programs did not enable information sharing among different departments or parties. In the 2000s, more extensive and advanced electronic health record systems (EHR) started using in hospitals (Brooks, 2020). Today, healthcare information technologies provide services not only hospitals but also many stakeholders include physicians, patients, insurance companies, medical devices and application developers, and drug providers, etc. Therefore, any developments in this industry affect all actors. As can be seen in previous examples that are given for other industries' innovation, almost all new drugs and devices are related to information technology because development process and business models are related data collections and interpretation of data.

The healthcare information system's role can be divided into two main categories as managing health records and managing hospital information.

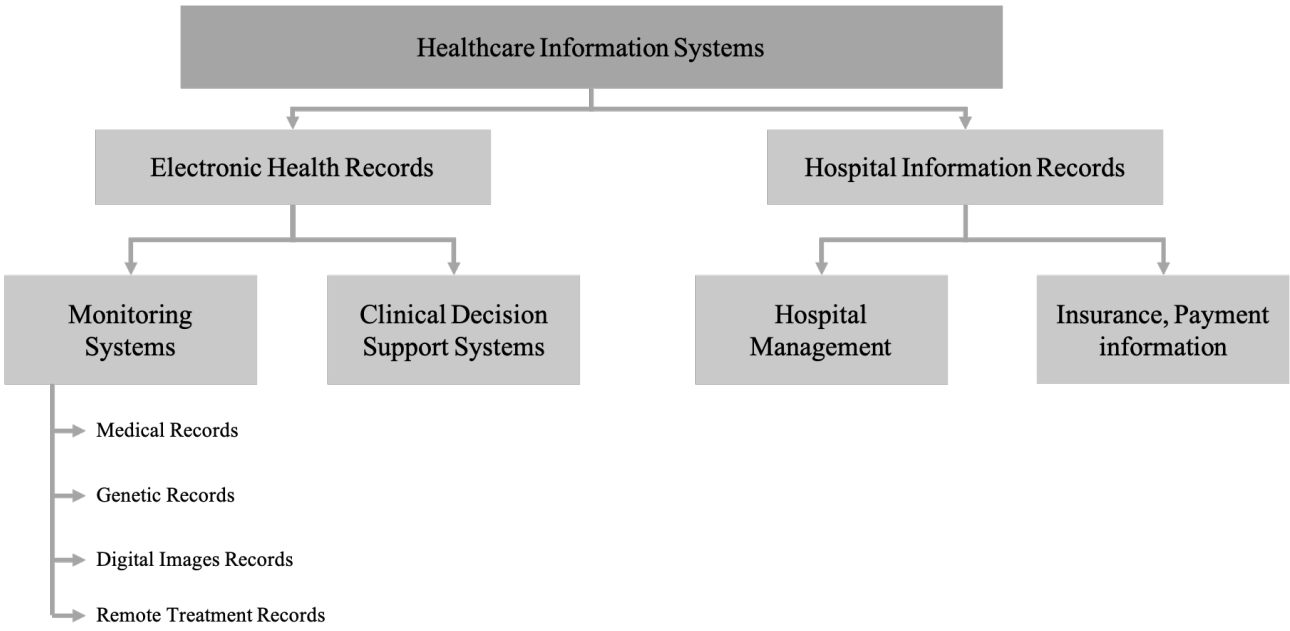

Figure 10. Applications of healthcare information systems. Retrieved from Ahlan & Ahmad (2014) and Goldsmith, (2005)

Hospital information records systems provide data for managing the business of hospitals and taking reimbursement from insurance companies. Therefore, they are related to the business management and finance part. On the other side, electronic health records systems are related to the patients' health conditions. This system also can be divided into two categories as monitoring systems and clinical

decision support systems (Ahlan & Ahmad, 2014; Goldsmith, 2005). Monitoring systems enable collecting and reading the patients' data for health providers while decision support systems by using these data help the physician to diagnose disease and apply convenient treatment. Systems perform as a reminder or assistant for doctors. For example, it prevents the wrong treatment by reminding the patient's allergic reaction to the ingredients of the medicine. (Agha, 2014).

Because the shift in health care to value-based business models, and connected health is related to a patient-centric approach, the system provides patients the right to read and managed own data. That is why, while previously health IT companies' customer groups consisted of hospitals, private clinics, and insurance companies, they have started to add the patients to their customers' groups. Moreover, software and data storages, interface architectures (such as using clouds, blockchain) reshapes according to meet the needs of all patients and healthcare innovation providers. (Streicher et al., 2020)

2.2. Summary of relationship among industries

It can be concluded that making effort alone for each industry in health care is getting difficult in order to overcome the bottleneck in innovation or generate a solution for meeting the market needs. When the historical order is followed, it can be seen that the connectivity in health care increases by collaboration among industries, license exchange, adaptation of technology that has emerged from different industries. Even it can be seen that the dependence to the pharma industry for the process from product development to launching market affects the business models in the biotechnology industry.

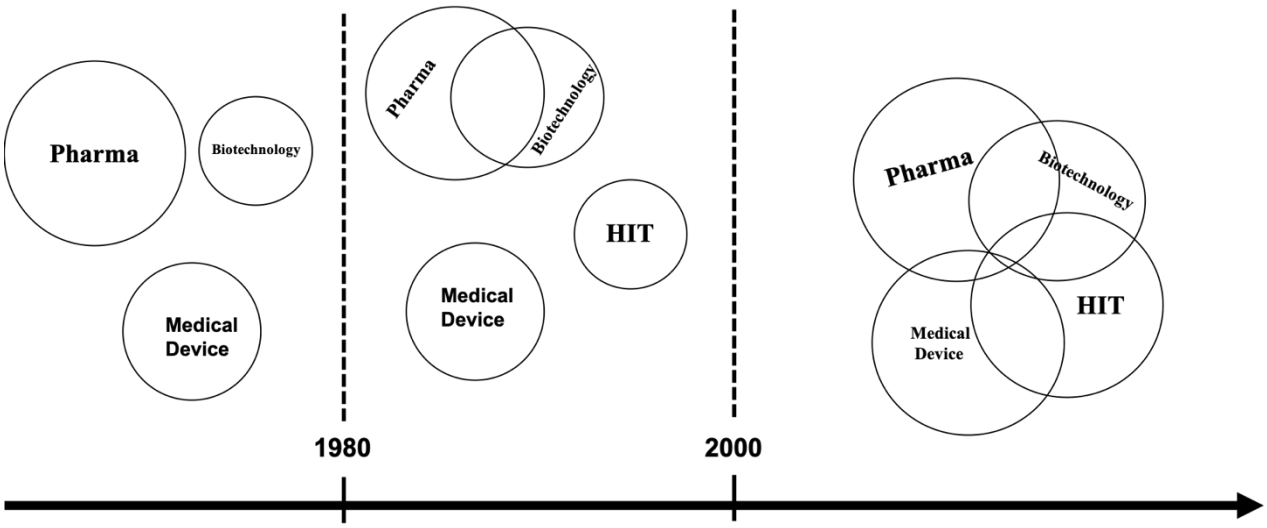

Figure 11. The relationship among health care industries

In the beginning, while each industry produces solutions to the problems of the health sector alone, this approach is replaced by the approach of producing solutions together with the problems. Nonetheless, this does not mean that firms or sectors have stopped producing individual solutions. When the novel products and research in health care are considered, it can be expected increases in interactions among industries in the sense of collaboration. Especially, the new approaches that are precision medicine and value-based healthcare, will influence products, product trends and business models. Because these approaches are related to emplace the patients, that are empowered with data,

into the center of the health system and also collect and use these data in order to generate more effective, more personal and cheaper service.

As it is explained previously, the relationship between the pharma and biotechnology industry is developed mostly by mergers and acquisitions, license exchange, while in the medical device industry is developed mostly by strategic alliance and partnership. Until these days, health information companies (HIT) only have provided their service as a seller. That means the relationship among HIT companies and other health care companies has been business to business customer and consumer relationships. However, after the shift in the health care environment to the precious medicine approach, these relationships can be changed. Frankly, today in health care, each producer has to create their own data in order to make market analysis after launched the product, gather clinical trials, analyzing the needs of the market. It follows that they create different data sets in different places. Moreover, some companies make an effort for the same issues, but they cannot be informed about each other's process. Consequently, they can miss the opportunity of collaboration. In this sense, the role of health information technology can be bigger than the previous in order to gather all industries. The novel products and services in health care are analyzed that it can be seen that there is a trend to remote medical treatment. This shows that the demand for products that can be used for remote medical treatment can be increased. Also, this can trigger collaboration among these health care industries. However, when the healthcare information industry is analyzed that it has not been seen any promising software or technology that can generate big data that can use for this kind of holistic approach until the blockchain is started to use. Therefore, in this thesis, it will be tried to answer if the blockchain can be used as a tool which increases the collaboration among industries and how it can bring these industries together in order to innovate. For this reason, the applications of blockchain in health care will be analyzed in the next part.

3. Applications of blockchain technology in health care ecosystems

Blockchain technology has started to use in healthcare for electronic health records, public health, education, health insurance, and procurement policies, biomedical research, and drug supply chain management and quality control. As a result of these applications companies' business models change. Therefore, understanding these applications' similarities, differences, and aims are essential. The studies which are related to these applications are analyzed in order. As a result of this part, it is aimed to see the factors of blockchain that can cause possible changes in the health industries' business models and innovation environment by blockchain applications.

Applications in electronic health records (EHR)

Generally, it can be mentioned about two types of health records. One of them is kept by governments or public health organizations in order to track public health and get actions in urgent situations. The other is kept by different hospitals, private clinics, and laboratories in order to track patients' healing process, provide information about patients to doctors to diagnose. Both of these records cannot solve the problem in health care because of inflexibility. This inflexibility generates because of recording methods. First of all, most public health record systems do not keep the patient record individually, instead of this, data are recorded anonymously. Therefore, it is not possible the tracking patients individually. The reason for choosing this kind of information system is the cost of keeping data at the individual level and the complexity of the system which enables the record of individual data.

(World Health Organization, 2012). Secondly, the records which are collecting by hospitals, private clinics, and laboratories are kept in different data sets. Also, these data sets are not brought together in order to create an open system. Therefore, from the health professionals' perspective, it makes difficult to follow patients' improvement or learning more information about previous complications. Especially, in countries, which do not have a central health record system, like the USA this situation can be more complicated. When we look at the USA, because of the lack of any governmental or central health information system, patients' records stored in different databases. Also, each institution has its own database and they do not share this data with patients. As a result of that, patients do not have any access to own record, and they lose their health history in time. Moreover, if they need to change any hospital, they have to repeat all previous tests which are made for diagnosis. This leads to additional costs for patients or insurance companies, also it is time-consuming steps. (Ekblaw et al. ,2016)

Today, patients' health records can be stored in one database which provides access to many different participants that are hospitals, insurance companies, and other healthcare-related institutions by using blockchain technology. While this kind of database can enable patients to manage their own data, also it enables healthcare professionals to reach patients' fool-proof health data notwithstanding from time and place to perform better service and diagnosis. (Radanović & Likić, 2018). In the literature, we can see many examples of blockchain-based EHR systems and prototypes. MedRec prototype is one of them. MedRec manages health recording system without independently by using smart contracts of Ethereum. It ensures patients monitor own records, while it enables health providers to monitor the treatment process (Ekblaw et al., 2016). Researchers emphasize that this system enables secure data sharing among parties, at the same time the system enables researchers to collect anonymous medical treatment outcomes' data in order to research purposes.

Another example is Med-DLattice, which consists of a permissioned blockchain and a public blockchain, to serve the management of users' personal health information. In this blockchain patients' raw health data is collected and stored in permissioned blockchain and regularly this data is transferred to the public blockchain. Thus, data is protected from any cyber-attack. Like other blockchain networks, it has specialties of transparency, decentralization, tamper-resistance. Moreover, it shows low latency and high throughput. However, the system has also some limitations. Researchers realized after the first implementation in case of the great quantity of data, data query does not work efficiently. Also, in case of a desire to cancel permission, the system does not support to take back permission. (Zhou, Li, & Zhao, 2019)

Yang and Li (2018) present a private (or permission) blockchain-based architecture that can implement on the current electronic health record (EHR) system. The main problem which led to making this research is individuals' data is collected in different services providers' database therefore providers cannot have a comprehensive overview of all the records of a single user. Because the main problem can be solved also with a less complicated system, researchers think that other mechanisms can be considered for further deployments. And they believe that this heuristic architecture is independent of any specific blockchain platforms, and its variations can potentially fit other similar multiple access electronic records systems (Yang & Li, 2018).

If each blockchain architecture is compared with others, the differences will be seen. The reason of this is that each chain is designed in accordance with the aim of use. Nonetheless, possible

opportunities or challenges can be generalized in order to figure out the effects of blockchain in health system and health care by analyzing the existing models in the literature.

Applications in wearables & embedded devices' technologies

Wearable devices make it possible to collect some real-time health data such as blood pressure, heartbeats, body temperature, etc. For this reason, this innovation is found promising for tracking the course of many diseases. Because this kind of technology offers an opportunity to monitor patients without interference in their life. In other words, this device helps to collect patients' life-sustaining data while it also helps to collect environment data. Thus, the relationship between these data can be analyzed and especially it helps to observe the process of some chronic illness. However, an obstacle, which decelerates the improvement in this direction, should not be forgotten. It is the sensitivity of health data. During the data are shared with any database or network, individuals' right to privacy should be protected. Therefore, the demand for the system, which is protected individuals and also allows to share data, is emerged. (Al Jawarneh et al. , 2019) When the literature is investigated, it can be seen that many researchers emphasized the importance of security and privacy. Therefore, blockchain-based systems are offered as a solution to this issue. This systems' basic working principle can be explained in this way. Wearable devices transform individuals' health information into an understandable format for people after collecting the data and then the data is moved to a private online account. Each account is matched with several wearable devices, so personal health records can generate from different data which is collected by several devices. When health data is generated, it sends to blockchain network in order to store (Liang et al. , 2018).

Brogan et al., in their paper, focuses on transferring data that is collected by wearable devices to a distributed ledger. As a result of their research, they think that using blockchain technology can be a method that is safe and effective for managing data while bringing into health care services to the digital platform. According to Deloitte and EY reports and also literature, wearable and embedded device technology have not shown their capacity yet. It is believed that this technology is at the early age, but also it will rise swiftly. Especially, when the world population distributions are considered, the requirement for these kinds of technology increases because of the old-age population and geriatric diseases. Within this context, this kind of device can be useful for managing the disease process which is related to old age such as Alzheimer's, Dementia, and Parkinson. The patients suffered from these diseases need to closely observation. By using these devices, many data can be collected without interfering in patients' environment in order to provide precision medicine, increasing knowledge about the disease, and tracking disease progression. This information can also be used for the research and development process depending on patients' permission. (Al Jawarneh et al., 2019).

Applications in clinical trials

A clinical trial is an experiment designed to answer specific questions about possible new treatments or new ways of using existing (known) treatments. The aim of clinical trials is to ensure the sufficiency of drugs' and treatments' properties. They should be safe for human health and also effective to cure. This process is a very long journey taken years. (University of Virginia, 2020) The reason of clinical trials' complexity is that the main data is generated from many data sources. This also increases the cost of multi-zone clinical trials (Choudhury et al., 2019). A clinical network arises from many participants. Therefore, huge data sharing and flowing of information are an essential part

of this process. All of this data is very sensitive and secret. However, during the data transfer, some man-made mistakes can be made. (Wong, Bhattacharya, & Butte, 2019). To promote the integrity of the many-sided study, it is obligatory to assure the quality of data in the frame of standard procedure and human subject regulations. Therefore, designing a structure which enables to sharing and collecting data in trusted, secure and efficient with performing legal obligation is more important than ever (Choudhury et al., 2019). So, many researchers propose blockchain technology to use in clinical trials in their study. Kendzierskyj and Jahankhani (2019) explain that using blockchain in clinical trials has some benefits as follow:

- Chronological order – the transactions can be recorded in accordance with time order
- Data integrity – while data from different sources are merged data falsification minimized
- Traceability – transactions are recorded with the timestamp to avoid changing data and provide credibility

Another benefit of blockchain technology in the case of using in clinical trials is that it enables the elimination of intermediaries by moving data to a decentralized network. Also, they mention the accessibility of clinical trials' data from the point of patients. Today, when patients participate in a clinical trial, mostly they do not have any access to results. This access depends on the sponsor's decision. By using this technology, the result can share patients securely and this strategy can be an attraction to motivate more patients for participating in clinical trials. The data can be collected from patients anonymously depending on patients' permission. Also, patients can monitor their results. In this way, all parties can get benefits and work in great collaboration. It can be a very effective way that is designed to create a patient-centric approach. (Mackey et al., 2019)

Applications in medicines supply

Supply network should be sensitive for data and should be organized according to demand. Therefore, access to different databases and merging these databases to analyze and planning can be a requirement. In order to achieve this analysis and merging, electronic supply networks' technologies are used. These technologies can lead to some changes in the value chain by creating new capabilities and value in conjunction with improving the supply process (Nowicka, 2019). One of these technologies is blockchain. Applications of blockchain technology in supply chain are quite new in a sense of scientific studies. This topic started being appeared in Web of Science and Scopus databases in 2016.

Jamil et al. (2019) propose a system architecture for drug supply chain management through a scenario. The working principle of the system, based on blockchain, shows on the following figure.

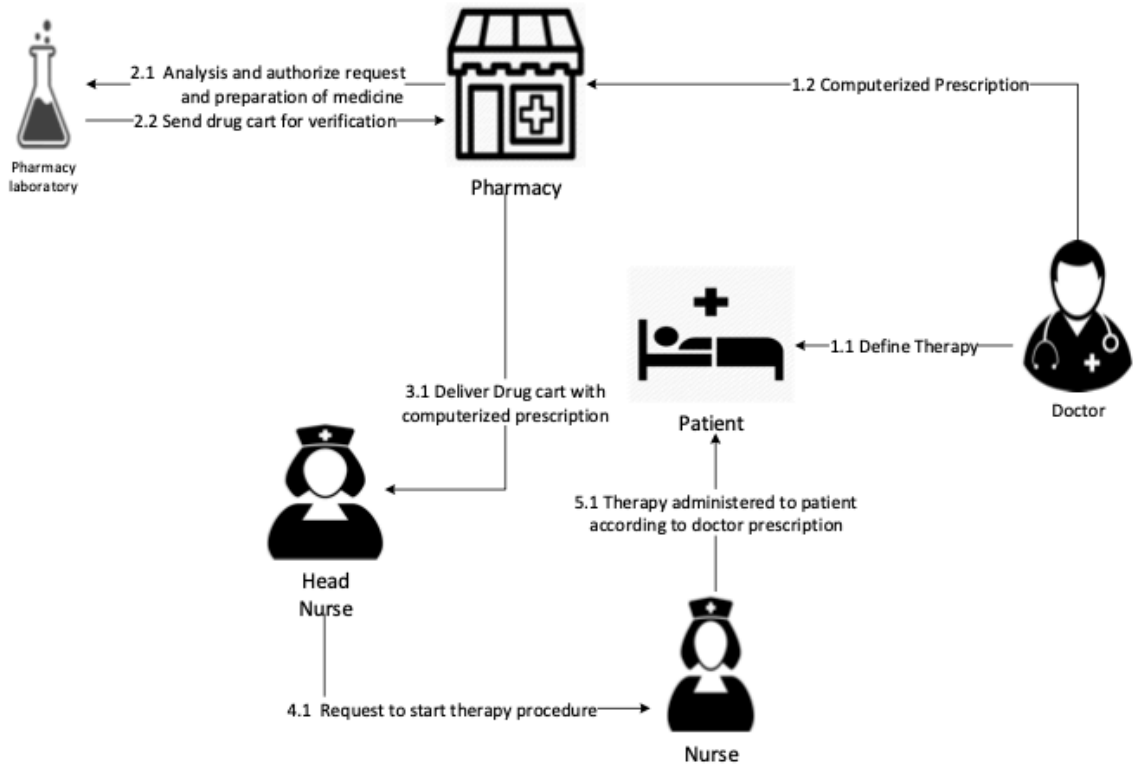

Figure 12. The proposed medicine supply chain management. Retrieved from Jamil et al. (2019).

Initially, the physician prepares an electronic prescription, which includes the dose of medicine, name etc., after diagnosis. This prescription is sent to pharmacist. After cross verification, while the pharmacist sends prepared drugs physically, prescription is sent to the head nurse to start the procedure and also send to an employee who accounts for the material management. After that therapy applies to the patient in accordance with prescription. Also, updating drug life cycle at individual level is the responsibility of the nurse. All this transaction which is related to prescription and stock level of drug is made on the blockchain network. This system enables to sharing medical records and also managing drug stocks in hospital. The result demonstrates that this system helps to minimize source consumption and increase performance in a sense of productivity. (Jamil et al., 2019)

Schöner et al. (2017) introduce LifeCrypter which is the prototype blockchain-based solution of the global drug supply chain. In LifeCrypter, each medicine is tagged with a distinct label, which enables to transfer of ownership by using smart contracts on blockchain from suppliers to customers. Thus, delivery of ownership can be made on a trusted network. Thus, all item in the supply chain can be followed by using an app which is the frontend of blockchain. While this solution enables patients to independently verify products, pharmaceutical supply chain stakeholders are enabled to considerably increase their efficiency during the process of distributing verifiable drugs all over the world.

Peltoniemi and Jarkko (2019), in their research, evaluate existing blockchain model in the area which is related to plasma and they adapt this model to the plasma supply chain to solve existing problems in the plasma supply chain. By using this model, each donation can be traced until delivered to the donee. When the delivery progresses in the supply chain, each step is recorded in the blockchain complemented with other relevant information. Supply chain parties can access the blockchain

through their nodes and enquire the origin of the delivery and individual donations while maintaining a high level of privacy. Blockchain's main role here would be to verify logistics transactions and provide immutable ledger, which prevents attempts to tamper any origin information or inject falsified plasma to patients. Moreover, the shipping condition of plasma can be followed. As a result of this, it would be realized that if there are any suboptimal conditions across the shipping chain that may cause defects in the plasma. Additionally, from an ethical perspective, blockchain could be used to implement a decentralized donor registry, which would enable the monitoring of donations and prevent too frequent donations. This would discourage unethical patterns, whereby addicts or otherwise distressed individuals would be exploited through frequent donations that would jeopardize their health.

Applications in biomedical database

The rapid progress of next-generation sequencing and genome editing has significantly decreased the cost of single genome-wide testing. While this technique can use in only contemporary laboratory, some hospitals, and institutions, applications of gene sequencing have leaped forward globally. This improvement shows parallel progression with the medical innovation and precision medicine approach. Genomic research applies in order to predict chronic disease by analyzing individual's genetic structure. Following that the results of the research are used in order to develop a drug. (Jin et al., 2019) In these researches, the main issue is how can be stored, collected and shared data which is so valuable. The privacy right of individuals who share genomic information should be protected (Ozercan et al., 2018) In this sense, blockchain-based platforms are shown as a solution to this issue. In respect to privacy, it is aimed at sharing and collecting people's biological samples in legal and ethical frameworks. Despite these platforms' maturity levels are low, it is considered useful for genomic studies. Blockchain enables the automation of data management and improves transparency and fairness in genomic data access (Shabani, 2019).

Today, there are some companies which collect genomic data based on blockchain technology. One of them is 23andme, which has the largest re-contactable research database of genotypic and phenotypic information in the world. They have sold more than 10 million DNA kits for analyzing people genomic's data and 80% of customers consent to attend research (23andMe, 2020). Since the launching, for the first time the firm has licensed a drug, it developed using that genetic information. 23andMe signed an agreement to allow the Spanish pharmaceutical company Almirall to further develop and commercialize the drug, which is designed to block certain small proteins associated with a variety of inflammatory diseases, including skin conditions and Crohn's disease (Mullin, 2020). Another example is Shivom. Their platform helps pharmaceutical companies gain access to DNA data for research, all the while incentivizing and protecting patient confidentiality. (Shivom, 2020)

3.1. Opportunities and challenges of applications of blockchain in health care

Blockchain technology helps to create immutable and undeletable data. Blockchain offers audit trails which is documentation of the events related to the creation, modification, and deletion of electronic records. That means although any information changes or delete, the record of this change is kept in the chain. Thus, it provides transparency. (Kshetri, 2018). There is not a central authority to grant authorization or manage to transactions. In contrast, each user of the network can be monitored every transaction on the blockchain. Each transaction is connected to the previous one and it has a

timestamp. Thus, data on the network can be protected from manipulation. However, changing any data is not impossible. Therefore, it does not provide a hundred percent protection. (Pirtle & Ehrenfeld, 2018). It is impossible to say that blockchain technology is a hundred percent secure, especially when it is known that blockchain technology has not able to reach real potential yet. However, it is thought to be more secure than most other current systems (Kshetri, 2018).

In spite of being protected by legislation, the patients are the least powerful players in the health care environment. Even they do not have any access to their own records. However, this data should be available for patients because in some situations, patients' disease or treatment history can clarify the current illness reasons and it can be used to diagnose. Therefore, some platforms should be created to keep health records. (Gutierrez et al., 2018) But also, the data in these platforms should not be changed by any actors because health providers have to trust also all data which belongs to patients. In this sense, patients' control over data can be limited by using blockchain, patients can monitor and share own data, but they cannot change it. On the other hand, reaching trustworthy, immutable, and accurate data is important not only for patients and physicians but also for insurance companies. It is seen in Mohan and Praveen's (2019) study, the absence of reliable information and documentation system can lead to false pretenses on data. In the insurance industry fraud could be made by any person which is related to the business, employee, and policyholder collude. Common medical insurance frauds are due to the following reasons:

- False pretenses prepared by doctors
- Wrong medical conditions that are indicated
- Identity fraud
- Billing treatment that does not happen
- Documentation fraud
- Over billing.

When the blockchain technology's structure is considered in a sense of transparency and immutability, it can be a solution. Therefore, using blockchain to reduce insurance frauds look promising.

Although, these benefits of blockchain, there are some challenges and limitations that exist. They can be categorized over three main perspectives; technical, regulations, mindset and ability to manage data individually. As it is mentioned before, it cannot be said that blockchain technology is completely secured from cyberattacks. Blockchain is defenseless to a cyberattack that is called fifty-one percent or hash rate. The aim of this attack is to take possession of a very big amount of networks' mining power. Frankly, if this kind of attack became successful, some of the blocks in a network can be changed by the attacker. However, it should be known that this is not easy because this kind of attack needs enormous resources (FXCM, 2020). Another technical issue is interoperability, to have blockchains from different providers and services seamlessly talk to each other as appropriate (Kamel Boulos et al., 2018). Every provider uses its own record system and collects data in accordance with their own way. Therefore, merging all these data can be an issue for the system’s developers. Except technical issues the mentality of healthcare providers also can generate a challenge. Many health institutions are the only owner of all patients' data, they do not want to share information with competitors. This mentality should be changed in order to meet market needs. Also, the all-ages group

in society does not have the ability to manage own health data. Some of them cannot achieve because of their current diseases while some of them cannot do because they do not reach the age of the legal majority. (Kshetri, 2018). At this point, society is faced with a lack of law, legislation about this situation. Today, in many countries, the right to the property about own medical records is not clear on the law. For example, in the USA, patients have the right to privacy patients have legal privacy, security and accuracy rights related to own health data and this right is protected via federal and state law. Nonetheless, if this data is collected by a health provider in its database. Because this health provider is the owner of the database, the legislation gives the right to providers the right to keeping this record. In this sense, the health provider becomes responsible for protecting your data. Moreover, patients' medical records are considered as doctors or other health professionals' medical opinions. Therefore, it can be considered as a physician property according to intellectual property law. (Sharma, 2018).

The summary of blockchain application in health care

All applications of blockchain in health care have a common aim, collecting data securely. In addition to this aim, each application field has different aims in accordance with target result. The aim of using blockchain to create biomedical databases and clinical trials is to develop drugs while the aim of using blockchain for electronic health records and wearable devices create individuals' health history. On the other hand, using the medicines supply has a completely different aim, which is to track each product (such as drug or donated organs) in the chain. Therefore, the importance level of blockchain's features changes in accordance with cases. Additionally, using the blockchain can generate invisible opportunities for health care. One of them is generating data pools. Sometimes, this can be the main aim of using blockchain-like in biomedical database applications. However, it not the main aim of wearable devices and electronic health records. Although this additional benefit looks like a fringe benefit for health care, the blockchain-based healthcare technology companies have already realized this opportunity. When these companies' business planed are analyzed, it can be seen that they are planning to use these pools for research purposes in some way.

In this thesis, it will be tried to find the answer to whether these pools can be used for researchers. Also, it will be tried to find the answer to whether the firms which use blockchain technology especially for electronic health records can be intermediary for creating network innovation. Thus, It can be figured out how the blockchain technology is used for business model innovation and how these business models can affect the innovation in health care.

Table 3. Aim of blockchain applications in health care and features of blockchain

Application	Main Aims	Important Features of Blockchain	Capacity to Create Data Pool for Research
Biomedical Database	• Collecting genetic data • Sharing results to participants • Provide high security	• Distributed Ledger • Immutable Record • Smart Contract Consensus	+
Medicines Supply	• Collecting data from different sources • Tracking data changing • Update live information	• Distributed Ledger • Immutable Record • Smart Contract Consensus • Timestamp	
Clinical Trials	• Collecting data from different sources • Provide high security • Tracking data changing • Sharing data with patients • Eliminating intermediaries • Mitigating data lost	• Distributed Ledger • Immutable Record • Smart Contract Consensus • Timestamp	
Wearable Devices	• Collecting data from different sources • Provide high security	• Distributed Ledger • Smart Contract Consensus	+
Electronic Health Records	• Collecting data from different sources • Keeping all data of individuals' together • Provide high security • Eliminating lost of data	• Distributed Ledger • Immutable Record • Smart Contract Consensus	+

3.2. Value drivers of blockchain technology and effects on business model innovation

Business model innovation is defined as "*the innovation in company's business model that is new to the firm and results in observable changes in the firm's practices towards its customers and partners.*" This innovation should be generated value for being experienced and perceived by customers, networks or any partners of the company. (Heikkilä, etc) Using modern technology in order to create a product or service can be led to some changes at business logic in operational and strategic levels. As a result of that different values can be generated via a new business model. It should be looked at the business models to understand what kind of economic value is created. Business models provide an explanation of how an institution creates, delivers, and captures value by commercialized a technology (Chesbrough, 2010; Osterwalder & Pigneur, 2010). In this sense, the value is generated by blockchain for specific business models can be analyzed by using the business model canvas that is suggested by Osterwalder & Pigneur (2010). The model is based on nine basic

components of business which are important for companies to make a profit end of the day. "*They are customer segments, value proposition, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure.*" This kind of study is done by Morkunas et al. (2019) to find a generalized answer that how blockchain can be used in core business components. As a result of this study, besides the expected effects of blockchain, such as transparency in customer relations, it has had positive effects such as strengthening the relationships in the supply chain, shortening transaction times, decreasing IT costs and reaching new customers. However, it is also observed that staff costs increased because qualified IT personnel are needed. Even though these findings provide some clue on potential differences for blockchain applications in health care, making studies are necessary to clarify changes for health care. Also, each blockchain architecture can create different or additional value to business models because all blockchain features are different than others. For example, the blockchain that is used in financial sector is different than biomedical database systems in a sense of consensus and supported technology such as artificial intelligence. The study of Angelis and Ribeiro da Silva (2019) shows how different blockchain architecture can generate different value drivers. They analyze blockchain from the perspective of value driver and they classify the value of blockchain technology in accordance with the maturity level of this technology.

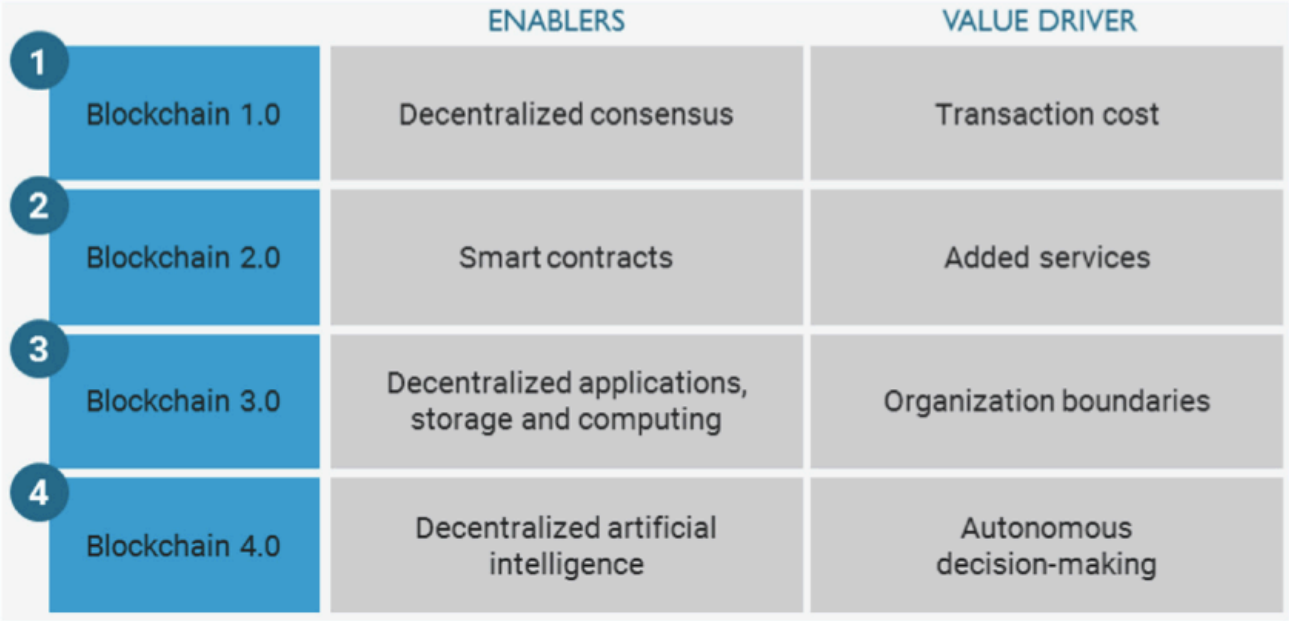

Figure 13. Enablers and value drives of blockchain. Retrieved from Angelis and Ribeiro da Silva (2019).

According to their study, blockchain 1.0 permits a reduction in transaction costs with decentralized consensus property of blockchain by removing the middlemen. After starting to use smart contracts on blockchain 2.0, addition to opportunities of blockchain 1.0, abuse and fault risk is minimized by transparency and autonomous nature of blockchain. Blockchain 3.0 launch the concept of decentralized applications and computing. This progress makes it possible to work in the same network for the different participants. It changes the more traditional type of transaction structure and typically requires governance modifications since services provided and the underlying required support functions fall outside the focal organization's direct control. Differently from Swan (2015), they consider the idea of using blockchain and artificial intelligence together as a part of blockchain 4.0. This combination allows systems to make decisions and act on them without the need for direct

human interference. Indirectly, management may manage by either (tightly) setting parameters or (loosely) dictating areas in which the blockchains then operate. Angelis and Ribeiro da Silva (2019) ‘s study provides a general idea of using blockchain in any business model. So, it helps to understand what kind of value driver can be added to any business model in case of using blockchain. Although these studies are helpful to generate an idea about the impact of blockchain on health care business, they are not enough to see the effects on health care innovation environment. Therefore, health care business models should be analyzed separately in order to see these new technology's impact on the interactions among companies.

3.3. The explanatory summary of blockchain's relevance between business model innovation and innovation in health care

To sum up, it is seen that the interactions among the suppliers of health innovation ecosystems increase in sense of innovation. Together with precision medicine approach, while the importance of data increases, the connection in health care value chain also increases. As it is already mentioned that blockchain is an information technology that helps to transfer and store the data, but it also enables to creation of a network by storing and collecting data simultaneously in different places. So, it helps to connect actors in value chain with data. This generates a real benefit especially for health providers in order to raise their service quality and efficiency of health care service outcomes. However, collecting these data is not make sense for innovation, if it is not utilized in order to develop new health technology. As a result of the blockchain healthcare applications, it is seen that many data lakes can be generated. These data lakes are full of valuable knowledge that can be used in health technology's development. Most importantly, more than one group or company can work on these data. Therefore, the cost of data collection can minimize, and collaborative results can be created. Also, these databases can feed on resources or actors, the synergy can be created by enhancing data. It can be possible to create solutions and understand the core reasons for the problem in health care by tracking the data through the value chain. For the health care environment, this can be tracking a disease life cycle or tracking the drug whole process from production to launch. Therefore, it can be said that these data lakes can be the main factor that brings many healthcare stakeholders together.

However, as it can be seen on blockchain applications in health, the companies can use the data in a closed node by using the consensus mechanism of blockchain. That means, they can share data with a network, or they can keep data private. In other words, the companies can be a part of a network by sharing data with others or they can use the blockchain technology only in their own close systems. Therefore, in order to understand how blockchain effects to relationship in sense of innovation, it should be looked at the network creators. In this sense, the network creator of health care can be health information companies because these companies provide data management services to all health care stakeholders. During they provide service, they have the capacity to connect all nodes (different companies) by using the blockchain decentralized features. Although all of these capacities can be sighted from previous studies, there is not any study to show the information companies’ role in this process and the impact of new business models in health care. Therefore, with empirical study it is aimed to demonstrate new business model of blockchain-based health information companies, create business model canvas by using value proposition, key partnerships, and key activities of health information companies in order to see possible business model innovation for health care businesses. Also, it is aimed to show how these new business models affect the innovation environment by companies' key activities and key partnerships.

Therefore, a framework is generated by considering previous studies of Angelis and Ribeiro da Silva (2019) and Morkunas et al. (2019) in order to analyze the business model innovation. This framework is derived from the following steps. First of all, the blockchain that is used in a business model is analyzed according to features because each blockchain is designed in different ways in accordance with using aim. These features provide information about the value drivers. After that, it can be analyzed that these value drivers how are used to generate value for each business component.

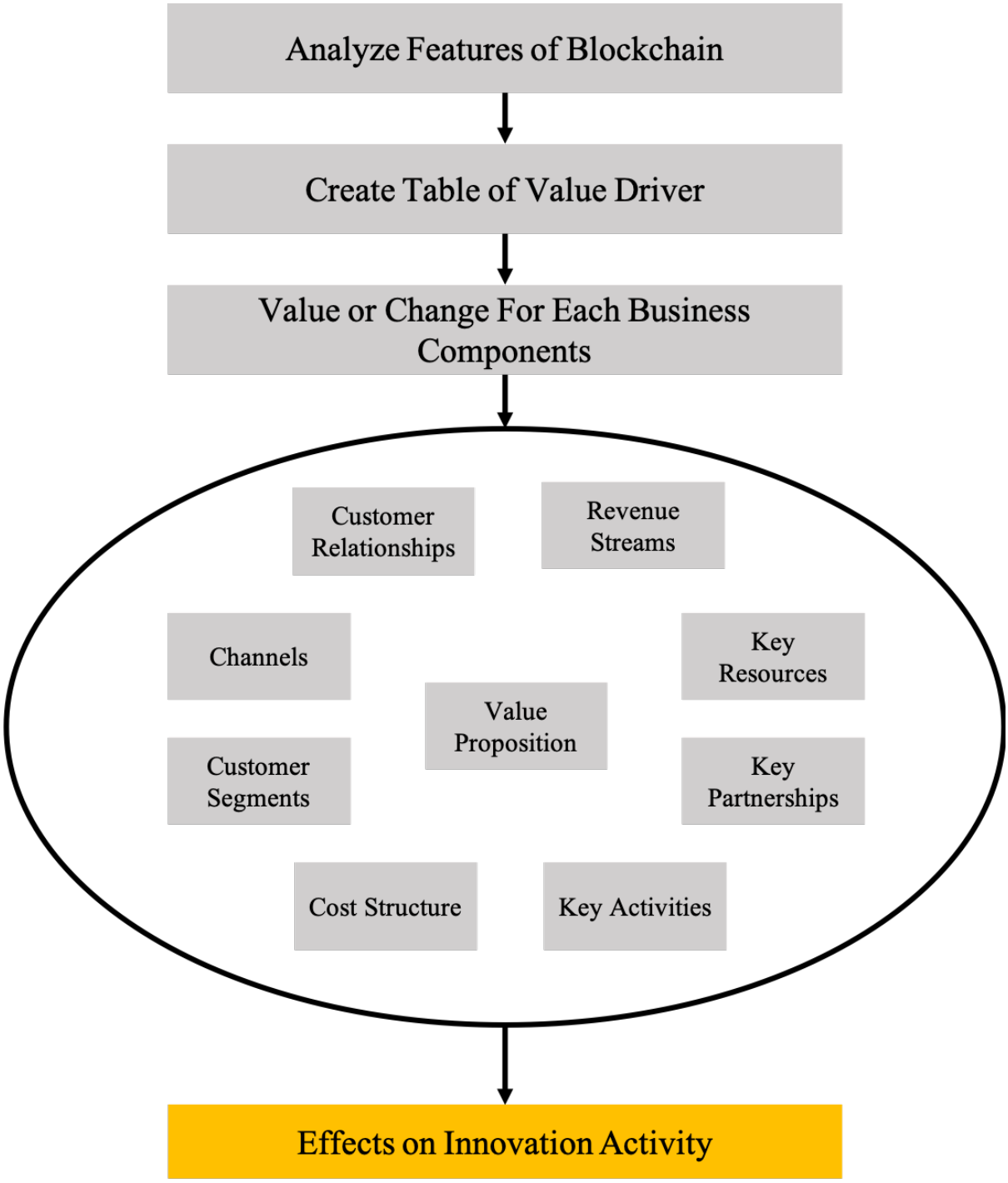

Figure 14. The framework for business model analysis

4. Methodological solutions

In this thesis, it will be approached health knowledge management from the holistic community perspective and aim to answer usage of blockchain in the health environment how it affects the innovation. Because of the research question's nature, the research will carry out from the base of qualitative empirical investigation. The reason for the preference of qualitative research in this study is to understand the effect of a technological phenomenon, which is new for health care, on innovation and compile to insights of experts in the industry about blockchain in the sense of innovation in close the future. The qualitative approach enables to find an answer about a phenomenon and its effects by collecting data in natural settings and analyzing these data with inductive and establish patterns (Creswell, 2007). The research will be comprised of three stages. Firstly, literature analysis was performed in order to construct a conceptual framework for the understanding of applications of blockchain technology in health care. In the second stage, qualitative multiple case study approach will be used to gain in-depth knowledge on cases. In the last stage, the findings will be interpreted according to comparative analysis.

Each stage will be considered separately to explain the reason for choosing methods, approaches.

4.1. Multiple Case Study

Case study is an explanatory, exploratory and descriptive research method. Especially, when it works on a phenomenon, it enables to investigate a phenomenon in depth while it is in a natural context. Also, distinctly from other methods, it enables collecting data from many sources. During the literature analysis process, it was possible to understand and find the answer to how blockchain technology can be used in health care, what kind of applications are exists in health care. But the aim of the research is to find the answer to what kind of business models are emerged as a result of using blockchain technology and how these business models affect innovation in health care and how they would affect innovation in the future.

In this research multiple case study are used in order to see the similarities and differences among the cases. Each business models are considered as a different case and collected data separately.

4.1.1. Choosing Cases

During choosing cases, it is considered that they have to address the answer to the research question. Therefore, first of all, the companies, which are assessed as cases, have to use the blockchain technology and they have to set their own business model based on blockchain. After that, these companies have to create new services that are related to blockchain or they have to be part of an innovation process that is related to blockchain in health care.

After these requirements met, the varieties of business models are tried to be kept more than one in order to look from different perspectives, increase the reliability of research, avoid overgeneralization because of focusing one business model and cases. The location of the companies is not considered as a criterion because the research is planned with a global perspective.

In this sense, Google search was used as the first tool in order to find the company by browsing keywords of “blockchain-based healthcare company”. Also, LinkedIn was used to collect information about the company and get in touch with authorized persons. As a result of searching, three information technology and one partner companies have accepted to attend research.

Table 4. The companies that participated qualitative study

Companies	Year of Founded	Company Size	Company Characteristic
Firm 1	2015	11-50	By using the platform, they create big data solution for health care
Firm 2	2017	11-50	By using platform, they create data solution for health providers.
Firm 3	2017	11-50	Application developer for health care
Partner 1	2017	51-100	A spin-off company of Big Health Care Service Group in USA. It is a service platform that aims to decrease costs and increase efficiency of outcomes in clinical and operational processes.

Firm 1: The company developed a blockchain-based platform in order to solve health care industries data management problems. This platform allows users to develop own block in order to use in their own business, also companies provide service to customize companies' blockchain in accordance with usage aim. During this moment, the platform is used by the partners of the company in order to following aims; creating enterprise data network, collaborative research, developing electronic ID programs, digital therapeutics, clinical trials, workflow optimizations, developing high-accuracy provider directories, the supply chain in health care.

Firm 2: The company developed the blockchain-based platform that addresses the health providers and patient electronic health records management problems. Also, the company by using own platform developed a currency, virtual consultation rooms, and bracelet that can be used in emergency situations.

Firm 3: The company focus on developing application for health care, especially for the pharma industry and distributor of health care, on the other hand they desire to create network and data pool in order to gain insight from data and develop a new application that addresses health care problems. Therefore, the company developed own blockchain and cryptocurrency that is planned to open public sale soon. Also, the company continues to develop new applications. In this research, the application that connects health providers, patients, and pharmacies were analyzed.

Partner 1: It is the partner of Firm 1. The company uses the blockchain technology as a part of their analytic platform. They target to improve the workflow of clinal and surgical services. The company aim to change physician practice and behavior through data in order to reach efficiency outcomes at low cost. After the company reached the ninety million US dollars saving, it was spun off from the parent's company.

4.1.2. Choosing Interviewee

The first interviewees are chosen from blockchain-based information companies according to their role in company. These interviewees should;

- be manager or commissioner for the adaptation of blockchain process to health care,
- create blockchain-based service or product.
- should be manager or commissioner blockchain-based company
- be researcher who works in on blockchain

After the first interviewees are chosen, snowball sampling method is used by researchers to generate a pool of participants for a research study through referrals made by individuals who share a particular characteristic of research interest with the target population are used (Frey, 2018). In this way, Companies' customers and partners are included in the research while the company and interviewee numbers are increased. Customers or partners (individual who represent the company) who attend the interview should;

- be manager or commissioner in managing partnership
- be user of blockchain
- be creator of service or product which is innovated as a result of blockchain
- be researcher in this field

Interviewees should have at least one of these properties. In this sense, the interviewees are chosen as representors of the companies.

Table 5. The interviewees who participated interviews

Company	**Interviewee**	**Position in Company**
Firm 1	Interviewee 1	Chief Scientific Officer
Firm 2	Interviewee 2	Chief Executive Officer
Firm 3	Interviewee 3	Co-Founder
Partner 1	Interviewee 4	Chief Technology Officer

Interviewee 1: She is chief scientific officer of Firm 1. She has a PhD in clinical science with a specialty in health information technology. She is involved in blockchain three years and she serves on a number of international committees. She is a co-chair of a life sciences research working group to develop standardization for blockchain across life sciences organizations. Also, she is a peer-reviewer of an open-access international peer-review journal.

Interviewee 2: He is the chief executive officer of Firm 2. He is currently a physician who works in accident and emergency. He decided to co-found the company after he realized the necessity to generate accurate medical records on patients during his service in national health care service.

Interviewee 3: His background is a pharmacist. He has a PhD in social Phycology and Pharmacy. He has been working with blockchain technology and Artificial Intelligence for more than two years.

Partner 1: He is the chief technology officer in Partner 1. He has worked on blockchain since 2017. However, he is an expert in analytics solution to healthcare. He has been working for more than 20 years for Information technology and more than 15 years in health care and insurance industry.

4.2. Research Ethics

This Research has been designed and performed against The Code of Academic Ethics of Kaunas University of Technology. All formal interviews were conducted and recorded with the permission of participants. All interviews ' records were used only with the aim of preparing transcription. All permission has been taken orally for using participants' and companies' names.

4.3. Data Collection

Case study data can be collected from different sources such as documents, archival records, interviews, observation, and physical artifacts. For empirical research, primary and secondary data are used. Especially, when it is created a business model canvas for each company, the secondary data is used. These data are gained from companies' official websites, the whitepapers, business news' websites (such as Forbes), forums of blockchain. The information which is not provided by using these sources is gained during the interview. On the other hand, the interviewers' opinion about blockchain, these companies' innovation activities, future expectations about using blockchain in health care and other topics which are except of business models is gained from the qualitative interview.

All interviews are made online by using Skype, Zoom, and Hangout which is depends on the interviewee's wishes. After taking the oral permission of interviewees, all online meetings are recorded to write transcript. Two different kind of interview structure are prepared. The first one is for interviewees who works at blockchain-based information company. This interview emerges two parts that are questionnaire and semi-structured interview. The questionnaire part is prepared to understand if the company makes a partnership with any other company or institution. Questions are designed as "yes-no question". If the answer is yes, then the questions continue with "how" and "what" in order to learn detail of partnership. The semi-structured interview questions are aimed to learn about companies' innovation activities, the roles of blockchain in the company and future expectations about blockchain. All interview includes twenty-nine questions. On the other hand, the second interview structure is prepared for the partners of blockchain-based companies. The interview is designed as a semi-structured interview, which has sixteen questions. Questions are aimed to learn detail of relationships with information company, and future expectations about blockchain. The length of each interview is between one and a half hours and forty minutes.

Table 6. Interview instrument for blockchain-based companies and their partner.

Research Elements	Address of Questions
Questionnaire	
1. Is there a research laboratory or product development unit in your company? If Yes, what is/are the purpose(s) of this laboratory/unit in your company? 2. How many employees work in this laboratory/unit? What are their specializations? With which departments do/did they collaborate in the company?	The aim is to learn the companies' current collaborations and their own product and service development process.

Research Elements	Address of Questions
3. Does/did your company cooperate with complementary firms in your industry? 4. Does/did your company collaborate with universities? 5. Does/ did your company collaborate with public or private research institutes, laboratories? 6. Does/ did your company cooperate with governmental institutions?	
Innovation activities	
7. How the company attends innovation activity in health care?	The aim to learn how companies are part of innovation in health care. That means, it is tried to learn if they attend other firms' innovation activities by collaboration for product development, technology cooperation, license sharing, etc.
8. Did you start or an initiative to innovate new products or services for health care? • If yes, could you explain what it is and how you start it? • If no, what kind of collaboration can be made in order to innovate?	The purpose of this question is to find out if the company cooperates with different companies or industries while producing products or services and how it uses innovation's tools.
9. What is the role of blockchain companies in the product development process in health care?	To learn for what purposes blockchain is used when developing a product or service. To understand how blockchain affects the product development process or the product/service.
10. Could you explain what is the difference between blockchain-based information companies and traditional information companies? What kind of dynamic capacities do they have in a sense of innovation?	The aim here is to understand whether there is an additional benefit of blockchain which is not written in literature, especially in the process of innovation. Considering the current business models, what kind of opportunities are created by blockchain in order to innovate.
11. Do you make any collaboration with other industries in order to improve blockchain and smart contracts? If yes, could you explain what kind of collaboration they are? What is your role in this process?	In order to understand how these companies affect and be affected improvement on the blockchain technology.
Partnerships	
12. How you help researchers, developers or innovators to find partner(s)?	To learn how these companies bring together different companies or industries in order to innovate.
13. What is/was your specific role in this relationship?	To learn the blockchain role in creating a network or partnerships.

Research Elements	Address of Questions
Partnerships	
14. What is your company benefits gained from these partnerships? What is/was your company's main motivation in getting involved in this relationship? 15. What do you think your partner's main motivation is/was? 16. What is the role of blockchain technology in this process?	To understand how the companies' role of creating a bridge among different parties can be sustainable. Is there enough or satisfying benefits to performing this role permanently.
17. According to your experience, could you say what kind of challenges you face during the innovation process? Could you share some examples to explain it?	In order to understand the limitations of the blockchain, what kind of problem can be emerged in partnership because of blockchain?
Data movement	
18. What kind of data is collected in your chain?	In order to understand the limitations of the blockchain and visualize the possible relationships to create a data pool for research purposes.
19. How do you motivate patients and other stakeholders to share their data to use in the research process?	In order to learn that the companies use additional instrument or different blockchain features for motivation.
20. How do you manage the data movement in research networks? 21. Who is the owner of data after the patient accepts to share data for any research? How do you manage or protect patients' IP right?	In order to understand the role of company in data network and real owner of data.
22. Do you think blockchain technology has limitation in sense of data movement among parties? If yes, what kind of improvement is necessary?	In order to understand the limitations of the blockchain
23. How your blockchain based business models connect with remote medical care?	In order to understand the blockchain role in service innovation of health care.
Addressing today's health care problem	
24. Could you share your opinion how blockchain technology address problems in health care? 25. How blockchain technology help or use in order to - control the spread of virus? *(creating scientific community, exchange information, monitoring the spread etc.)* - develop drug/ vaccine /treatment? - mitigate social damage to people's life?	Taking into account the epidemic of Covid-19, to get information about how blockchain technology can produce innovative solutions in the health care.
Future expectations	
26. What is your expectation about products, applications or social innovations after this pandemic? How can they change?	In order to learn the tendencies for future products or services related to blockchain in health care. The possibility of bringing different industries together with by using the features of blockchain.

Research Elements	Address of Questions
Future expectations	
27. How will this pandemic affect the health care environment in a sense of innovation investment and product and service' tendencies? What will be the role of blockchain in this period? 28. What do you think about these new business models' effects on new product trends in health care? How these kinds of platforms reshape the collaboration? (such as bringing medical device and pharma industry together to make more alliance) 29. Is there anything in our discussion that you would like to comment on or that you think hasn't been mentioned despite its significance?	In order to learn the tendencies for future products or services related to blockchain in health care. The possibility of bringing different industries together with by using the features of blockchain.

During interview with a partner, the following questions are not used; 1,2,3,4,5,6,7,8,11,12,21,23. Because these questions are not related to both companies' partnership.

4.4. Data Analysis

As a nature of multiple case study, ***comparative analysis*** is used for data analysis during the desk study. The comparative analysis helps grasp the peculiarities of each case and compare the similarities and differences. (Chris Pickvance, 2005) Data that is collected as a result of desk study are brought together, the result is analyzed in accordance with differences and similarities. After, that this data is merged with data that is collected with interviews. All this data is interpreted in consideration of the ***critical approach***.

All interviews are uploaded to MAXQDA software program after they are transcribed. By using this qualitative software program data is coded in order to prepare for analysis. During this process, ***directed content analysis method*** is used. Because previous studies have already provided some structures for creating a code system. Frankly, interview questions are prepared in a frame to find the answer to some key points (Hsieh & Shannon, 2005). Coding helps to order the data in accordance with similarities and differences, thus it can be seen easily the relationships among data. During the coding process, ***deductive approach*** is used because of the readily prepared code system that is ***hierarchical coding frame.*** In other words, categorized questions have already created categories and some codes for the code system. Data is started to be coded by using this code system. However, according to the data new codes and sub-codes are emerged. Using software for the coding process provides flexibility to revisit the code system and make an arrangement by studying the code system.

4.5. Research Limitation

One of biggest issue is determining companies that used blockchain technology. This can be also considered a challenge. Even though some companies are used blockchain technology in their process, they do not prefer to announce to the public. For a researcher or any other person who is out of the industry, there is not an opportunity to learn which companies use specifically use blockchain. Therefore, snowball sampling method is used to reach other companies. Also, because of Covid-19

pandemic, it is not possible to get in touch with the hospitals and doctors that are customers or partners of blockchain-based companies.

Even though it is known that some biotechnology companies and big pharma companies also use blockchain technology in their business process and innovation process, it was hard to get in touch with them. Because it was not received any positive mail to attend research, in this research, the cases are limited with blockchain-based information technology companies.

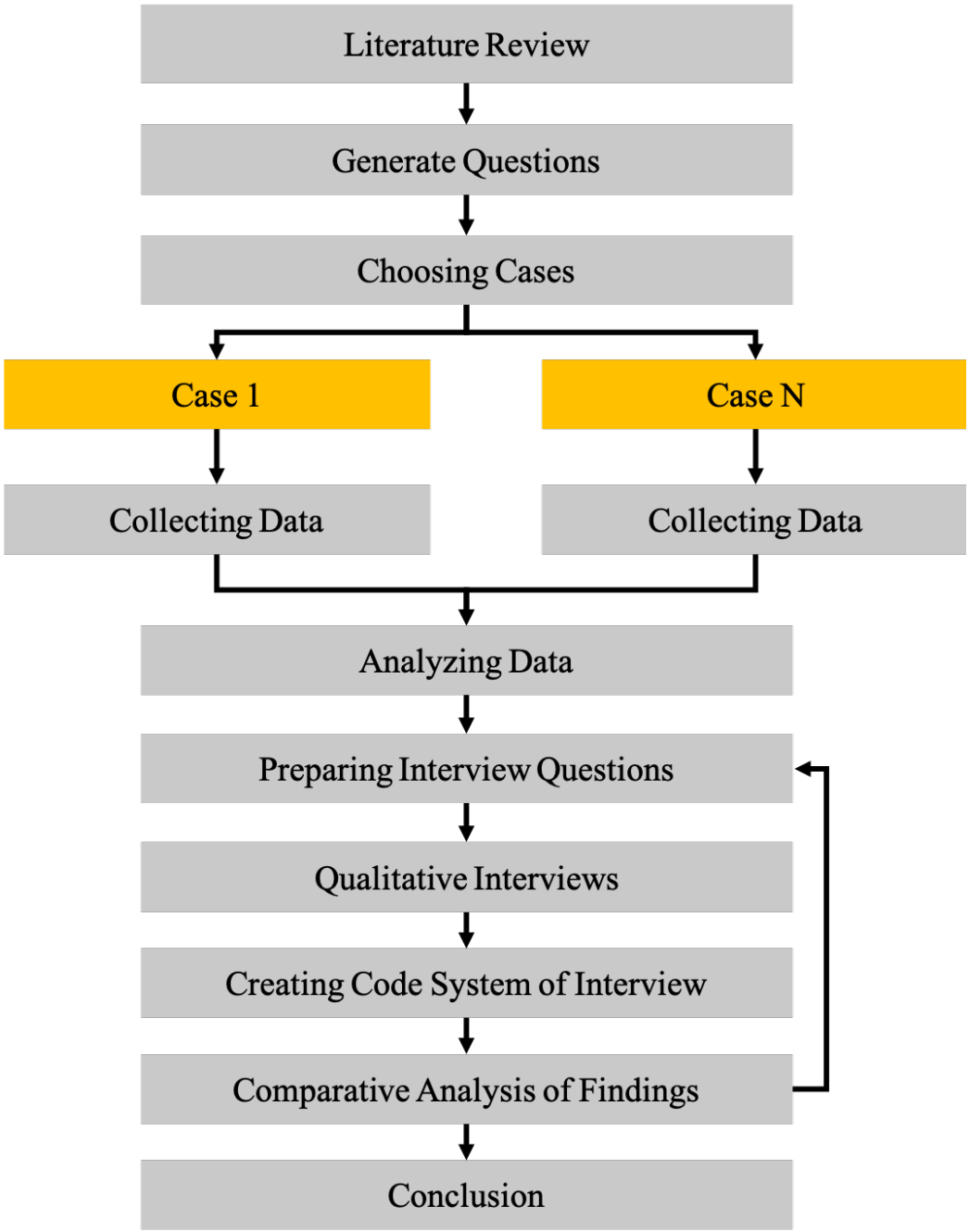

Figure 15. Research method's framework

5. Analysis and discussion of empirical research results

5.1. The result of multi case studies

During qualitative research, three different health information technology' s firm business models and their blockchain technologies were analyzed in order to understand what kind of values are generated for the health care environment by using blockchain technology. Therefore, first of all, essential information was collected from three firms' official websites and their white papers. After that, semi-structured interviews were used to communicate with three firms' representatives and Firm 1's partner. During these interviews, the information that belongs to seven different categories was collected.

Table 7. The categories of coding systems

Category	**Explanation of Category**
Value Creation	Under this category, the answers to how blockchain creates value and how blockchain answers today's problem of health care were collected.
Complements of Blockchain	The relationship between blockchain, artificial intelligence, and machine learning.
Innovation Activities	The innovation tools and activities are used by case firms were collected under this category. This category is explained firms own activities that enhance the innovation environment in health care.
Partnership	This category is explained that the firms increase the interaction among health care industries in a sense of innovation. Also, it helps to understand the role of blockchain technology to bring all industries to increase synergy.
Limitation of Blockchain	Information on Blockchain technology limitations in accordance with data capacity and performance was collected.
Challenges	The challenges were faced in the practice of blockchain as a result of experts' experience were collected under this category.
Future Expectations	The experts' opinions and forecast about the future of blockchain and the applications of blockchain in healthcare were collected.

Each category enables to be explained the gaps and questions that were generated from literature analysis. The information that was gathered under "value creation" and "complements of blockchain" categories figure out the values that these firms provide the customers and partners by using blockchain and artificial intelligence while the category of "limitation of blockchain" shows the limitations of this technology in the sense of performance and data capacity. "Innovation activities" and "Partnerships" includes the information that experts' explanation of how these companies help to adopt blockchain technology to other health care business. That means, the information that was gathered in these two categories show how the generated values are used in other health care business or how they affect the other health care business models. All these pieces of information were used

to understand how the business models in health care can be affected from the blockchain. As a result of these analysis changes were showed on business model canvas.

Moreover, the insights and experience of the experts about blockchain technology were gathered in “challenges” and “future expectations”. The detailed information about codes and sub-codes were explained in related titles.

Three healthcare information companies ' blockchain features and value drivers

Blockchain is a technology that can answer the different needs of industries. These needs change from industry to industry while they change also for each business in the same industry. The architecture and consensus of blockchain can be designed according to the aim of the problem that is desired to solve. A blockchain, used in health care, should have the main features in order to comply with the requirements of HIPAA and GDPR about the protection of health care information. In this research, three different blockchain architecture will be analyzed for determining features that generate value drivers. After that, it is analyzed how these value drivers affect each business model's components by creating value.

Table 8. Features of companies' blockchain

	Firm 1	**Firm 2**	**Firm 3**
Platform	Own Platform	Hyperledger Fabric Ethereum	Hyperledger Fabric
Degree of Decentralization	Permissioned	Permissioned Public	Permissioned
Token	-	+	+
Network Support by AI	+	-	+

Each firm creates its blockchain by using a platform. Although it can be seen as a difference that Firm 2 and Firm 3 use HyperLedger Fabric and Ethereum platform to create their blockchain while Firm 1 has its own platform, this situation does not lead to any changes, because HyperLedger Fabric and Firm 1's platforms are generated to service same purpose. The aim is to create a network that gathers enterprises that want to keep some data private while they are sharing some of them. This approach differentiates into Ethereum platform in sense of sharing data principle since Ethereum platform is designed for data exchanges between public to consumers. Therefore, it can be seen that Firm 2 uses dual platform because it aims to create cryptocurrencies and also to create a secure and private network for health records. This cryptocurrency is different than Firm 3 in a sense of usage. Firm 3 tokens can use only in-network for business two business, Firm 2 can use in the public network. This situation will be explained more detail in business model parts.

All firms have chosen to use permissioned blockchain that is called also as hybrid and consortium blockchain. The reason to choose this type of blockchain is by giving the controls on data to nodes. The nodes can be organizations or individuals. By using these privacy options nodes can organize which data will be shared in the network while the private data is isolated from the network. Experts from Firm 1 explained this structure with these words; "*what we do is have a separate blockchain for each of our companies that... we will move back up. We have... we can set up a separate blockchain starting with the genesis block for any company that starts or that they can have a shared space. They can have their own space in a shared blockchain where we just kind of wall off permissions. And because we have separate... like separate chains and in many cases separate forks for different departments or divisions. Scalability has not been an issue at all."* (Firm 1, Pos. 117)

Firm 2 and Firm 3 create the token for their business by using blockchain. If two tokens are compared with each other, it can be said that Firm 3' token can use only in the network, Firm 2' token can be used in public network. On the other words, the exchange of Firm 3's token is limited in network because it is generated in Hyperledger Fabric while Firm 2's token is generated in the Ethereum platform. Therefore, The Firm 2's token appeals to wider network.

Firm 1 and Firm 2 are connected their blockchain with artificial intelligence (AI) in order to empower data insights. More clearly, blockchain provides real-time data to AI in order to insight and use it in the organization's products or services. Thus, they can be created dynamic systems that are not only collect and store data but also enable analyzing of data sets.

Table 9. Value driver of blockchain features

	Value Drivers
Platform	Creating distributed data storage in a network.
Degree of Decentralization	Keeping data privacy while the store in the network and managing data transactions in own rules
Token	Creating own currency
Network Support by AI	Gaining deep insight from data Creating an autonomous decision system

These value drivers appear when the main features of the blockchain are analyzed through these three companies. Nonetheless, these value drivers are so general to learn what kind of value is generated by them. Since all features can create different values in accordance with the aim of usage. Therefore, companies' business models will be analyzed to see the value of each feature in the health care business.

Blockchain impacts on health information technology companies' business model

Customer segments

Customers are the essential parameter for any company because all products, service and process are designed in order to address customers' problems or meet the customers' expectations. Even though sometimes one company's customer comprise only one segment, also it can comprise from diversity of segments that is separated in accordance with requires, distribution channels, relationships, and profitability level (Osterwalder & Pigneur, 2010). When these three firms are assessed and compared with any traditional health information companies; it can be realized that there are some similarities and differences in the case of customer segments. Some information companies specialize in hospital information systems and provide these kinds of services and products to the niche market, while others provide a software system in a segmented market that has slightly different needs. Frankly, customer groups of traditional healthcare IT companies and blockchain-based healthcare IT companies are mostly the same. That means these three firms' keep providing services and products to the same health care providers and suppliers. However, additionally to these customers segments, these firms also target interdependent customer segments of the health care environment. Therefore, as it can be seen in table 8, all companies' customer segments have shifted to a multi-sided market. Since the blockchain enables creating a platform that can be managed sharing data in a permission structure in order to work on the same data for the interdependent organization, these companies can provide service or sell their product to also interdependent organizations. More clearly, Firm 2 offers service also to insurance companies while Firm 3 also offers service to any other application developers in addition to their main customer groups.

Table 10. Customer segments of firms

	Firm 1	**Firm 2**	**Firm 3**
Customers	All Healthcare Organizations	Health Providers, Patients, Researchers	Applications Developers, Pharma Industry
Additional Customers		Insurance Companies	Health Providers
Customer Segments	Multi-sided market	Multi-sided market	Multi-sided market

Value Proposition

Value proposition is defined as a reason to be preferred the company instead of other companies by costumers. The company should create value by using own sources in order to answer customers' hidden or clear needs. All these values should offer quantitative or qualitative benefits to costumers (Osterwalder & Pigneur, 2010). Each firm in research cases has different customer segments, although health providers are common ground for all cases. Therefore, using blockchain can lead to generate some common value and also some special for each customer segment.

Firm 1

As a difference from other companies' data that are stored in blockchain, Firm 3's data variations are wider than Firms 2 and 3. In Firms 1's blockchain, all possible health data which include from laboratories results to genomic information are stored. Therefore, this expanded data diversity facilitates third party collaboration. The Firm helps organizations in order to reach customers, partners, or any other individuals and organization in order to product development, research design. Because all data in the blockchain, are transferred or merged snugly and without risk of losing information. This also is emerged from the capability of the platform that provides support for several interfaces and multiple transport language and systems. The experts explain how the blockchain creates value for this capacity with these words; " *One of the things that I really like about Firm 1 a huge solution to is that because we add data to the blockchain, you can control that what people can analyze versus see. But you can also do what we design is called a schema on read. And that means you design queries so that you can analyze the data on the blockchain, and you can pull data from other sources at the point of query. So, you don't have to have it all on blockchain. You can have it in servers. You can have it in the electronic health record. You can have it in a data lake. And so, as a result, and you don't have to recode or reformat the data, you just keep it in its raw form. However, you have saved it to begin with. And then with the schema on read, you can you can design for the read that you're bringing together some different data sets that might be named differently or have variables named differently. So, for example, in one dataset you might have name as registered as just one field for name and then another dataset. It might be one variable of last name and one variable of first name. While you teach, you can design mapping so that you tell the ...the query mechanism that when you're querying that this variable and these two variables are really the same thing. And so, when you query, you can you can pull it all together as one single variable that you can then analyze. And it allows ... it allows you to pull together like what Firm 1 talks about how they design Millgate faceted profiles of an individual. So, you can pull together their health information, you can pull together the demographics of the city that they live in. You can find out about the pollution for the city they live in. You can find out about the schooling system and you just pull that data together during query to see if there are more complex public health components influencing the health and well-being of a city or person. You just cannot have that level of capability with any traditional information systems and the flexibility for how you can design. You can modify your data collection methods that the information you store modify on the fly as opposed to traditional software where the... you know, it's that software company that tries to think about what's important and they're not interested in being sufficiently creative to let use to pull in different information that could really influence health. But we just haven't thought of it before. So blockchain allows us to integrate whatever information could be meaningful and study it to see if we can identify trends."* (Firm 1, Pos. 89)

Moreover, using blockchain makes possible to reduce licensing and IT cost since all information can store in a blockchain instead of several data silos. This can be clarified by using a healthcare application example. Normally, if an application for patients in order to give access to merged health records is desired to develop, developers have to use many different data silos. Furthermore, they have to pay a license and additional IT cost in order to use these silos which provide data from different licensed programs. In this sense, using Firm 1's blockchain-based platform reduce all this cost significantly. Also, Firm 1 gets all responsibility to solve for the improvement and performance issues of blockchain, and they reduce the workload of customers.

Additionally, Firm1 leverages the benefits of the blockchain by using artificial intelligence and deep learning to create stronger decision systems. Thus, customers can generate a more powerful and smart product, as well they can use this technology in order that they provide additional service for their own customers. The expert explained how artificial intelligence can be used in order to utilize the data that is stored in blockchain by using these words; "*that's really opening the doors for public health surveillance as well. And that you can use things like Google search terms about what kinds of symptoms people are searching for and what geographic location you can look at. Weather patterns, you can look at symptoms that people are reporting in social media forums and you can use these pieces of information and machine learning to try to determine where the next outbreak is going to take place. Blockchain again space solution for bringing all that information together.* (Firm 1, Pos. 176)

Firm 2

Firm 2 has three different customer groups. They are patients, healthcare providers, and researchers, or other health care companies that want to find participants for their research or they want to reach related data for their own research. Since all participant has different motivation to be used this company's service and products, the delivered values for these groups are not same. As a result of that, the values are analyzed according to customer groups. From the patients' perspective, the biggest value is gaining access to all health data. Frankly, this business model is generated to place patients in the center of health care systems. Managing and reaching own data is also eliminate the risk of losing data in case of travel around the world or changing health providers has not become a problem for patients. Moreover, having trustworthy and accurate data is to eliminate mispricing risk by insurance companies. Thus, the patients are empowered by own data. Another value is related to payment methods. In addition to manage health records, the company uses the blockchain technology to launch its own token. The aim of creating a token is eliminating the loss of patients and health providers because of currency exchanges and money transferred fees. The firm's CEO explains this situation with an example.

"When we originally launched the company two and a half years ago. We are a big believer in blockchain. Obviously, we're a big believer, an advocate of cryptocurrencies. And we wanted to utilize cryptocurrencies or digital currencies to ease the transfer of funds from one area to another. So, the ultimate aim would be having a Turkish patient speaking with an American doctor. And it is hard for you to pay the American doctor in dollars from your bank account. Two or three transfers fees takes about one week. Crypto currency would facilitate that transfer much quicker, much easier with minimal fees. So, this is something we hope to do. But crypto currency in the meantime, has all come down, bitcoins down. MedToken is down. So, it's harder to use that as a funding mechanism at the moment, but it's something we still want to do". (Firm 2, Pos. 127)

On the other hand, Firm 2 also creates value for health providers by using blockchain. First of all, Firm 2 helps healthcare providers to reduce administration costs. However, it should be emphasized that this value is not directly related to the adaptation of blockchain technology. The reason for cost reduction is connected with the digitalization process of documentations. For instance, if it is necessary to give records of health to patients, all documents are should be printed. Additionally, these printed documents can be duplicated in order to provide information for clinicians, physicians. However, moving all data to clouds systems are eliminated the needs of printed documents. Also, it reduces the time for spending to gathering information. Moreover, blockchain helps to design a data-

sharing structure for remote consultation for healthcare providers. Thus, both data sharing and payment process can be tracked on the blockchain.

From researchers' perspective, firms help to find related patients' groups or data. This helps any research organization not only to reduce their advertisement or managing clinical trial but also to reduce the misinformation about participants' health conditions. Researcher organization can share their result with patients while they can make payments to participants by using the platform.

Firm 3

Firm 3 creates a network among healthcare application developers. For this purpose, they focus to produce applications that enforce the connection between healthcare and pharma industry. The working principle of the network is creating a data pool in order to get the benefit of cumulative information. All applications in network collect data with smart devices and these data are shared with the data pool. These data are analyzed with help of artificial intelligence. As a result of that, it is gained insight for using generate value in health care. Developers or researchers can develop new applications or services in accordance with the needs of the market. Moreover, it eliminates the duplicated data or creating new data sets for each application separately, since all applications are in connection and it is possible to use the same data in different applications. Also, this occasion can be used to attract different users. Developers can create supplementary applications in-network in order to attract other applications' users, such as developing diet applications for sport applications.

Additionally, Firm 3 provides a token-award system in the network by using blockchain. This system helps developers to create applications based-on rewards systems. This rewards system enables earn token when people share data with applications in order to enhance data pool and artificial intelligence that works behind the network. Also, developers do not lose their own data sets when they share or not with the data pool. Each application's data can store in blockchain without risk of loss.

Table 11. The value propositions of the firms

	Firm 1	**Firm 2**	**Firm 3**
Value	Facilitate third party product development	Reduce administration cost	The insight gathered from the data pool
	Support for several interfaces	Provide mobility and access all data	Token-award systems
	Reduce licensing and IT Cost	Cost benefits for insurance fee	Create secure data sets
	Taking all responsibility of blockchain	Payment transparency and ease of Payment	Finding anchor partners
	Provide powerful decision system	Transparency of clinal trial	
		Provide data for remote Consultation	

Channels

Channels refer to how a company deliver value and reaches the customers. Basically, it can be divided into two as direct and indirect channels. (Osterwalder & Pigneur, 2010) With respect to firms' products and services, it can be said that they directly communicate and reach their customers without using any intermediate. Since the blockchain is a novel technology, it is also essential to raise awareness of blockchain's benefits to customers. Especially Firm 1 makes an effort to raise awareness and helps customers evaluate their service and products by using their platforms. The interviewee from Firm 1 says that "*So first we ask each company. We get to really know the companies who use our product and we offer a lot of educational services for them. And as they start to develop their product…" (Firm 1, Pos. 93).*

Consequently, it can be said that these Firms are especially focused on direct channels in order that they want to explain how their novel technology brings benefits to their customers.

Customer relationships

Customer relationships describe how firms interact with their customers. Firms can be fully or semi-automate this process or customer relationships can be designed based on human interaction (Osterwalder & Pigneur, 2010). These three firms are technology companies, and they are selling software-based services and products. Therefore, with respect to the nature of their products and services, relationships in the routine of business go automatically. However, at the beginning of the business or when the companies and customers face problems different relationships can emerge.

Firm 1 use also creates collaboration among customers in order to enhance their experience with blockchain. When they realized that they have two or more customers are working on the same or similar area, they bring them together. The Firm's executive explains this with these words; *"we ask them if they want to be introduced to other companies that are working on an area where they could benefit from some help or from another company that's doing something similar to them to see if they could collaborate. And so, we have made several introductions between companies working on similar products, and we will continue to do that. It just really helps people to connect with others who are kind of early in their development to get ideas, motivations and to see if they can share pieces of technologies to make each other more successful." (The Interviewee 1, Pos. 93)*

Revenue Stream

Each firm can generate cash from its customers in different methods. Sometimes firms can generate recurring revenue streams by methods like subscription fees or leasing while sometimes they can generate it with one-time payments for service or product (Osterwalder & Pigneur, 2010). Firm 1 generates revenue streams by charging of each transaction on their blockchain while Firm 2 and 3 revenue streams are mixed methods. Also, they provide their sources free for some customers segments. Firm 2 gets revenues mainly from subscription fee which is paid by Healthcare Providers. However, at the same time, they gain revenue from brokerage fees as a result of finding participants for researchers. On the other hand, Firm 3 gets revenue from three different sources. The first one is the usage fee that is taken to set up a dataset in the blockchain. The second one is a commission that is taken from reward tokens is used in the network. In other words, When the users share their information with the data pool, they gain rewarded token. Firm 3 takes a constant percentage of this

reward as a commission. Finally, they get revenue from selling their reward systems to other developer as an in-app payment method. Thus, the other developers can generate payment method in their application.

Table 12. The revenue stream of the firms

	Customer Segment	**Revenue**
Firm 1	Universities	Free
	Third world countries	
	The participants of open call	
	Others user of network	Transaction Fee
Firm 2	Patients	Free
	Health Providers	Subscription Fee
	Researchers	Brokerage Fee (Transaction Fee)
Firm 3	App Developers	Usage Fee, One-time payment for payment system
	Users	Commission Fee (Transaction Fee)

Key resources and activities

Key resources are the assets that companies use to create value propositions and survive. Key resources can be physical, financial, intellectual, or human power. On the other hand, key activities define the companies on how to create value and survive by using key resources. (Osterwalder & Pigneur, 2010). It can be said for all three firms that their blockchains are key resources. But it is not the only resource that companies use. Firm 1 created own platform by using blockchain and artificial intelligence. Firm 1 core aim is creating solutions for data storage and data exchange among health care. Therefore, it uses the blockchain and artificial intelligence technology. However, these technologies are quite novel and also complicated to design. Therefore, because of the novelty and complexity of system architecture, blockchain experts are also golden sources for these three companies. Even though the number of experts is getting increase each year, finding qualified experts are quite difficult.

In addition to blockchain and blockchain experts', Firm 2 has its own token, the virtual waiting room, and the bracelet system. The virtual waiting room and bracelet systems are developed by the company by using the facilities of blockchain technology. The virtual waiting room is an online consultation platform which helps to bring patients and physician together in a protected environment. This platform is differentiated from any other platform because the patient can share all health records that are stored in the blockchain with the physician in real-time. The other resource is the bracelet system. The system working principle is based on backup systems. More clearly, the vital information about patients that are stored on the blockchain such as an allergy to any medicine, blood type, chronic disease, etc. is copied to back up systems. The link of this information is connected with QR code

which can be carried on a bracelet. Thus, health professionals get access to this information by scanning the QR code in case of emergency situations and they can apply immediate treatment.

On the other hand, Firm 3's key resources are the data pools, blockchain, and artificial intelligence infrastructure, blockchain experts, token, and its own applications. Also, Firm 3 uses its information structure for the same aim as Firm 1 and Firm 2. Nonetheless, it uses token in order to create reward systems. Thus, they motivate people to share their data with the data pool. They use the data pools in order to create own applications. One of their application that is analyzed for this research is the platform which provides service for the patients, clinicians, and pharmaceutics. The platform aims to fill the information gap in health care because data that is related to treatment or diagnosis is not collected when the patients arrive at the pharmacy. However, these data can be also useful in order to track disease progression. Firm 3's expert explained the product with these words; *"it was an algorithm-based product that tried to incorporate technology within the patient pharmacist consultation. So, the product, the idea behind the product was that the patient that a pharmacist would conduct some physical examinations on the patient and they would input basic, you know, physical examination results into this algorithm and it would use NHS data to try and give the pharmacist areas where the consultation should be driven. So, for example, the pharmacies would conduct a blood pressure test, would input the blood pressure scores. They would conduct some weight and height measurements. And there would be, you know, analyzed by the algorithm. Give them a BMI, very, very simple things. But the idea would be that it would incorporate technology within the consultation. And this data can be recorded locally for the pharmacy. I can see a kind of progression of the fact that the patient returning to the pharmacist and, you know, receiving repeat consultations. So that was you know, that was kind of the first product that we released here."* (Firm 3, Pos. 56)

Table 13. Key resources of the firms

	Firm 1	**Firm 2**	**Firm 3**
Key Resources	-Platform based on blockchain and artificial intelligence -Employee	-Platform based on blockchain -Employee -Token, developed on different blockchain -Virtual Waiting Room -Bracelet Systems	-Blockchain and own applications -Data pools and Artificial Intelligence -Employee -Token

As it can be seen that, the companies' key resources are different than each other except blockchain and blockchain experts. However, it is possible to categories the companies' key activities as setting and maintaining the information technology infrastructure, managing main services, and perform activities to promote the platform to new users and increase the benefits of the platform for each user because of their multi-sided business pattern.

All firms are responsible for setting and maintaining own blockchain- based platforms. However, Firm 1 is also responsible to change consensus mechanism and adjust query systems per customer's needs. When the customers groups are compared among these three companies it can be seen that Firm 1 has a wider range of customer groups from the other companies. Firm 1 generate the research

network in order to increase transaction among industries by creating synergy from data. The company has to maintain this network's infrastructure. Also, they are organizing educations and seminars in order to explain how blockchain technology can be used in customers' processes. The experts explain this with these words; "*But we are speaking with some of the biggest universities and academic medical centers so that we can teach them how to do research with blockchain. And so, it's not enough to sell them the blockchain and wish them well. We have to teach them all of the features on how to use it. And the best way for me to do that as a scientist is to do research with them and have them test out features that are new and scary to them. Blockchain is a different concept. And so, we have to help them understand how to design research so that they can maximize some of the features that blockchain offers that you can't get from central databases."* (Firm 1, Pos. 49)

Moreover, Firm 1 organizes hackathons or opens their sources in order to improve blockchain technology and supporting innovation environment in health care. With these activities, the firm aims to raise awareness of blockchain technology in order to use in research environments and increase the usage of blockchain applications in health care.

When Firm 2 is analyzed, it can be said that in addition to developing and maintaining the process of key resources, the company has to organize pre-selling and crowdsale in order to fund the development process of the company. After the sales, the company also manages this financial process to utilize effectively the investment. Another main service is also updating backup systems and organizing the distribution of bracelet systems. Firm 2 also provides brokerage service for researchers or producers. Therefore, the firm gets in touch with the patients in order to ask if they want to attend the research or they want to share their data. Moreover, the firm continues to develop their systems in accordance with health care providers' software needs.

On the other hand, Firm 3 has to build and maintain its blockchain and artificial intelligence infrastructure in order to develop own applications and provide service to other applications' developers and also feed their own data pool by collecting data. Also, in order to promote their own applications and attract the other developers, the firm uses the token. By using own token, Firm 3 generates passive rewards systems. Therefore, individuals share their data in order to earn money while application developers also earn money and get benefit from creating reward-based applications. This benefit is using the token as an attraction and advertisement tool for their applications.

Table 14. Key activities of the firms

	KEY ACTIVITIES
Firm 1	**Setting and Maintaining the Information Technology Infrastructure**
	Setting up blockchain and customizing consensus it in accordance with customer's or partners wishes
	Managing Main Services and Perform Activities
	Providing support to adapt blockchain in different process

Firm 1	**KEY ACTIVITIES**
	Promote the Platform to New Users and Increase the Benefits of the Platform
	Creating Research & Innovation Network and Maintaining infrastructure of network
	Providing Education
	Organizing Open Call or Being Sponsor
Firm 2	**Setting and Maintaining the Information Technology Infrastructure**
	Setting up blockchain and maintaining for health records
	Developing virtual room
	Developing blockchain for token service
	Developing bracelets systems
	Managing Main Services and Perform Activities
	Maintaining virtual room service and developing
	Organizing token pre-sale and crowdsale
	Updating backup systems and maintaining for bracelets
	Promote the Platform to New Users and Increase the Benefits of the Platform
	Provide brokerage service
	Developing software solution for healthcare
Firm 3	**Setting and Maintaining the Information Technology Infrastructure**
	Developing Blockchain
	Developing own applications
	Generating data pool
	Managing Main Services and Perform Activities
	Feeding data pool by collecting data from all applications in network
	Maintaining token rewards systems
	Maintain key service in accordance with applications
	Provide insight from data pools
	Promote the Platform to New Users and Increase the Benefits of the Platform
	Making advertisement of token reward systems in order to gain new customers

Key partnerships

Partnerships can be preferred for many reasons by companies. These reasons can be reducing costs, sharing risks, empower the products or service facilities, gaining more customers, using partners' facilities, increase the reputation of the companies. (Osterwalder & Pigneur, 2010). As a result of the

interview analysis, it is seen that these three companies make partnerships with four different types of partners. These are competitors, complementary institutions, governmental institutions, and universities. In order to clarify the type of partnerships, all categories can be explained in order. First of all, competitors include companies that are providing the same service or software solutions to health care. Therefore, they are information technology companies that target the same customer segments with the partner. Secondly, complementary institutions include the whole companies in health care except competitors such as hospitals, pharma companies, biotechnology companies, software companies that target different customer segments, etc. and other blockchain development association. On the other hand, governmental institutions include national and global health services while universities represent private and public universities.

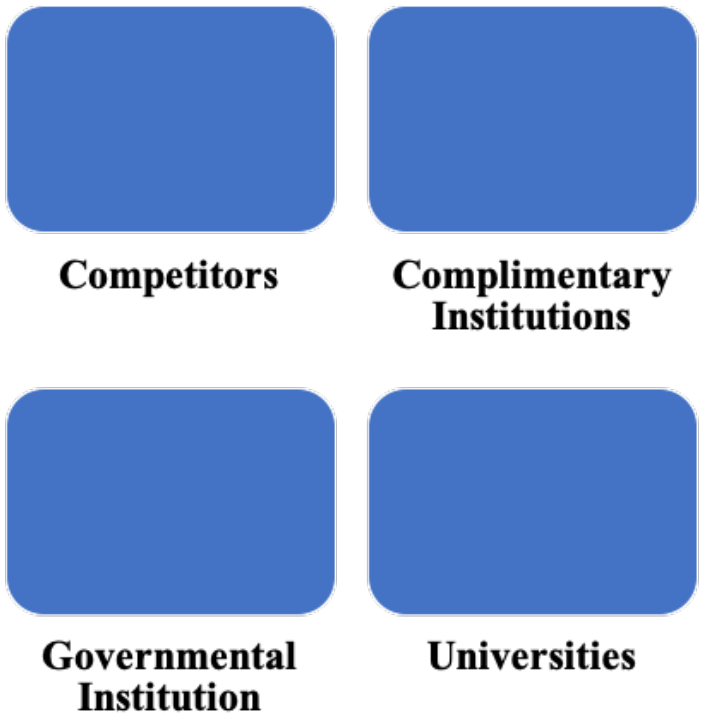

Figure 16. Categories of the companies' partnerships

All partnerships are made to generate different benefits for companies. However, all these aims can be collected under six categories. The firms' motivations to be partner with these industries are giving in Table 15.

Table 15. The firms' motivation for partnerships

Partnerships' Categories	**Firms**	**Motivation**
Competitors	Firm 1	-Improve blockchain infrastructure -Raising awareness
Universities	Firm 1, Firm 3	-Test Feature -Raising awareness -Develop product or service
Governmental institutions	Firm 2	-Create global health standards
Complimentary Institutions	Firm 1, Firm 2, Firm 3	-Develop product or service -Social Responsibility -Raise awareness -Gain customers -Gain experience

Professional from Firm 1 explain the motivation of doing a partnership with their competitors as building a bridge that can help to reach opportunities to increase the quality of data and increase the visibility of blockchain technology. Also, they say that it is too early to compete in the market because the blockchain technology is quite new and still, need to improve. Therefore, Firm 1 shows the tendency to make collaboration with even its competitor in order to improve its infrastructure. The expert from Firm 1 shared their co-founders' opinions about collaboration with competitors with these words; *"They believe that if they partner with other companies that are even competitors, that it improves the quality of blockchain research and improves the visibility of blockchain in the health care community, improves the nature of... I guess, data quality and opportunity cross industry, and so we do partner with some of our competitors. (Firm 1, Pos. 45)*

Firm 1 and Firm 3 choose also universities as partners. They agree on the idea that Universities can be good partner in order to test their software infrastructure. Also, Firm 1 provides some education for researcher in universities to explain designing research by using the blockchain technology and it support that these partnerships is useful to increase the visibility of blockchain technology among researchers. "*We are in the process of designing contracts to collaborate specifically with universities. Now, I came from a university background, and so I still have all my friends and contacts. And the research that I do involves research, university faculty. But it's not a formal collaboration yet. But we are speaking with some of the biggest universities and academic medical centers so that we can teach them how to do research with blockchain. And so, it's not enough to sell them the blockchain and wish them well. We have to teach them all of the features on how to use it. And the best way for me to do that as a scientist is to do research with them and have them test out features that are ..are new and scary to them. Blockchain is... is a different concept. And so, we have to help them understand how to design research so that they can maximize some of the features that blockchain offers that you can't get from central databases"* (Firm 1, Pos. 49).

Moreover, the expert from Firm 3 said that they had tried to develop product with universities however they could not be successful because the universities and its company expectations are

different and he explained these with these own words; "*Because blockchain in its nature is quite an exploratory phase. Universities and public research institutes look at trying to explore the technology to its maximum potential, whereas with business you do need to at some point look at a cost benefit analysis because indeed if we're investing in a certain project, we need to be able to see the clear returns and how we... how the money's going to be generated. What kind of cash flows we're looking at. So, it is a conflict of priorities, I believe."* (Firm 3, Pos. 40)

Even though the expert from Firm 1 said that they plan to collaborate with governmental institutions, during this moment only Firm 2 make a partnership with a governmental institution that is National Health Service (NHS). The relationships between Firm 2 and NHS can be described as a buyer and supplier relationships. Because Firm 2 helps NHS to create national health standards by providing a decentralized health information system. Therefore, Firm 2 advantages here is promoting its own blockchain based information structure as future standards and expanded own platform usage at the national level.

On the other hand, it is seen that all firms make partnerships with complementary firms. The reason for being a partner from the perspective of complementary firms that makes partnerships can be explained as wishes to outsource the blockchain technology in order to create value for their own business. These wishes will be explained deeply further. From the perspective of these three firms, the reasons or motivations for partnerships are mostly related to reaching more customers and expand own business. Firm 1 has varied complementary partners that help to expand own business in health care. The firm performs and provides own technology in all health industries by using these partnerships. Firm 1 is in partnership with a hospital's Chain, a crowdsourcing platform, a pharmaceuticals company, and a software company that produces digital therapy products. The interviewee from the firm explained how they gain customers and raise awareness of blockchain by using partnerships as a social responsibility of business with these words; So*, I'm mean, explain a little bit. I'm going to answer the next question about your partners main motivation at the same time. So ultimately what we've been talking about is how collaboration makes research more successful. And so, Firm1 has designed an entire platform about how you make data more successful with collaboration. And so, we realized that... what would we primarily gain? So, we gain tremendous satisfaction. We're addressing part of our mission because we also work with third world countries, not the governments, but we work with small healthcare companies or hospitals in Africa, for example, and some in India. And this provides an important piece of what we believe is our humanitarian mission in the world and how we can make. Firm 1 more helpful and more relevant in the world as well as we are a member of the United Nations Global Compact and Global Compact requires us to promote equality in health care across the world to promote educational development in third world countries and promote economic development. And so, this is an important part of our mission. In fact, it's such an important part of our mission that when we work with companies in Africa, we know that the standard of living is very different in Africa. They can't afford United States prices. And so, we give them our platform for free. And so that's... it's very important that... that's our way of enabling them to be more successful. And then each time we develop a partnership, one of the benefits that we gain is that we'd let that company know that we're going to help promote them. And when we promote companies on LinkedIn and other social platforms, that they get exposure and we get exposure for our humanitarian initiatives. And it's just... it's good news to share. But when we share this good news, other companies take notice and they say, hey, I want to talk to you, too. Maybe I want to purchase some of you. So, we benefit from the marketing of being able to do all of these*

connections. And the partners have benefited tremendously from getting access, especially for free to a platform. And we give them a lot of publicity, which is good for their marketing as well. So that has been just an extremely satisfying process in relationship. (Firm 1, Pos. 101)

Firm 2 is in partnership with a big medical group that is London, UK based. When the partnership had started, the company use this partnership as a big opportunity to reach a huge number of users while they apply their pilot application. Thus, they were able to use test their platforms before launching globally their own platform by collecting feedbacks from doctors and patients. The partnership has still continued as a part of the improvement and innovation process of the platform. Similarly, Firm 3 has a partner that is in pharma industry. Their partner also helps to develop products for pharma industry. The expert used these words to explain that; *these are based in the north of England region. And these guys obviously took on the products. They trialed it to give us feedback. And it was a bit of an iterative process of trying to fine-tune it. So, yeah, so we do... we do focus primarily on working within our own means and within our own structures using stakeholder feedback to try, you know, find key areas of development, try to find problems that haven't been sold for pharmacies and trying to develop something for them specifically.* (Firm 3, Pos. 52)

In addition to these, Firm 3 and Firm 2 are in buyer and supplier relationships with HyperLedger Fabric Platform in order to create blockchain while Firm 1 has own platform. This relationship helps Firm 2 and Firm 3 for improving capacity and performance of blockchain technology by being part of a network.

Cost structure

Cost structure of business model defines the main costs that are incurred during operation. Costs of companies can be classified as variable and fixed costs. In this sense, blockchain does not lead to the main changing for our case firms. Only, it can be said that blockchain helps to decrease companies' data capacity costs. That means companies collect own data on one data source and this data source allows to manage all data by using one API. Thus, the costs of licensing, subscription fees etc. are reduced. Also, the banking cost can be reduced by using own cryptocurrency systems that Firm 2 and Firm 3 have. Since, transaction fees and the loss of currency exchanges are eliminated or reduced significantly. However, it should be emphasized that the companies have not satisfied yet by using these systems because the cryptocurrencies have not reached the real potential. The expert from Firm 2 claimed this with these words:

"When we when we originally launched the company two and a half years ago. We are a big believer in blockchain. Obviously, we're a big believer, an advocate of cryptocurrencies. And we wanted to utilize cryptocurrencies or digital currencies to ease the transfer of funds from one area to another. So, the ultimate aim would be having a Turkish patient speaking with an American doctor. And it is hard for you to pay the American doctor in dollars from your bank account. Two or three transfers fees takes about one week. Crypto currency would facilitate that transfer much quicker, much easier with minimal fees. So, this is something we hope to do. But crypto currency in the meantime, has all come down, bitcoins down. Our Token is down. So, it's harder to use that as a funding mechanism at the moment, but it's something we still want to do. (Firm 2, Pos. 127)"

5.2. Summary and discussion of the results of the qualitative research

Pattern overview of health information companies and effects of blockchain on other stakeholders' business models in health care

As a result of the business model analysis of the three firms, it can be seen that these firms show different patterns. These differences are emerged because of the different customer groups and their needs, and also different solutions they want to create. It can be seen on the table each firm has the potential to affect some common and different stakeholders of the health care environment by generating value for them. Also, they have the potential to connect each of these stakeholders by exchanging data among them. Therefore, the networks that are created by these firms can help to create a connected healthcare environment.

Table 16. The overview of the firms

	Firm 1	**Firm 2**	**Firm 3**
Pattern	-Multi-sided platform -Open source	-Multi-Sided platform -Free usage	-Multi-sided platform
Affected stakeholders	-Biotechnology Firms -Universities -Medical Device Industry -Health Software Developers -Pharma Industry -Health Providers	-Patients -Health Providers -Researchers -Insurance Companies	-Pharma Industry -Health Software Developers
Rationale for Innovation in Health Care	Creating safe data share solutions to create a research network.	Empowering healthcare environment with patient data	Connecting Pharma Industry to health care environment by developing digital solutions.

These firms in order to generate value for own customers, perform innovation activities in addition to their own digital product or solutions. These innovations activities are making brokerage among researchers and patients to exchanging data, opening resources in order to develop products, organizing a hackathon to solve health care's digital problems, mentorships in order to design research by using blockchain technology, provide educations about blockchain technology. Thus, they help to enhance the healthcare innovation environment with data. This innovation environment is visualized in Figure 17. In Figure 17, it is seen a connection between Firm 1 and Firm 2, and Firm 1 and Firm 3. It should be emphasized that it is not real connections. These connections are shown in order to explain the position of Firm 1 in accordance with Firm 2 and Firm 3. Because the Firm 1 is a bigger blockchain provider than Firm 2 and Firm 3. While Firm 1's core aim is providing blockchain technology to health care companies, Firm 2 and Firm 3 use blockchain technology in order to solve health care digital problems.

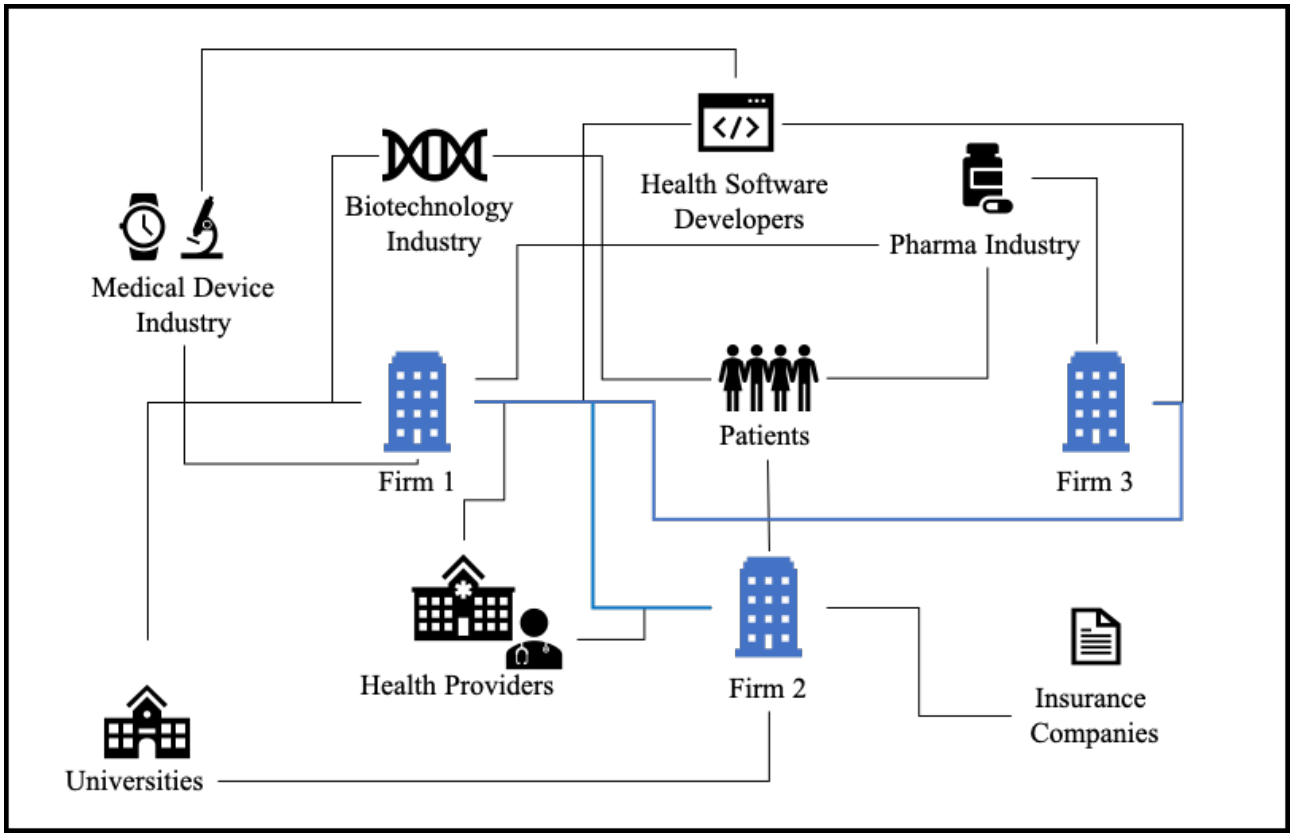

Figure 17. The connected health care and the firms' position

On the other hand, these companies help their partners to generate new business models by adopting blockchain technology in their process. That means, any companies in health care industries make partnerships with these three firms in order to improve some part of their value chain. As a result of these three health information companies' business model analyses, the effect of blockchain technology in health care businesses can be summarized in Figure 18.

<table>
<tr>
<td rowspan="2">Key Partnerships
-Increase partnerships opportunities by exchanging data
-Strengthen connection on value chain in health care
-Capacity to work on the same data
-High data integrity
-Inner-network payment and reward system</td>
<td>Key Activities
-Data Management
-Network Relation Management</td>
<td rowspan="2">Value Proposition
-Access for Its own data (For Patients)
-Transparency
-Access for autonomous data market
-High Security
-Vertified information and higher acccuracy
-Mobility for patient
-Generating automatic decision systems with artificial intelligence</td>
<td><u>Customer Relationships</u>
-Build trust is based on transperancy
-Creating communities/ networks
-Automatization in decision systems
-Self-service on data management for patients</td>
<td rowspan="2"><u>Customer Segments</u>
- New Customers Opportunities by shifting Multi-sided Customers</td>
</tr>
<tr>
<td>Key Resources
(In addition to other resources) Data and Network</td>
<td>Channels
-Reaching new customers by using network
-Shifting indirect channels to direct</td>
</tr>
<tr>
<td colspan="3"><u>Cost Structure</u>
-Minimize transaction cost
-Minimize licencing cost
-Reducing administrial cost of clinical trials by eliminating intermediaries
-Reducing cost of market research
-Reducing advirtising cost</td>
<td colspan="2"><u>Revenue Streams</u>
-Transcations-based pricing
-Crowdsource with cryptocurrency
-Additional revenue by data selling or brokerage</td>
</tr>
</table>

Figure 18. The blockchain effects on health care business models

First of all, blockchain technology can be used by companies in order to reach new customer segments since when any healthcare companies start to use blockchain technology, they become a part of the network and they start to collect data that can be useful for other stakeholders. After that, they can get in touch with more customers and also other healthcare stakeholders by using easiness of blockchain on data sharing. Therefore, this technology always provides to opportunity in order to expand its customer segments and increase the number of customers. In order to reach new customers and its current customers, companies can generate new channels by using blockchain networks. Also, Companies, such as information technology that could not have reached the patients directly in the traditional model, they can start to reach the patient by eliminating intermediaries' institutions.

While blockchain helps to create communities and networks in health care ecosystems, also it brings transparency in the transactions. As a result of that, more open and trustful relationships can be built among patients and health care companies and also among health care companies. As it can be seen in the cases' companies, many platform and business process can be supported by artificial intelligence. Thus, creating automatic decision systems is possible by using the blockchain structure that is supported by artificial intelligence.

When the healthcare companies are adapted the blockchain technology in their business, they automatically add data management to their key activities, since the companies collect the data from their business process or their patients, they have to manage which of data will be shared while the other data are stored as private. Also, they have to decide the receivers of data. Moreover, ownership of data can be completely changed. While in the previous health care systems models, health providers such as private clinics and hospitals were the owner of the patients' data, the companies which use blockchain technology and shift their business model to patient-centric prefer to give ownership of data to patients. However, they continue to collect and keep patients' data with permission of patients.

Also, the companies utilize the benefits of a network that is created by blockchain. Transparent, secure, and easy share of data in networks, strengthen the relationships among partners. Frankly, blockchain makes it possible to connect all healthcare system's suppliers, providers, users, financiers, and regulators with the power of data. Therefore, a new environment supported by the blockchain network has the potential to create new partnerships or enhance the connection among exist partners in order to utilize sources.

When the cost structure of possible new business models is analyzed that it can be said that blockchain can reduce some variable cost of companies. First of all, as it is mentioned in literature several times, the blockchain technology can reduce transaction cost. However, it should be known that this reduction effect can be only worked when the company has enough transaction numbers because an investment is necessary to develop and maintain. If the transaction numbers are not enough to amortize investment, owning blockchain is not meaningful for small enterprise. But they can outsource these technologies by being a customer of companies such as Firm 2 and they can get benefit of this technology. On the other hand, Blockchain technology can be reduced cost of administration and marketing research by eliminating intermediaries because all nodes, companies, and patients, can reach directly to each other by using a network. This network effect can be also useful to eliminate advertisement costs because if the companies are part of a network such as Firm 1 provide, they can quickly find a partner and they can reach the participant of their research. Moreover, they can generate some complementary product or application by using a network such as

Firm 3 does in its applications, and they can attract the other users or customer that is called as bait and hook patterns (Osterwalder & Pigneur, 2010).

Blockchain can have two main effects on health care business revenue stream. The first one is creating transaction-based pricing by tracking the companies' activities on platform and network. Also, companies such as Firm 2 can create a fund for their business by using cryptocurrencies. Also, they can get revenue by making brokerage among companies and patients or among companies.

As can be seen from the effects of blockchain on the business model canvas (Figure 17), most of the benefits of adopting blockchain technology in business models are generated from being part of a network. In this sense, companies in health care have two options in order to build a blockchain structure for their own business. The first one is creating own blockchain platform by being partner or customer with membership service providers such as Firm 1 or Hyperledger Fabric. The second is participating in a network by being a customer of blockchain-based platform business, such as Firm 2, or being a customer of decentralized application developers, such as Firm 3. The differences in the first options and second options are customizing the blockchain structure. More clearly, Firm 2 and Firm 3 provide their own blockchain-based systems in order to integrate customers' own business while Firm 1 in addition to this can develop a more customized blockchain design in accordance with the partner's wishes. Therefore, any health care companies desire to use blockchain technology in more specific purpose, they should prefer to Firm 1 instead of Firm 2 or Firm 3. The benefits and motivation of choosing first options to be part of connected health care environment are summarized by the partners as using the membership service providers' experience and data pools, minimizing design issues, speed up the adaptation process.

First of all Partner 1 explained how they used the Firm 1 experience and data pools in order to design own model with these words; *Firm1 is ...we use them primarily as a kind of a leapfrog opportunity that had a lot of the platform already built out that knew we needed. They had a robust data repository that included a health care type of model. They already had a lot of the analytics types of tools that we wanted on top of that. And so, we engaged with them to do a custom build out at the analytics stack. And again, the blockchain piece was part of technology stack. So, the course about a year, we worked with them to do that. In 2018, we implemented platform. Actually, we did the initial implementation first quarter twenty eighteen. So, there's really less than six months from start to go until we were working with it. So that that's sort of the history and again, identify as one of our key partners. (Partner 1, Pos. 4).*

Also the partner of the firm explain that since Firm 1 has already worked similar data analysis tools and they have already many experience with design blockchain based IT solution health care, Firm 1 helped to solve design issues and these help increase the total time of adapting and designing process with these words; *In the... when the company was first formed in February 2017, there was a review of the technology in approach that our parents firm had used to do the work they had done when they developed this approach, this methodology. It was largely based around an enterprise data warehouse and using tableau to do various reporting mechanisms. Was pretty quickly determined that would not scale and it really wouldn't be viable in a commercial market. We're bringing multiple customers. It wouldn't be a good multi-tenant type environment for the repository. It just wouldn't. It needed to be redone, refactored rebuilt from the ground up. The CEO of Partner 1 was hired in July of that year and he quickly realized, yeah, we're going to have to rebuild that. The Firm 1 was brought in to say, OK, we need to do this, and we need to do it quickly. And because they already had many*

of the key foundational components, including the blockchain. But some of the other things I mentioned earlier, we realized that by bringing them on we could really get a functioning stack, a functioning product very quickly. And in fact, that's what happened. We managed to get from their involvement actually up and working on... on a viable platform and under six months. So, the initial choice was that speed to an MVP speech, a useful type of product. Now, the ongoing strategic piece of this is as a small company. It's good to have a partner that can kind of flex up and down with you as your needs change. So, they were able to add or reduce up and down on soft engineering resources that also provide a great depth of knowledge on information security, which also relates to blockchain fees. So, as a small, innovative company, it's good to have a partner who can help. You know. Really, you're not relying on trying to go out and hire a bunch of people that they want (Partner 1, Pos. 16).

Although all of these benefits of blockchain technology, companies can face some challenges and limitation during adaptation process of blockchain in their business models.

Challenges and limitation of blockchain during adaptation in healthcare business models

Challenges sometimes can be related to both blockchain technology, and patient-centric new business models that are created by blockchain. These challenges can be generated from the reasons, that are behavioral, environmental and technic reasons.

All interviewees, included partner of Firm 1, agree that bias and lack of knowledge about blockchain technology are one of the challenges to make a decision to use this technology. There are many doubts about the performance and capacity of blockchain technology. Therefore, the companies behave timidly for making an effort to adapt or use this technology. Partner 1 explained own concerns and reason of his concern with these words; *Well, let me give you two examples. One example is for me coming into it, blockchain was actually new technology for me. I'm certainly aware of it, but I hadn't done any hands-On type of work or business experience where we were using blockchain to leverage it prior to coming in third. So, for me, there is a little bit of a learning curve. And it was not clear to me in the first couple of months what the real benefits would be for us and whether it was going to be more trouble than it was worth. That was one of my initial concerns, is that it could just be unnecessary overhead. Performance was a concern. And I... you know, I had heard really bad stories about how bad performance could be in blockchain tax environments.* (Partner 1, Pos. 32)

Also, from health providers perspective, expert from Firm 3 said that physician suspicious about sharing the all health data with patients because of information pollution. They are afraid that this openness can be led to wrong treatment when patients reach some information by using searching motor. He explained this with these words; *There's also an aspect of doctors sometimes doesn't necessarily want the patient to have all the data that they have access to. They believe that, you know, this could... for example, open up issues where the patient sees some data and they actually go out and start Googling their symptoms or Googling some issues on the prescription, etc. I think is, yes... So, I think that all aspect that you have to develop an interface for each person* (Firm 3, Pos. 99)

In addition to these biases, there are some environmental difficulties that are related to regulation and political decisions of different countries and internet connection. All of cases companies works in global scope. Therefore, all companies have to adjust their consensus mechanism in accordance with government rules. The experts explained these situations with their experience in different countries.

"It depends on the country's attitude. I know when we spoke to the Chinese health system, for example, they said that they're not there yet with the idea of patients owning their own medical records, but they were happy for patients to access their medical records. Again, in the Middle East, if you go kind of blockchain systems, it's a decentralized, distributed way of handling data. But in a country like in middle east, the government wants to hold all the information and doesn't want this decentralized or distributed against different people." (Firm 2, Pos. 151)

"I will add a wrinkle about a challenge that that you may not have thought of when we offer services to third world countries. There is often political instability. And so, what has happened to us is that like we have companies that we are assisting in Nigeria and the Nigerian government is pretty corrupt. And the US issued new sanctions against Nigeria. And so, then we had to back off the services that we provided. We couldn't provide as much individual help because then that would violate the United States sanctions against Nigeria, which was a huge challenge that we didn't anticipate at all. And we're just trying to help health care clinics. We believe in the greater good of health, but it still was a service that was being provided that had financial value. And that is not permitted under your current U.S. sanctions." (Firm 1, Pos. 113)

Moreover, Firm 1 added that all countries facilities can be changed country to country. The Internet connection is very essential for blockchain based business because all information collecting and stored in an online network. But in some countries, especially in third world countries, are unstable. "*You know, one other one other challenge I could share, too, is that you need the Internet to be able to connect to our blockchain. And in countries or neighborhoods that have unstable Internet connections, they can't connect as consistently as they would like to an Internet based blockchain which is stored in the cloud. And that has been a challenge that we have no capability to address but is inherent with any Internet based service. And so, we are looking at options for, you know, can any of the software be downloaded? Don't think so, cause the blockchain works by increasing the ledgers which are stored in the cloud. But we're trying to figure out some way to help organizations that have unpredictable Internet access." (Firm 1, Pos. 113)*

Also, all firms think that blockchain technology has a complex architecture. Especially in the healthcare environment, there are many stakeholders wants to work on the same data, but they also interest different part of these cumulative data. Therefore, all stakeholders have different permission to read, proceed, and share. So, this multi-sided environment makes the design quite complex. Moreover, because of this complexity and blockchain's novelty, finding engineer that can design this architecture is mentioned as difficult and expensive by Firm 2.

"So, I think that all aspect that you have to develop an interface for each person. So, you know, because in our business model, idea we have the pharmacies, we have the patient, we have the doctors. You can also, in addition to that, have potentially the regulator being involved the CCD, which is the clinical commissioning groups being involved. So, each of them has their own agenda when they're looking at the prescription and looking at the whole network. So, the doctors obviously want to write a prescription and be assured that there won't be any tampering with any of the data on that. The patient wants access to be able to choose which pharmacy they want to dispense, subscription on, etc... The pharmacy obviously wants to make sure that they receive exclusion and they are paid for whatever they are dispensing. But then you've got people in the clinical commissioning groups who don't certainly care about the individual patients who care more about which drugs are being prescribed in the local area. So, I think the biggest limitation is the whole

interface of it. You know, you're ...you are introducing new stakeholders to the group that you need to think about." (Firm 3, Pos. 99)

"The challenge has been trying to find the developers with the special... specialty skills of doing blockchain. They're not easy to find and they're not cheap to find either or to fund." (Firm 2, Pos. 112)

Even though the experts from Firm 1, Firm 2, and Firm 3 did not mention about any limitation of blockchain technology, Partner 1 said that generally, blockchain technology which is used in all industries have performance problems related to integrating data from many different sources. He thinks that this can be an important issue in order to solve. On the other side, Firm 1 mentioned about the data (file) size that can be stored in blockchain is limited up to 13 megabytes, but they are solving this problem storing the point link of these files on blockchain. "*Now, the one challenge that we have with images is that we can only store a file up to 13 megabytes at this point. And of course, many images are gigabyte size. Those are files that we store in a data lake and then just point to that file on the blockchain. We store quote. Absolutely anything you can imagine. And we can connect any electronic system that has an application programming interface."* (Firm 1, Pos. 117)

Future direction of blockchain technology in health care

Although all these challenges and limitations, all interviewees consider the future of blockchain technology as a promising structure. Especially during and after COVID-19 Pandemic, they think some changes come with blockchain technology in health care and other industries. In order to support their idea, they gave some examples of how blockchain is used to fight with COVID-19. In accordance with interviewees examples, it can be seen that blockchain technology play role to develop drug, vaccine and at the same time it helps to take under control of the spread of the virus by monitoring the infected people. The interviewee from Firm 1 explained that one of their partners how used blockchain and artificial intelligence in order to develop drug for corona virus.

"*There's another aspect of where I think that blockchain will help with the Coronavirus specifically, and that's with federated drug development. So, the concept from that arose from Melody, which is machine orchestrated learning for drug development. And with that technology, there are ten different pharmaceutical companies that are sharing their molecular discoveries on blockchain. But when I say sharing, I'm... I should say they're placing their .... their molecular discoveries on a blockchain, but they are not allowed to see each other's molecular discoveries and they're just applying machine learning in order to learn from the aggregate."* (Firm 1, Pos. 168)

Also, she explained that how the blockchain technology and machine learning can be used in order to estimate the next outbreak of the virus. "*So well, with the Coronavirus, we actually have outbreaks pretty much everywhere now, but it's believed that watching can a while... I don't know if you were aware of this, but the country of China used blockchain to collect information about the coronavirus spreading there, and it's believed now. But that's really opening the doors for public health surveillance as well. And that you can use things like Google search terms about what kinds of symptoms people are searching for and what geographic location you can look at. Weather patterns, you can look at symptoms that people are reporting in social media forums and you can use these pieces of information and machine learning to try to determine where the next outbreak is going to take place. Blockchain again space solution for bringing all that information together."* (Firm 1, Pos. 176)

Partner of Firm 1 also said that this monitoring can be used as a global system. And the effects of the next pandemic can be minimized by being stopped earlier. "*that could be something that's truly a global ecosystem. And that would mean whether it's whoever, you know, government issues aside, if you've got health care agencies and China. signed up and reporting, then you get that data out there real-time is things tend to spread across from one country to the next. You have better, more Real-Time visibility of that. It's me that that's... that's where. I can see a real opportunity and I think people hopefully will wake up to the need to do that coming out of this."* (Partner 1, Pos. 66)

The companies also agree with the health care business models also make investment to remote consultation and medical treatment structure because this pandemic also shows that health systems needs to this kind of investment and models. *"I think health care year upon year is having a record level of investment in Europe and in the US internationally. Even this is investing more into health care and see this being a big profitable market. And I think blockchain is going to be an important role in that going forward when it takes off as an industry norm in the financial sector or insurance sector. Healthcare will naturally follow as well. I think you can already see the uptake for technology, which now this pandemic, everyone is moving to remote consultations, video consultation because of the doctors who are self-isolating, all the patients are isolating and our product x (he said the name of their platform), which we just released last Friday. It's been one week leaved out and the system is being used by other countries. So, people are much more happy to adopt this technology because they need it rather than waiting a long time for it."* (Firm 2, Pos. 195) The expert from Firm 1 also said that while the companies make investment to remote medicine and new products and business models are developed, these can be good or bad for small business in accordance with governmental manipulation. "*I think it will affect people at having to do things more remotely. I think the other point to take as well is it could be a good thing. It could be a bad thing. It could be a good thing because it opens up the playing field for anyone who's a small business, who has a quick innovation to launch quickly and get learnings very quickly. But it could also be a bad thing because governments are very desperate to find any solution which works. And they might offer the main contract to one big company, which is going to monopolize the area and not let other small companies get involved."* (Firm 2, Pos. 199)

Additionally, Interviewees agreed that there is some possible usage of blockchain on social innovation that is related to health is possible for the future. Even they shared some current applications as an example of social innovation. The interviewees from Firm 1 and Firm 2 shared similar examples that how blockchain technology can be applied to control travel during any pandemic. According to experts, blockchain can be used to create a health passport or wallet and people can use this digital passport in order to prove they acquire antibodies. Thus, people's travel right is not held down. "*So, you know, people go into the shops and going, however, web blockchain potentially might have a benefit is where people, for example, travel. So if you're traveling abroad, some countries might start, especially when travel restrictions in east. I know, for example, in the states, then they might start introducing checks. Where has this person had coronavirus? Have they not had coronavirus yet? You know, are they currently carrying coronavirus? You know, who knows? So potentially blockchain might help with these kinds of checks or somebody goes to the doctor. You know, they provide them with a certain confirmation that they have had coronavirus and they are now immune to it. For example, blockchain can be used to as a kind of framework to spread this information so that people on the other side that are relying on this information can be assured that this information has not been tampered with. There isn't any source fraud within that. There is a clear*

chain of command between the test and then the result and the confirmation. But in terms on the micro level, within cities and within people's interactions, you know, I personally can't see blockchain having an effect." (Firm 3, Pos. 112)

On the other hand, the experts from Firm 1 shared an application which help to people find a partner. The originality of the applications is using the blockchain technology in order to prove both sides healthy. That means every users of application can prove that they do not have any sexual and contagious disease. *"There are some very unique applications to blockchain right now that I think will get expansion. There's a company called Loly.io l o l y dot i o I believe, and it's a blockchain based dating website It's not dating in the sense of not dating. It's more of a hookup site to find instant gratification. But they use a blockchain based application in order to provide informed consent for sex. And you have to provide some details about your health to ensure to your prospective partner that you don't have diseases. Well, why not add an additional question about your current prospective illness or your exposure to illness? because People are using blockchain based applications in so many creative ways now, why not see some innovations in different aspects of social?"* (Firm 1, Pos. 189).

Conclusions and recommendations

1. Health care industry has started to change the approach to more personalized treatment that is called precision medicine. This change is not affected only products, treatment, and medicine but also effected business models in health care. As a result of the literature analysis, it is seen that all actors of health care are digitalized their business process in years. Also, it is seen that their interaction increases in years in a sense of innovation. Especially, this interaction that is between the pharma industry and the biotechnology industries affected the biotechnology industries' business models.
2. Information technologies are the key factor that helps to shift to precision medicine in health care. As information technology, blockchain with the capability of a decentralized ledger, transparency, security, data integrity, and scalability can be used to integrate personal information of patients and connect the health care stakeholders around these data.
3. In this research, information technology companies' business models that provide the blockchain technology to health care ecosystems are analyzed in order to demonstrate the role of health information technologies in the new ecosystem and demonstrate to blockchain effects on new health care business models by showing the values that are generated by these information technology companies. Also, this analysis was performed to see if all these new business models can affect the innovation environment.
4. As a result of empirical study, blockchain technology can change the companies' customer segments by moving them to the multiple-sided network since blockchain technology helps to create new channels which help companies to reach new customers. Also, companies can find new partners by using these channels and networks that strengthen relationships with the help of blockchain's scalability and transparency. Moreover, it is seen that the blockchain structure that is supported by artificial intelligence and machine learning such as Firm 1 and Firm 3' examples helps to create autonomous decision systems. This system helps to improve health care service by minimizing human mistakes and also support the product development process by gaining insight from anonymous data that is created with the contribution of companies in the network. Additionally, in a sense of financial part, blockchain can be used for changing the pricing methods as transaction based. Also, payment and funding systems can be developed by using cryptocurrencies.
5. Moreover, it was seen that health information technologies can be transformed with blockchain from only software developers and software providers of health care to network creators of health care by using the platform business models. Since the companies' key activities and key partnerships were analyzed that it was seen that the companies do not only sell their technology but also organizing hackathons, open calls and provide brokerage service and open source in order to meet researchers and patients and help to find the partner for firms to work collaboratively.
6. Additionally, it was seen from the current partnerships of the companies, it can be said that blockchain-based information technology companies can enhance collaboration among competitors. Because the platforms, such as Firm 1's platform makes possible to work on the same data without sharing companies' private molecular discoveries to other competitors to develop the drug. This situation can be possible for medical device industries if they move the necessary data to the network.
7. Also, it was seen that although biotechnology, pharma industries have started to make the investment to be part of these developing networks, it can be said that medical device

industries have not been a real participant of these networks during this moment. On the other hand, from the health provider business side, it looks that they show intense interest in remote medical service products. Especially after COVID-19 pandemic, this interest shows sharply increase according to interviewees' explanations.

8. It can be said for the future of blockchain in health care that the usage of blockchain technology can be increased. However, it cannot be forgotten that this technology is still in the developing process. Therefore, there are still some performance issues that exist for blockchain and it is hard to say that this technology is only and unique solution for health care. However, during this moment it is the only system that is developed with support from many industries in order to generate a decentralized information system. And, especially after this COVID-19 pandemic, it is seen that the healthcare system needs this kind of solution in the sense of public health and innovation.
9. To sum up, blockchain technology has the power to enhance the innovation environment by creating a network among health care stakeholders. The role of health information companies in this environment is providing blockchain technology, creating the network, and supporting the network with brokerage activities.

Recommendation for health care companies: The companies should be analyzed what kind of value they can generate by using blockchain in accordance with possible effect of blockchain in their business model. For example, they can want to reach new customers, or they can keep the same their customer segments, but they only want to create new channels to reach them. In these situations, they should decide if they should build their own blockchain or if they can outsource it. Because this decision automatically effects the companies cost structure. On the other hand, companies should consider seriously to be part of these developing networks in order to survive this innovative environment. Blockchain can be a useful structure to make effective partnerships, solve the bottleneck of their product portfolio, minimizing cost, speed up the research process.

Also, medical device industries should see the gap in remote medicine, and by using the network power of blockchain they should consider creating products that are related to remote medicine and they should consider using a blockchain network for collaborative working. Small enterprises can get more benefits by being part of these networks.

Recommendation for further studies: In this study, only healthcare information companies are analyzed. For further studies, it is recommended that working on the companies from each health care industries that are a stakeholder of the health care environment and analyzing their value chain to gain more deep understanding.

Also, these examples of companies provide service in the global scope. Therefore, the results are global. for further studies, these global firms' effect on national health care and effect on small-medium local enterprises can be analyzed.

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Appendices

Appendix 1. Transcript of interview with Firm 1

1	**Tugce**
2	Thank you again for accepting my interview's invitation and the first of all, I want to ask you, could you please tell something about yourself and your company, Introduce yourself.
3	The Interviewee 1
4	Yeah. I'll start with myself. My name is The Interviewee 1. I have a PhD in clinical science with a specialty in health information technology. My background is as focuses on clinical research. I either conducted clinical research or oversaw clinical research for about half of my career and more than half my career. And I also was responsible for regulatory compliance of clinical research. And so my thinking has always been from... like when I work on projects including blockchain, that when you start planning your project in the beginning, you think of the compliance solutions all the way through the end.And just like with the GDP PR, with privacy by design, I believe in compliance, by design. So that's probably going to influence some of my answers. I've been involved in blockchain for three years and I serve on a number of international committees. I am the co-chair for an eye. Tripoli Life Sciences Research Working Group to develop standardization for blockchain across life sciences organizations. I am very active in the Government Blockchain Association and let's see, I have a role in the state of Colorado to teach blockchain to institutions of higher education.And so in December, I became the chief scientific officer of Blockchain Research. Blockchain Healthcare Company. And I lead the life sciences division for that company.And the organization the company that I work for was designed... designed its blockchain from scratch. It does not use any of the popular commercial blockchains like Bitcoin or hyper ledger. It was designed from scratch to be compliant by design with privacy regulations. And so we specialize in health care because there are so many more privacy concerns for health care information than there. There might be for other uses of blockchain. And with the life sciences division, I work with life sciences companies, universities, academic medical centers to help them understand and implement blockchain solutions that would enable research data to be more effective.
5	Tugce
6	...in this research can we mention about your company's name ?.
7	The Interviewee 1
8	Yeah, sure. I work for Firm 1.
9	Tugce
10	So it's also I want to ask something about Firm 1 because its business model is very interesting.
11	The Interviewee 1
12	Oh, good.
13	Tugce
14	Yeah. So, I want to learn as well. Who is the... What... what is Firm 1 really do and who is their customer? how they get revenue?
15	The Interviewee 1
16	OK, so what? Firm 1 has some features that make it really special. So, one feature is that it can you can customize permissions at a very, very granular level and have multiple layers of permissions. So that works really well in both healthcare and life sciences because a patient can specify who they want to share their health information with or they can specify what types of research or not types of research they can give access to their entire medical record or a certain date frame timeframe of visits, or they can give their record, but not one data point or only one data point. Its can be very customized and for Lifesciences organizations. One of the aspects that makes it so appealing because of the way that we design permissioning is that an organization can store data on the blockchain, which is also something else that makes us very unique, is being able to store data directly on the chain.But then with. Lifesciences organizations, they can allow access to analyze data that are stored on chain, but not actually see not let other people see the data or to download it. It's just like you run an

	analysis and you get this wealth of data, but you you're not allowed to actually see certain data points that would constitute individually identifiable data or protected health information. And so, it's really... it allows them for Federated Learning, where organizations can collaborate and use the same data for machine learning, but not being able to see each other's individual data points to protect the intellectual property.
17	Tugce
18	I am ... they can see it as the cumulative information for analyzing
19	The Interviewee 1
20	Yeap. All right.
21	Tugce
22	And there are data of anonymous people.
23	The Interviewee 1
24	Yeah. Yeah, exactly. And you can grant permissions to see certain variables, but not certain variables. But you can still run analysis on the aggregate and you can get means..and... like it all the same measures of central tendency. You can run all the same statistical analysis. You just can't see certain individual data points to protect the privacy of those individuals.
25	Tugce
26	So that's mean your customer are only individuals like a patient who wants to share data you get, for example. Can you get the money from them to use their platform or it's kind of free platform.
27	The Interviewee 1
28	the platform we currently. So the way sorry this addresses more of the business model question. So, we actually give access to individuals who want to get started like startup companies. We give them access to our development environment for free for the first year. And then we ...for companies that want a more professional solution or longer term, we charge for all the development services to build in the solutions that they are looking for. And then we charge a transaction fee of half cent per transaction that's conducted on the platform. And you know, it's any of the create retrieve update. Something else that makes us unique is that it is theoretically possible to delete information from our fortune. It's very, very difficult to do. And the our company has to be involved in order to protect the integrity of the data so that our users can't delete it. We have the capability of going in and deleting certain information. We had to build that into the solution in order to be compliant with every facet of GDP.
29	The Interviewee 1
30	The right to be forgotten.
31	Tugce
32	So we can now continue to our real questions.
33	The Interviewee 1
34	Okay. Sounds good. Yeah.
35	Tugce
36	OK. So, first of all, I want to start from questioner part. Do you have any research laboratory or product development units?
37	The Interviewee 1
38	Not really.Now, we do have an active developer team, but we don't have... we don't have a specific unit that would be creating new products.
39	So that's reason I will skip the second question. Okay. You don't have .

40	The Interviewee 1
41	Sure.
42	Tugce
43	Does or Did your company cooperate with complementary firms in your industry?
44	The Interviewee 1
45	Yeah, we. OK. So this stems from the owner is Frank Recorder with Brian Jackson. And they have a philosophy that a rising tide lifts all ships. So they believe that if they partner with other companies that are even competitors, that it improves the quality of blockchain research and improves the visibility of blockchain in the health care community, improves the nature of... I guess, data quality and opportunity cross industry, and so we we do partner with some of our competitors. We use our blockchain where you can add data. But the competitor can't see it. (laughing) And... and then we share our scientific resources to design research. And... and we haven't gotten the publication out yet, but we definitely believe that it's ..it's too early to start competing. And if we start competing and saying negative things about competitors, it will drag the whole industry down, which makes it difficult for any of us to prosper.
46	Tugce
47	And so does or did your company also collaborate with universities?
48	The Interviewee 1
49	We are in the process of designing contracts to collaborate specifically with universities. Now, I came from a university background, and so I still have all my friends and contacts. And the research that I do involves research, university faculty. But it's not a formal collaboration yet. But we are speaking with some of the biggest universities and academic medical centers so that we can teach them how to do research with blockchain. And so, it's not enough to sell them the blockchain and wish them well. We have to teach them all of the features on how to use it. And the best way for me to do that as a scientist is to do research with them and have them test out features that are new and scary to them. Blockchain is... is a different concept. And so, we have to help them understand how to design research so that they can maximize some of the features that blockchain offers that you can't get from central databases.
50	Tugce
51	And another one does or did your company collaborate with the public or private research institutes or laboratories?
52	The Interviewee 1
53	Sure. We're working with two public universities right now and one private and in the sense of work, kind of trying to get the contracts in place so that we can collaborate with them. But I do. Here's another one that I do. I am currently mentoring a student at the United States Air Force Academy and it is for her student project and her data are stored and managed on the blockchain.
54	Tugce
55	But it is related to medical health care.
56	The Interviewee 1
57	It is. It's a public health project where she is studying toxic exposures of military personnel who are assigned to different parts of the world. It's usually where they may have received exposure to toxic chemicals as part of five different types of warfare. And so, we're using the blockchain to aggregate information and be able to perform machine learning on that, collaborate collaborative data.
58	Tugce
59	And does or did your company cooperate with the governmental institution? Not yet. Not yet. But you are. Or we have you here.

60	The Interviewee 1
61	Yeah, we are definitely talking to some about having them use our blockchain, but we haven't gotten to the contract stages yet.
62	Tugce
63	And now interview questions part. How your company attends innovation activity in health care?
64	The Interviewee 1
65	So, OK. I see your examples. An open call, arranging hackathon. OK. So, we've done. OK. So, first of all, the product itself that we use is very novel for health care. And it has been ...What is... I'm just making sure I don't answer some of the other questions. OK. So like, for example, we've placed a blockchain underneath the electronic health records system for Intermountain Healthcare and it's a twenty two hospital, one hundred and eighty clinic system in Utah, United States. And they were able to aggregate data from not just electronic health records, but from the billing system, from the H.R... human resources system, from the supply management system, and then correlate different features of surgery like time to clothes versus how much equipment they used during the surgical process and how much it cost for each surgery. And they broke it down by time. The number of staff, the equipment, the supplies, and were able to identify outliers, educate the surgeons that they were doing things that were not standard for what other surgeons were doing. And over three years, they saved ninety million dollars us. So that's a huge amount of money. And as a result, we have partner Intermountain Health Care has created a spinoff, which is a new product or health care. They offer a service to do that same type of analysis using blockchain connected data for other hospital systems. And so that is definitely one new innovation that we have been part of in order to raise awareness. We have done hackathons on using our blockchain. We are gonna be rolling out this week, as a matter of fact, a new research. Collaborative environment that's free two researchers from around the world to work together to try to solve problems related to the corona virus and beyond. It's not this..the Corona virus is a temporary problem in the span of health care. We are hoping to learn in targeting Corona virus. We are hoping to create new blockchain based solutions that would be able to prepare for the next pandemic and the next outbreak. And in order to get people to use the blockchain and work collaboratively together, we're offering that free. So I hope I...I think those are some of the primary examples of new products and services that we offer.
66	Tugce
67	OK. Did you start or any initiative to, you know, a new product or service for healthcare, maybe as a result of such a hackathon or something? Did you start to any process for innovating something maybe you got any such as a medical device company or pharmacy company to start creating some new drug or device now?
68	The Interviewee 1
69	Not not yet. Not not a device that would be specific on its own for health, but definitely some new ways of using blockchain.
70	Tugce
71	But also, it can be not just have to be device or drug can be in software or an application, anything which you can imagine.
72	The Interviewee 1
73	Well, we do have a product that we developed as a response to some of our clients in healthcare. We call it a sandbox. And it's an environment that companies can create and control for themselves, where they'd let in additional people who want to test and experiment and to create their own federated learning, their own exponential learning. And so companies can design that and see what people create. We just it for our efforts. Thus far, it hasn't resulted in like a new.. and a new health care mechanism. So...
74	Tugce
75	So until this time you didn't do this kind of collaboration and you didn't start anything. But as I understood from your company's business model in the future, this is this looks very possible. So, do you plan cooperate with companies in this industry to create something. Do you have any plan for doing this?

76	The Interviewee 1
77	Well, that's certainly a hope. That's certainly what we're trying to do right now for a rollout for Corona virus. It's ...blockchain in itself is a data management solution. So it's about how are... it's really about people coming to the table to use our technology to be able to innovate. And we definitely believe that it will influence health care in more ways. Like I specialize in how to design clinical trials to include blockchain, which helps manage data collection and access throughout the course of an entire multi-center trial and how the data have much more. You can enhance the capabilities of what you can study from the data as well. That's. Yeah. It's really a data management platform with data capabilities, and so I guess where you would be able to innovate to create new products is by.. by having more access to data and then trying to answer unique questions by having big data and being able to do machine learning or just having access to more information.
78	Tugce
79	So actually, in here, I want to ask what is the role of blockchain companies like you in the product development process in healthcare? So just we can say the providing data or... selling the technology.
80	The Interviewee 1
81	It's really designing a way to manage data very differently than traditional databases. And so, yeah, like we in the blockchain community don't have the knowledge to create new drugs that has to be done by pharmaceutical companies and their chemical laboratories. But we can help them do more with the data they collect and we can help them collaborate with other companies so that they can do more with this collected data. So I would say that it's really about creating that that environment where people can be, can brainstorm, can be more successful with using the data they have.
82	Tugce
83	So... for example can I say, creating network is the role blockchain technology in here?
84	The Interviewee 1
85	That's true. Yes, it definitely does. Well, blockchain in itself is a distributed network. And so, when you apply that to a medical setting, it's about how do you maximize the capabilities of the network and all of the individuals on the network. And so that's what we do really well, is to be able to bring organizations together, managed data in ways that still protect privacy.
86	Tugce
87	OK. Could you explain what is the difference between blockchain based information companies and traditional information companies? And then what's kind of dynamic capacities do they have in sense of innovation?
88	The Interviewee 1
89	Sure. Well, traditional information companies design data to fit in unique fields like if they design software, then they are looking for a specific field types and entries. So like for example, if it's a user interface that has options for data entry and there is a data field, you can only enter a data. You cannot explain what the why that data or what that data means to the larger purpose. And when aggregating data in traditional information companies, it is designed in columns and rows. And that's those are some features that are very limiting with software that's off the shelf or even electronic health records. These are designed to allow people to enter data based on what the programmers think is important. But that's not necessarily everything that's important. What blockchain does sense so unique is that it's a ledger. You can store anything on the ledger. You can... We believe that you have more control over data if you actually store it on the ledger and we encrypt each piece of data that isn't stored on the ledger individually with multiple layers of encryption so that if someone could hack into the blockchain, they still couldn't unlock and unencrypted the data. So with the ability to store it on chain, you can have much more promisioning designed by the multiple owners. And the owners for health care can be patient. It can be the doctor. It can be the hospital or the clinic. And they can all share ownership. And so then this is a method of programming that's just not available in a database. With a database, it has to be administered by somebody. And permissions are typically very limited of what you can control. They give patients, you know, the opportunity. Certain data. But they don't give patients any control over how the patient's own data can be used. And when looking at what clinics and other hospitals, these hospitals, their systems aren't designed easily to share information. Well, with the blockchain, you can set up well with our blockchain. You can set up this permission thing so that there are multiple owners, there's multiple ways of controlling the controlling

	information so that you can share information much more easily. So going back to the ledger, what makes the ledger so meaningful to is that you can store anything instead of just storing a data. You can store the data and add an explanation behind it to say, wow, this is actually three days later than planned because this person was sick or something like that. And you can instead of analyzing with just research analytics that use columns and rows, you can use natural language processing as a part of artificial intelligence to get more meaningful information. And one of the things that I really like about Firm1 a huge solution to is that because we add data to the blockchain, you can control that what people can analyze versus see. But you can also do what we design is called a schema on read. And that means you design queries so that you can analyze the data on the blockchain and you can pull data from other sources at the point of query. So you don't have to have it all on blockchain. You can have it in servers. You can have it in the electronic health record. You can have it in a data lake. And so, as a result, and you don't have to recode or reformat the data, you just keep it in its raw form. However, you have saved it to begin with. And then with the schema on read, you can you can design for the read that you're bringing together some different data sets that might be named differently or have variables named differently. So for example, in one dataset you might have name as registered as just one field for name and then another dataset. It might be one variable of last name and one variable of first name. While you teach, you can design mapping so that you tell the query mechanism that when you're querying that this variable and these two variables are really the same thing. And so when you query, you can you can pull it all together as one single variable that you can then analyze. And it allows ..it allows you to pull together like what Firm 1 talks about how they design Millgate faceted profiles of an individual. So you can pull together their health information, you can pull together the demographics of the city that they live in. You can find out about the pollution for the city they live in. You can find out about the schooling system and you just pull that data together during query to see if there are more complex public health components influencing the health and well-being of a city or person. You just cannot have that level of capability with any traditional information systems and the flexibility for how you can design. You can modify your data collection methods that the information you store modify on the fly as opposed to traditional software where the... you know, it's that software company that tries to think about what's important and they're not interested in being sufficiently creative to let use to pull in different information that could really influence health. But we just haven't thought of it before. So blockchain allows us to integrate whatever information could be meaningful and study it to see if we can identify trends.
90	Tugce
91	Ok.Thank you.And now I saw on your website also you are saying that you can find the correct ,decent partners for your research or something. So that's where I want to ask how you help researchers and developers or innovators to find partners.
92	The Interviewee 1
93	Yes. So when... when each new company joins our platform, we try to find out what they're working on. And... in particular, we're teaching people how to do research that involves their blockchain, which is a whole new area for software developers.(giggling) They don't understand health related research, but if they want to design a product that touches with health, they have to do research in order to make their product more credible. So first we ask each company. We get to really know the companies who use our product and we offer a lot of educational services for them. And as they start to develop their product, we ask them if they want to be introduced to other companies that are working on an area where they could benefit from some help or from another company that's doing something similar to them to see if they could collaborate. And so, we have made several introductions between companies working on similar products, and we will continue to do that. It just really helps people to connect with others who are kind of early in their development to get ideas, motivations and to see if they can share pieces of technologies to make each other more successful.
94	Tugce
95	And ok ..., Actually I wanted to ask that what is your role in this relationship? But I think you explained it.
96	The Interviewee 1
97	Okay. Great. Okay.
98	Tugce
99	So, what does your company's benefits gain from these partnership? And what is your company’s main motivation in getting involved in this relationship?
100	The Interviewee 1

101	So, I'm mean, explain a little bit. I'm going to answer the next question about your partners main motivation at the same time. So ultimately what we've been talking about is how collaboration makes research more successful. And, so Firm 1 has designed an entire platform about how you make data more successful with collaboration. And so, we realized that... what would we primarily gain? So, we gain tremendous satisfaction. We're addressing part of our mission because we also work with third world countries, not the governments, but we work with small healthcare companies or hospitals in Africa, for example, and some in India. And this provides an important piece of what we believe is our humanitarian mission in the world and how we can make. Firm 1 more helpful and more relevant in the world as well as we are a member of the United Nations Global Compact and Global Compact requires us to promote equality in health care across the world to promote educational development in third world countries and promote economic development. And so, this is an important part of our mission. In fact, it's such an important part of our mission that when we work with companies in Africa, we know that the standard of living is very different in Africa. They can't afford United States prices. And so, we give them our platform for free. And so that's... it's very important that… that's our way of enabling them to be more successful. And then each time we develop a partnership, one of the benefits that we gain is that we'd let that company know that we're going to help promote them. And when we promote companies on LinkedIn and other social platforms, that they get exposure and we get exposure for our humanitarian initiatives. And it's just... it's good news to share. But when we share this good news, other companies take notice and they say, hey, I want to talk to you, too. Maybe I want to purchase some of your. So, we benefit from the marketing of being able to do all of these connections. And the partners have benefited tremendously from getting access, especially for free to a platform. And we give them a lot of publicity, which is good for their marketing as well. So that has been just an extremely satisfying process in relationship.
102	Tugce
103	And what do you think your partner's main motivation was. Actually, you already answered that.
104	The Interviewee 1
105	Yeah.
106	Tugce
107	What is the role of blockchain technology in this process?
108	The Interviewee 1
109	So it's just the unifying theme of how all of us are using blockchain to try to achieve some purpose related to healthcare.
110	Tugce
111	And according to your experience, could you say what kind of challenges you face during this innovation process? And also this partnership process also you can say and if you if it is possible, you can share some examples.
112	The Interviewee 1
113	Well, every time you try to do something new, you encounter some obstacles that you had not anticipated. And for us, what happens periodically when doing development with other companies we design like... we just keep updating the user interface. We keep updating the software development kits that we offer them. We have a number of interfacing modules. And you know what happens when you work on one module. Then it may not it may interfere with something else in the other module. So that's just kind of a general component. I will add a wrinkle about a challenge that that you may not have thought of when we offer services to third world countries. There is often political instability. And so, what has happened to us is that like we have companies that we are assisting in Nigeria and the Nigerian government is pretty corrupt. And the US issued new sanctions against Nigeria. And so, then we had to back off the services that we provided. We couldn't provide as much individual help because then that would violate the United States sanctions against Nigeria, which was a huge challenge that we didn't anticipate at all. And we're just trying to help health care clinics. (giggling) We believe in the greater good of health, but it still was a service that was being provided that had financial value. And that is not permitted under your current U.S. sanctions. You know, one other one other challenge I could share, too, is that you need the Internet to be able to connect to our blockchain. And in countries or neighborhoods that have unstable Internet connections, they can't connect as consistently as they would like to an Internet based blockchain which is stored in the cloud. And that has been a challenge that we have no capability to address but

	is inherent with any Internet based service. And so we are looking at options for, you know, can any of the software be downloaded? Don't think so, cause the blockchain works by increasing the ledgers which are stored in the cloud. But we're trying to figure out some way to help organizations that have unpredictable Internet access.
114	Tugce
115	And about that... We should talk about data. What's OK? What kind of data you collected in your chain?
116	The Interviewee 1
117	Ok. Sure. Everything. We can store everything on the blockchain, including files, images, genomic information. Now, the one challenge that we have with images is that we can only store a file up to 13 megabytes at this point. And of course, many images are gigabyte size. Those are files that we store in a data lake and then just point to that file on the blockchain. We store qoute. Absolutely anything you can imagine. And we can connect any electronic system that has an application programming interface. They can plug right in in just real time data collection of all wearables, all the electronic health records we have designed. We are in the process of designing electronic health information exchange for an entire country. Haven't gotten through the contracting part yet. So anything can happen. But... because it's just you can... the blockchain doesn't know what kind of data it is. And so it's to that to the blockchain. It's just data. So, you can put anything on it. And being able to store it on chain has... We don't have issues with scalability either, which is a big problem with many other blockchains is that as the ledger grows, it becomes unwieldy. But what we do is have a separate blockchain for each of our companies that... we will move back up. We have... we can set up a separate blockchain starting with the genesis block for any company that starts or that they can have a shared space. They can have their own space in a shared blockchain where we just kind of wall off permissions. And because we have separate... like separate chains and in many cases separate forks for different departments or divisions. Scalability has not been an issue at all. We have on our blockchain has been in production for three years. We have... which is the longest. We are aware of any health related blockchain. And it hasn't slowed down our capability or scalability at all. It's... Yeah. So, it's just really how it's been designed and how it can grow. As to what... I guess how it's manage them.
118	Tugce
119	So that's mean only limitation is about sometimes the size of data
120	The Interviewee 1
121	Yes, the size of an individual file.
122	Tugce
123	You solved this problem. So, you know, collecting these data from different maybe database and then you take the link and you click. Store the link on the blockchain.
124	The Interviewee 1
125	Yes. That's correct. That's correct.
126	Tugce
127	And another question, how do you motivate patients or individuals who share their data on your blockchain and other stakeholders to share their data?
128	The Interviewee 1
129	OK...So we are a business to business blockchain. And so, we don't interact directly with patients to share their data. It would be our business partner, the business that we work with to encourage their patients. And I know that for some of the companies that we work with. They have patient facing interactions, they promote their blockchain to patients as being much more secure and giving patients much more control over their information. And so that's how they encourage patients to use their data on the blockchain. For other stakeholders...because we can implement much more like..OK, here's an example in the United States. If you receive research funding from the National Institutes of Health, which is one of our most our largest federal funding sources, you must sign an agreement with the federal government. Call the data sharing plan. And you have to agree that if you receive money from the federal government, do your research. You have to share your individual data sets with

	others who request them. Well, that's a horrible thought (giggling) We spent years collecting data and blood, sweat and tears. I don't want to give that away. But when we talk to these comp... these universities about saying, well, you can share your data by giving someone access to the blockchain platform. And when you give it to the platform, you can set it up so that, yes, when a different university requests data under the data sharing plan that you have with the federal government, you can share your data. You're just like, let them log into the blockchain platform, let them combine their data set, run their analysis, and they can never download your data. They can't see the individual identifiers, but you're still sharing. So it's ...the really it's about the capabilities that you can create and the controls that you can have that make it much more appealing. Using blockchain for managing. Oh, I thought of one more thing. The Food and Drug Administration in the United States, which oversees the drug development process, requires that there be compliance with a separate set of regulations. It's 21 CFR Part Eleven, which is the electronic regulations for data... electronic records and electronic signatures. And as part of that regulation, you have to have an audit trail from beginning to end of everyone who created or retrieved data throughout the entire study in order to have data integrity. And a blockchain is a perfect solution for that. You don't have to build a new database. You don't have to buy a new database. You could just put blockchain underneath your existing data solutions because the blockchain is inherently an odd trial no matter which blockchain you use. And so that has also been a big selling point that for both the FDA regulate and research. And even though it's not required by the Office for Human Research Protections, which is the regulatory body for federally funded research, you still have to have integrity of your data. And you have to ensure that the data hasn't been tampered with because you have a contract with the federal government to verify that you are going to be honest with your process. And some major universities have gotten enormous fines for having researchers tamper with data to make the results look more promising so that they can get more grants. And we're actually talking to one of those universities right now. Last year, they were assessed a one hundred twelve point five million dollar fine because some researchers tampered with data for their grant application. And so now this university is very interested in creating tamper resistant options for their data so that they can better preserve the integrity. So there's huge selling features about what blockchain can do that other data in order to get them to use blockchain.
130	Tugce
131	And so how do you manage the data movement in research networks, actually, Is the control of the all data yours or just it happens by technology.
132	The Interviewee 1
133	So, the company that contracts says always managed the data and then they can of individual owners. They can be an owner. They can like allow patients to be owners of some of their data. And what we set up are we give them a user interface that the administrator gets a user interface so that they can grant permissions and then they can set up the controls and permissions however they can possibly imagine. And then the system whenever someone creates or retrieves data. If there is a there's a record of that, someone going into the cloud and we do track that data and movement so that we can charge a transaction fee for it. And that makes a sustainable business model.
134	Tugce
135	So, you don't actually see the what is inside data, but you just see how the data move. Right?
136	The Interviewee 1
137	Yep. Yep. We see when it moves and then which we charge for that.
138	Our goal is to give our clients a platform to use the data, but then they own the data and then we try not to...We don't look at it unless we have a business associate agreement in place, which is a... it's a hip a term for how we can see their protected health information if we have to. And then we promise to the federal government that we will ensure appropriate security and privacy. And we have that in place just in case the business that we're working with needs our help to manage some feature that would require some incidental exposure to their actual data, and we can help them address that. But then we step back out and then we tell them, you manage this, you manage it yourselves so that we don't have access to your health information
139	Tugce
140	another things is when, for example, a patient or someone decide to sell or donate their data to third party but after she or he give up to do this and who is the owner of these data after that moment?
141	The Interviewee 1

142	Well... well, with GDPR, our patients have the right to be forgotten. And in that case, no one would own their data anymore. Now, I'm aware that when GDPR there are exceptions to that requirement, especially for research, once research funds aggregated then patients can no longer request that their data be removed. We generally encourage... OK, so this this prevelant this goes to the concept of data governance and we encourage every company that we work with to set up a business plan for governments. If you are going to share the data, who is responsible for maintaining the platform for performing risk assessments, for interacting with patients when patients have questions or concerns? And also what to write down, what their terms and conditions are for how patients have control over their data, too, and its patients. It's just good to have a business plan in place so that when questions arise that you have an opportunity to address that. So in specific answer to your question, there isn't a single limitation for patients to know that there's no single rule. We just encourage the businesses that we work with to create rules and a business strategy so that they can understand how best to promote their product to people who use it. And as well as managed requests and manage problems that come up.
143	Tugce
144	okey...How your blockchain based business models connects with remote medical care? Like telemedicine.
145	The Interviewee 1
146	Sure. So we do... we do a couple different facets with remote medical care. So one is that with remote medical care, it's common to use electronic sensors and remote data collection. And so that can integrate very, very easily with the blockchain so that it can all be on one source and the physicians can have ready access to it as well. Instead of having to log in and look at a bunch of different systems, we can actually set it up that no matter how many sensors, no matter how many company are providing sensors to that patient that it's all integrated on one platform. For telemedicine, we also do something unique in that we have partners. We provide a blockchain for a credentialing system for medical providers. And so since in the United States, you have to be licensed within the state to practice medicine. And people who perform telemedicine are often contracted with multiple different health systems. What each health system has to verify, their licensing and their standing with the state medical board and very tedious process. Well, we provide a blockchain where companies that provide telemedicine can store credentials so that different organizations can just look at and update the blockchain instead of performing all their own individual and independent qualification verification. And so for telemedicine right now, that's been a huge hit. (giggling) It makes it a lot easier to maintain the physician's credentials, to allow them to practice telemedicine much more readily and still maintain the proper documentation for that.
147	Tugce
148	And do you make any collaboration with other industries to improve blockchain or smart contracts?
149	The Interviewee 1
150	Yeah, we actually have... we specialize in health care, but data are data and it doesn't matter what kind of data you put on the blockchain. So, we specialize in health care because it has the most privacy controls. But you can apply the same privacy controls to financial organizations. So, for example, we had talked for a long time with certain banking systems as well as on credit card processing systems because they just love the privacy and confidentiality features that we offer. We have some discussions right now with energy systems because they can implement smart contracts for smart cities and be able to allocate energy more effectively when they have more access. So... So those are just some examples of additional industries.
151	Tugce
152	So, you are in a collaboration to improve some of it?
153	The Interviewee 1
154	Yeah.
155	Tugce
156	Okay. Could you share your opinion how blockchain technology address problems in health care?
157	The Interviewee 1

158	Well, they're there. There are lots of opinions on how it can be done. And so I'll kind of share some of the range of opinions. So, first, some people have said that blockchain can help with health care by enhancing data capabilities. Just by saying that we can connect. We can connect data. We can do more research on it. We can enable more access to health information. And so that's just the data function. Others have a view into blockchain technology that is a little bit more futuristic and more expensive. Some are saying that if we are able to.... it connect health systems like electronic sensors. And if we can... we can connect information to the blockchain in real time. Then the smart contracts of blockchain can enable something for health care. So, it can either enable more rapid decision making or it can potentially enable alerts. For example, if you have someone who's wearing medical sensors and it's connected to the blockchain, then the doctor can get an alert from these sensors that the person isn't moving as often. Their A1C has been consistently out of range things that are outside of what the patient might normally communicate. But the blockchain can connect all these technologies or even combinations of technologies so that a provider can have more real time access to the patient's well-being and health and can make more rapid decisions.
159	Tugce
160	And especially in now we are really fighting with the Corona.
161	The Interviewee 1
162	I know.
163	Tugce
164	Yeah.
165	Tugce
166	So what do you think about it? How blockchain technology will help or how we can use this technology in order to control the spread of virus or these kinds of things when it will be happen?
167	The Interviewee 1
168	Sure.. my company is actually sponsoring a... we call it a research foundry, but it's a research consortium where we're bringing together stakeholders from various industries to work together on the blockchain to share their innovations and ideas so that we can find solutions more rapidly. So, and there are several blockchain based organizations currently doing that. They are like opening up competitions or just even fostering a network where people can share. There's another aspect of where I think that blockchain will help with the Corona virus specifically, and that's with federated drug development. So, the concept from that arose from Melody, which is machine orchestrated learning for drug development. And with that technology, it there are ten different pharmaceutical companies that are sharing their molecular discoveries on blockchain. But when I say sharing, I'm... I should say they're placing their .... their molecular discoveries on a blockchain, but they are not allowed to see each other's molecular discoveries and they're just applying machine learning in order to learn from the aggregate. So, I think those are those are two ways right now. No, there's a third way. The United States government has actually put together website, Kaggle. Have you seen it?
169	Tugce
170	Yeah, I read some news.
171	The Interviewee 1
172	Yeah. Yeah. And the journals are open source. And the hope is that people can all contribute collectively to the solution. Yeah. Use the journal articles as filing machine learning. So we'll see.But it's a it's a great effort to try to do something collaborative
173	Tugce
174	and can be some of these efforts stay in the future as permanent effort . What do you think
175	The Interviewee 1

176	For... for the Firm 1 Yes, we intended to be a long-term effort and solution and I don't know about the others. I was just looking at about your questions about coronavirus and for controlling the spread. There... There is another way that blockchain can be used in that ...blockchain has is a great solution in order to integrate public health surveillance because you can integrate so many different sources of information. And with public health surveillance, you can put together small, somewhat disparate pieces of information in order to start seeing trends that would indicate outbreaks. So well, with the Corona virus, we actually have outbreaks pretty much everywhere now, but it's believed that watching can a while... I don't know if you were aware of this, but the country of China used blockchain to collect information about the coronavirus spreading there, and it's believed now. But that's really opening the doors for public health surveillance as well. And that you can use things like Google search terms about what kinds of symptoms people are searching for and what geographic location you can look at. Weather patterns, you can look at symptoms that people are reporting in social media forums and you can use these pieces of information and machine learning to try to determine where the next outbreak is going to take place. Blockchain again space solution for bringing all that information together.
177	Tugce
178	And how we can use it for the social life? Because probably after this pandemic stop, we'll change somethings in our social life.
179	The Interviewee 1
180	Oh, I don't know.
181	Tugce
182	OK. And what is your expectation about some products, application or social innovations after this. how can they change?
183	The Interviewee 1
184	Well, I believe that the first aspect that will change is that people will become more comfortable with blockchain in health care, in academic arenas. There is certainly a lot of skepticism about whether blockchain is a meaningful technology or whether it's a fad. And because, like even yesterday, the United States Department of Homeland Security issued a notice saying that they believe that blockchain will be a critical part of the coronavirus solution. And the more that there is news, the more that there is adoption within accepted areas we're going.
185	My expectation is the first major things, people are going to become more comfortable. They're going to be more curious, more open to using blockchain potentially, and will be more likely to ...to be accepting of it for... for products and applications. I think that what will happen is that ...I don't... I work for a company Firm 1. That's very advanced when it comes to blockchain. So I think what you're going to see is you're going to see evolution in some of the other health care providers to offer more fine grained, more granular consent options to refine their features. And there's going to be a broader audience receptive to using blockchain. So, I think you're going to see the expansion of companies in the industry or social innovations on that part of it. There... There are some very unique applications to blockchain right now that I think will get expansion. There's a company called Loly.io l o l y dot i o I believe, and it's a blockchain based dating website.
186	Tugce
187	Oh. okey
188	The Interviewee 1
189	It's not dating in the sense of not dating. It's more of a hookup site to find instant gratification. But they use a blockchain based application in order to provide informed consent for sex. And you have to provide some details about your health to ensure to your prospective partner that you don't have diseases. Well, why not add an additional question about your current prospective illness or your exposure to illness? because People are using blockchain based applications in so many creative ways now, why not see some innovations in different aspects of social?
190	Tugce
191	It's really like ...like a one section of The Black Mirror.

192	The Interviewee 1
193	Oh, yeah... I hadn't thought of that, but it's fine with that Loly Website is that they even have a hotness factor so that you answer questions about yourself and you get a hotness factor number. And other people can rate you as well to determine whether or not they'd want to. So, I know it's...Yeah. Oh, there is one thing that I do believe will change. It's not health care, but it's... But it's ...it's a really powerful tool. More and more countries are voting online using the blockchain. And because in-person voting creates risk of exposure due to corona virus, that I believe that online voting is going to become much more pervasive. The state of Colorado where I live will be using online voting in November for the upcoming presidential election. But they're doing it only for military personnel who are... who are based elsewhere. The state of Wyoming in the United States is going to use it for all of their citizens for the entire election. I know that we're still behind Estonia, which is massive blockchain for a long time in many government applications. But it's good to see that United States is catching up.
194	Tugce
195	And how will this pandemic affect the health care in sense of innovation, investment and product and service tendencies. What will be the role of blockchain in this? So actually this is quite similar with the previous question, but what we will see to next... after this pandemic.
196	Yeah, Well, one is that companies like... OK, so I can tell you like Firm 1 has many major corporate partners who were interested in blockchain but were just cautiously moving forward. Now they are aggressively moving forward with blockchain applications. And as we see more companies becoming receptive to it, what Firm 1 is seeing in a way is that companies are becoming much more aggressive to try to use blockchain for health information exchanges in particular.And because if someone presents with Corona virus, has those need immediate information about their medication, passin allergies, information that may not otherwise be readily available in the country of India, for example, they're just now starting to... just last year started to roll out requirements in long term requirements for health information exchanges. And we have actually been talking to the government of India about how blockchain can better connect the health...the electronic health records across hospitals. So that, they can communicate more readily and implement telemedicine. And telemedicine is going to be a critical solution for addressing people's illnesses while they're home. But again, this telemedicine providers need access to their health care. So I believe the blockchain based health information exchanges are just going to explode. And what I do see here is that more companies are offering telemedicine at no charge. And for example, my health care provider, United health care provides encourages all of its members to download an app. And from this app, you can specify that you want to speak to a doctor and they will connect you to a firm or a video for free, which is... which is new to the United States. They've had telemedicine, but it wasn't widespread. Now they're saying, please don't go to your doctor. Please contact us for telemedicine. And the goal is there to create mechanisms for these telemedicine providers to also have access to health records. And as we talked about yesterday. As more and more telemedicine companies are getting established or are growing. There are also more states that need to verify the credentials and you can use blockchain for that, too. So.
197	Tugce
198	And the last question. What do you think about your new business models? That's mean Firm 1 effects on new products, trends in healthcare. And actually, you have already answered for these questions, but how these kinds of platforms reshape the collaboration. Can they increase the collaboration among different industries, such a medical device and pharma? What do you think?
199	The Interviewee 1
200	Sure. Well, it has changed our business model in that we are more aggressive about ... We promote the technologies right now that are most in need because of coronavirus. So, we are really advancing our capabilities for health information exchanges, for telemedicine, for connection of electronic remote data collection, for research. Because as you can imagine, this is... this is extremely disruptive to research right now where it was important to have a patient visit. So can you do your research based business remotely and still make sure that your patients are safe and how there are... how well are they doing there...One thing we've seen, too, is that with electronic devices that were used remotely, there used to be a requirement from the FDA to ensure that they were medical grade devices. And now the FDA is becoming more receptive to consumer grade devices, not necessarily for diagnostic purposes, but they still provide a lot of valuable information about patients well-being. And so, because you can use of remote spirometer to assess someone with asthma and the range of accuracy is a little wider, it's not quite as precise as the hospital, but overall freight equipment. But it can still tell the doctor whether that patient needs care right now. And so, yes, for I would say that many watching

	companies are now because there's need... There's... there are different... There are more urgent needs for connectivity of devices and information as we talked about then there... they are promoting those features right now. And the FDA is then surprisingly more receptive to allowing. Well, I don't know how familiar you are with what the FDA is doing with blockchain in the United States anyway. Do you follow them
201	Tugce
202	I don't know about what they are doing specifically, but of course, I know what is the role of the FDA in product development in pharma and device industry?
203	The Interviewee 1
204	Oh, yeah, sure. Well, the FDA itself is leading a pilot for the Drug Security Supply Chain Act in the United States. No. It says drug supply chain security act in the United States. And the FDA is leading and it's using blockchain to lead an initiative where they will bring together data sets from all the drug development data that has been submitted to the FDA so that you can use better machine learning on that. And the FDA is leading an initiative to use blockchain to trace the food supply chain. And so when the FDA itself is so supportive of blockchain, then it's shifting some of its enforcement discretion and allowing broader uses of blockchain as well.
205	Tugce
206	And ...thank you. So... Is there anything in our discussion that you would like to add, or do you think something more important about this topic that you want to share.
207	The Interviewee 1
208	I... I became...what is the right word? When I first heard about blockchain in 2017, I was like entranced. I... It just took over my life because I could see how this technology would revolutionize the way that we manage health information. And I don't think it's going to be as much of a disruptor. I really don't think it will create massive disruption because it doesn't require you to replace the technologies that you're already using. It just makes the technologies you're using more effective. And so, I... I really believe that blockchain is going to become ubiquitous in health care. I think we're going to see it in every major company within the industry. I... I believe that regular citizens are going to be interacting with blockchain in some way or another every day in some industry and without necessarily even realizing it. It's just kind of become pervasive in the way that we manage businesses and health care.

Appendix 2. Transcript of interview with Firm 2

1	Tugce
2	So, if you're ready, we can start.
3	The Interviewee 2
4	Yes, I'm ready.
5	Tugce
6	OK, then. First of all, I want to start with a questionnaire part... And is there a research laboratory or product development unit in your company?
7	The Interviewee 2
8	That is a research element, but it's not a formal one. We tried doing some kind of research and knowledge transfer partnership with the university at the moment, but we haven't formalized the arrangements yet.
9	Tugce
10	What is the purpose of this unit or laboratory?
11	The Interviewee 2

12	So, we are doing some work with Leeds Beckett University in the United Kingdom. And Bradford Hospital Trust. We are the tech company which is experimenting with them. And we're looking to see is there a possibility of using AI to risk stratify patients who have been sent home early and whether they need to return to the hospital or not, depending on that score. So, this is something separate from the main objective of the company and separate from blockchain. It's just something we are working on at the moment.
13	Tugce
14	Okay. And how many employees work in this laboratory? Our unit
15	The Interviewee 2
16	3
17	Tugce
18	What are their specialization.
19	The Interviewee 2
20	One is a clinical. No, two are clinical doctor, but one is a clinical doctor at the hospital pediatrics. One is a clinical doctor who is working in my team. One is a professor and AI, artificial intelligent specialist at the university.
21	Tugce
22	OK. And which ...which departments collaborate in the company?
23	The Interviewee 2
24	I don't understand what you mean.
25	Tugce
26	That's mean. Do you collaborate in any other department in your company, such as marketing or I.T. department?
27	The Interviewee 2
28	No, no, no, no, no.
29	Tugce
30	Okay.
31	Tugce
32	Does your company cooperate with complementary firms in your industry?
33	The Interviewee 2
34	No. No.
35	Tugce
36	Okay. Does your company collaborate with universities? You said Yes.
37	The Interviewee 2
38	Yes.
39	Yeah. Okay. Does your company collaborate public or private research institutes or laboratories?
40	The Interviewee 2

41	No. No.
42	Tugce
43	Does your company cooperate with a governmental institution?
44	The Interviewee 2
45	Yes. With the National Health Service. it is governments... government health service.
46	Tugce
47	Okay. Okay. Now we can pass the interview questions. How the company ... how your company actually attends innovation activity in healthcare.
48	The Interviewee 2
49	So, we are a health tech company. We have been around for two and a half years and we are trying to deliver innovation, which helps patients have access to their own medical records.
50	Tugce
51	So, you just innovate some technical.... technological products or software? I don't know.
52	The Interviewee 2
53	Yeah, we make we make the software. So, I'm a doctor, as I was saying earlier. I'm the founder and CEO of the company. And I can see there's a few issues with software in healthcare. So, we need it. We need a team developing software to help healthcare problems not just in the UK but internationally.
54	Tugce
55	OK. Did you start or initiate to innovate new products or service for healthcare?
56	The Interviewee 2
57	Yeah.
58	Tugce
59	What is that? Could you explain?
60	The Interviewee 2
61	Yes. So, the... the company is called the innovation is to empower patients to have access to their own medical records. So, I'm not sure what it's like in Lithuania or in Turkey, but when you are going to a clinic to see a doctor, the doctor only has a certain amount of information about you. If you speak to another doctor, the other doctor has different information about you, and you don't share one version of the truth. So, what we're trying to do is help the patient carry their medical records on that small device. So, when they go from appointment to appointment, they can share their health passports. They can show every doctor wherever they're travelling, whether it's inside the country, outside the country. This is my UP-TO-DATE medical records. You can view them, and you can add to them. And we secure all of this information using blockchain. So, you've got the next doctor who read the information knows that this. This is correct. Data hasn't been manipulated in any way.
62	Tugce
63	Actually, on your website. When I looked your white paper, I saw one product is emergency bracelet. So, did you create this product themselves or cooperate with any other companies? What is this? Could you give some information about it?
64	The Interviewee 2

65	The bracelet is a prototype, which we made, and it is still in our roadmap to deploy it. But we made it ourselves and we will use it later on in our development. At the moment, we're still trying to focus on the software before the hardware.
66	Tugce
67	OK. And what is the role of blockchain companies in the product development process in healthcare?
68	The Interviewee 2
69	So the reason we use blockchain in our software is because we want to have a way of keeping an audit trail of where the data has been, who has access to the data. And we needed to be secure and incorruptible in a way that the doctor called, go back and change the information. The patient comes back to information. So blockchain is a good way of doing that.
70	Tugce
71	I see. And could you explain what is the difference between blockchain based information companies and traditional information companies? What kind of dynamic capacities do they have in sense of innovation?
72	The Interviewee 2
73	There shouldn't be any difference, to be honest with you, when you talk about blockchain. It's like saying you're talking about the Internet. It's just a way of managing data. Storing data. That's what it is. It doesn't affect the rest of the company or the way that the company runs. It runs in exactly the same fashion.
74	Tugce
75	Do you think if it's much more advance for, you know, cooperate for innovating any... for example, drug or medical device, it is much more advanced... they have advanced more than traditional information companies.
76	The Interviewee 2
77	I think ...I think it is advanced because the change we have seen in the past 10 years or so has been people moving towards a blockchain industry as a more secure way of managing data and sharing data. This is already being done in the pharmaceutical industry or the drug industry where you need to prove your supply chains, where your medications came from. And blockchain is a great way of doing this. Proving the authenticity of the supply chain of where it came from,
78	Tugce
79	How you help researcher, developers are innovators to find partners?
80	The Interviewee 2
81	Yes. So we invite them to work with us to be a node holder call the blockchain elements. This is essentially how we collaborate with them, but we don't have any formal agreements with any pharmaceutical companies.
82	Tugce
83	And what is your specific role in this relationship?
84	The Interviewee 2
85	So I'm the CEO and I'm the co-founder. And my background is that I am a medical doctor, clinical doctor. So when it comes to making decisions for the company, what would help doctors and health care? This is what I do
86	Tugce
87	Actually, Which I want to ask in here. For example, your company... if some pharmaceutical companies come to and ask for using your database to learn something, some... maybe using data in clinical trials, doing something like that. And also, if you can connect, bring together with any hospital or any other customers

	which you use your platform. So, if you can meet these two organizations, what can be your role in this relationship?
88	The Interviewee 2
89	Yes, so.Our role in this relationship is if we have patients using our system and us to connect using our system, we will have a large database of patient records. We don't sell . We don't plan to sell the patient's medical records. Instead, we want the patient to have access to their own medical records and carry their own medical records. And this is the same with interactions with pharmaceutical companies or researchers where we will just broker the relationship between the patient and the pharmaceutical company. So we will say you are looking for patient data. Here is the patient who has access to their own data. Why didn't you pay the patients directly, openly and ethically to have access to that information? We were just broker in that relationship.
90	Tugce
91	OK. So what is your company's benefits gain from these partnership?
92	The Interviewee 2
93	benefits for us is financial. We would charge a fee for introducing the pharmaceutical researchers to the patients.
94	Tugce
95	And what is your company's main motivation in getting involved in this relationship?
96	The Interviewee 2
97	Get money.
98	Tugce
99	OK. What do you think what your partners' main motivations are?
100	The Interviewee 2
101	I think the motivation for them is they have wide access to a variety of patients information and records.
102	Tugce
103	And what about the patients?
104	The Interviewee 2
105	for the patient... patients, they'll be financially incentivized. So the patients are going to make money from sharing that data. And the patients are going to be introduced to research facilities and pharmaceutical companies. So, if they have a medical condition, they may want to be the first one to learn about this or to be involved in these kind of trials.
106	Tugce
107	And again, what is the role of blockchain technology in this process?
108	The Interviewee 2
109	Sharing data.
110	According to your experience. Could you say what kind of challenge you faced during the innovation process? If it's possible, could you share some examples?
111	The Interviewee 2
112	Yes. The challenge has been trying to find the developers with the special... specialty skills of doing blockchain. They're not easy to find and they're not cheap to find either or to fund. The subjects can be a bit complicated. It can be complicated by governance and by different rules from country to country. So every

	country has their own rules when it comes to data and data controller, data process and accessibility between those. So those are the challenges. But I think there is a good thing to aim for.
113	Tugce
114	Okay. And I want to ask what kind of data is collected in your network? That's mean. Is it only laboratory results or genomic data? What is that?
115	The Interviewee 2
116	So, it will be laboratory results, imaging results. It will be the consultation notes. So, the doctor has actually written about the patient as well. I know also be the patient's own personal journal where they write their own experiences and feelings towards their own health problems and what medications they started.
117	Tugce
118	How do you motivate the patients and other stakeholders to share data to use in the research process?
119	Say that again. Sorry
120	Tugce
121	how do you motivate patients and other stakeholders to share their data to use in the research process?
122	The Interviewee 2
123	So you motivate them by them already having health problems and you're trying to encourage them to interact with people that are trying to find new and novel and better ways of helping them in their health problems. And again, you can finance incentivize patients to be involved.
124	Tugce
125	And actually, I saw on your website something about MedTokens do you use this, you know, any money transfer to motivate patients for sharing their own data for using the research process.
126	The Interviewee 2
127	Yes. MedToken when we when we originally launched the company two and a half years ago. We are a big believer in blockchain. Obviously, we're a big believer, an advocate of cryptocurrencies. And we wanted to utilize cryptocurrencies or digital currencies to ease the transfer of funds from one area to another. So, the ultimate aim would be having a Turkish patient speaking with an American doctor. And it is hard for you to pay the American doctor in dollars from your bank account. Two or three transfers fees takes about one week. Crypto currency would facilitate that transfer much quicker, much easier with minimal fees. So, this is something we hope to do. But crypto currency in the meantime, has all come down, bitcoins down. MedToken is down. So, it's harder to use that as a funding mechanism at the moment, but it's something we still want to do.
128	Tugce
129	And how do you manage the data movement in research networks?
130	The Interviewee 2
131	try to say that?
132	Tugce
133	How do you manage the data movement in research networks? And, you know, maybe you can talk about the consensus.
134	The Interviewee 2
135	So, the research network or the pharmaceutical companies or whoever they may be, they can't access any information without the patient's consent. So the cost, the consent, the private key, everything is held by the patient as the patient who decides who has access to the information, when and for how long.

136	Tugce
137	And could you see the, you know, any data or information as Firm 2? Do you know that what is written in these data?
138	The Interviewee 2
139	No, we don't know ourselves.
140	Tugce
141	You can or you can just see the transaction, right?
142	The Interviewee 2
143	That's it. Yeah.
144	Tugce
145	Okay. And I want to ask you, who is the owner of data after the patient accepts to share data for any research? And how do you manage or protect patients IP Right.?
146	The Interviewee 2
147	So, the data should always be the patient's data and the patient can run access and revoke access when they want to.
148	Tugce
149	Do you think blockchain technology has limitation in sense of data movement among parties?
150	The Interviewee 2
151	it shouldn’t. No. I mean, it depends on the country's attitude. I know when we spoke to the Chinese health system, for example, they said that they're not there yet with the idea of patients owning their own medical records, but they were happy for patients to access their medical records. Again, in the Middle East, if you go kind of blockchain systems, it's a decentralized, distributed way of handling data. But in a country like in middle east, the government wants to hold all the information and doesn't want this decentralized or distributed against different people.
152	Tugce
153	So, but the technology doesn't have any limitation?
154	The Interviewee 2
155	No, the technology doesn't
156	Tugce
157	How your blockchain based business models connect with remote medical care? Such as telemedicine.
158	The Interviewee 2
159	Sorry you can repeat that again.
160	Tugce
161	Oh, yeah, of course. How your blockchain based business models connect with remote medical care.
162	The Interviewee 2
163	Yes, it does connect to the remote medical care.

164	Tugce
165	How. How is it? So Do you have own system or..., for example, do you provide your platform to this kind of company?
166	The Interviewee 2
167	So, we provide our own system. It's something we're working on in the background. But just last week, because of the Corona virus, we released our video consultation capability early. It's called My Clinic.com, which anybody can use on the Internet from now. Any any doctor, any patients locally, nationally, internationally, anyone can use it.
168	Tugce
169	And do you make any collaboration with other industries in order to improve blockchain and smart contracts?
170	The Interviewee 2
171	Not at the moment.
172	Tugce
173	Okay. Could you share your opinion how blockchain technology addresses problems in healthcare today?
174	The Interviewee 2
175	Yes, I think it addresses problems because we need to change the way that we do health care. I think technology has come a long way. And health care needs to catch up with that technology. Unfortunately, health care very slow and always slow to catch up. And I think what we need to do is we need to move to a system where patients have better access to that information. I think with Facebook and Instagram and all these other kinds of social media, you see people are a lot more careful about their data and who has access to it and who's benefiting from it. And I think medicine or health care should be the same when you come to see the doctor. You should be bringing your information with you to the doctor, not you go to the doctor and you're hoping the doctor has the right information about you.
176	Tugce
177	And as you know, now it's a big problem, coronavirus. And when you consider this situation how blockchain technology help or how we can use this technology in order to control the spread of virus.Do you think?
178	The Interviewee 2
179	I think... I think that will the only time you'll see the benefit is if we actually have better tests or we have better vaccines. So, if you have a very good test, which proves bioblood test, antibody tests, you no longer have... you had the virus and you developed an immunity to the virus. It would be very useful if you go to the airports where you want to travel. You can prove to somebody with your medical records, look, I'm immune to a corona virus. I had it before. I don't have it anymore. And I want to travel. This will be the same in the future if we ever develop a vaccine for this same principle. You can prove digitally on your health passport. I've really had the vaccine for this corona virus. So please let me travel. I'll go to work or do whatever I need to do.
180	Tugce
181	And How we can use this technology to develop drug or vaccine or treatment. how we can use this technology?
182	The Interviewee 2
183	I think just when it comes to the supply chain, which is not an area we're involved with, but supply chain would be a good way of showing how this medication was... was made for other people can replicate as well.
184	Tugce
185	How this technology mitigates social damage to people's life?

186	The Interviewee 2
187	No, no, I don't think it's something we do or health will contribute with at all.
188	Tugce
189	Mm hmm. Okay. And today, blockchain technology is used to, you know, develop drug, especially by genomic companies and also for device and treatments to fight chronic, genetic disease. And what is your expectation about products application or any kind of social innovation after especially this pandemic. By using blockchain technology, how can they be changed?
190	The Interviewee 2
191	So I think the one good thing the pandemic has done is.. it's that... it's loosened very obstructive rules to do with information, governance and other ones such as GDPR, because people have realized we can't wait one year to check. Does this comply? Is this okay? You know, you need to just help people from now. And I think this might even open the door for blockchain solutions because there's still a bit of doubt about how it can be used. So I think this kind of pandemic has up to relax the rules and will make things move faster.
192	Tugce
193	How will the pandemic affect the healthcare and environment? In a sense of innovation, investments and product and service tendencies, what will be the role of blockchain in this period.
194	The Interviewee 2
195	Yes, I think health care year upon year is having a record level of investment in Europe and in the US internationally. Even this is investing more into health care and see this being a big profitable market. And I think blockchain is going to be an important role in that going forward when it takes off as an industry norm in the financial sector or insurance sector. Healthcare will naturally follow as well. I think you can already see the uptake for technology, which now this pandemic, everyone is moving to remote consultations, video consultation because of the doctors who are self-isolating, all the patients are isolating and our product x (he said the name of their platform), which we just released last Friday. It's been one week leaved out and the system is being used by other countries. So people are much more happy to adopt this technology because they need it rather than waiting a long time for it.
196	Tugce
197	And now, what do you think about these new business models effect on new product trends in healthcare? How these kinds of platforms reshape the collaboration because as you said, that now it's people go to much more remote consultation in healthcare. So probably they need to collect data remotely. So this is how effect the industry such as medical, pharma industries especially.
198	The Interviewee 2
199	Yeah, I think I think it will affect people at having to do things more remotely. I think the other point to take as well is it could be a good thing. It could be a bad thing. It could be a good thing because it opens up the playing field for anyone who's a small business, who has a quick innovation to launch quickly and get learnings very quickly. But it could also be a bad thing because governments are very desperate to find any solution which works. And they might offer the main contract to one big company, which is going to monopolize the area and not let other small companies get involved.
200	Tugce
201	What about bringing to different industries such as pharma and medical device? Do you think it help to increase collaboration?
202	The Interviewee 2
203	Yeah, I think... I think that shouldn't have been a reason not to increase these collaborations and relationships. If something good can come from this pandemic to make people work together and be better funded to work together, then yes, I hope it does work. But I think it's too early to say.

204	Tugce
205	Okay. Is there anything in our discussion that you would like to comment? Or, you think we haven't been mentioned which is significant.
206	The Interviewee 2
207	I would just say the way that I look at blockchain, I don't think the blockchain is the answer to everything. And I think we have to talk about blockchain like we talk about the Internet. It's a it's a tool to getting a job done to finishing or completing a task. But it's not. That's you know, if something is successful because it uses blockchain, I know that the main thing that the user is going to want is a good experience. And they don't care how it works, whether it uses blockchain doesn't, whether it uses AI or it doesn't, the user doesn't care. The user just says, how do I get my job done? So, I think it's good to try to innovate things and it's good to try things. But the main objective for me, for example, let's say if in five years time my company is still active and we realize the blockchain is not needed for a product, then we will we will leave blockchain because we're not going to keep doing blockchain just for the sake of doing it. We're using it because it has a purpose. And I think it's it's going to make a big difference. But if something better comes out, then it's something which is more advanced. And again, we would move to the more advanced technology. So, it's for me, it's less of an importance whether something is blockchain related or not. It's more important to know what is the task is trying to complete. What is our objective is trying to solve. And if it does that great, that it solves the problem.
208	Tugce
209	When you consider your business models, can I say that is your main customer is patients, the individuals or hospitals and health providers.
210	The Interviewee 2
211	Yeah, I think... I think health providers and their patients are going to be our main customers. And that's the main area we need to work on and focus on and develop and mature. And once that is much more established, then we can try to see what we can do in the insurance industry, pharmaceutical research industry later on.
212	Tugce
213	Okay.
214	The Interviewee 2
215	Thank you. Thank you so much for accepting to make interview with me. Actually, it's my pleasure. My pleasure. I'm very happy.

Appendix 3. Transcript of interview with Firm 3

1	Tugce
2	Is there a research laboratory or product development unit in your company?
3	The Interviewee 3
4	Yes, we do have product development. Our company is primarily looking at product development. In fact, you know, our whole business model looks her on developing new innovative ways to transfer prescriptions. And that's what a lot of our researchers are looking at. How do we ensure increased safety, increased efficiency with the transfer of prescriptions in the health care system?
5	Tugce
6	So this is the purpose of your laboratory, right?
7	The Interviewee 3
8	That's right.

9	Tugce
10	Okay. How many employees work in this laboratory?
11	The Interviewee 3
12	Four.
13	Tugce
14	And what are their specialization?
15	The Interviewee 3
16	The specializations are in software development and coding and then kind of things. So, my background is pharmacy. So, I'm ...I'm a pharmacist. So, I don't necessarily get too much into the technical details with them. But I know obviously their qualifications are all software related and coding related.
17	Tugce
18	Which departments, uh, do they collaborate in the company?
19	The Interviewee 3
20	Directly with the strategic initiatives department.
21	Tugce
22	Does your company cooperate with complementary firms in your industry?
23	The Interviewee 3
24	We have explored this idea. We haven't actually pursued any collaborations as of yet. Cooperation is as of yet, but we have pursued it. And so we have discussed it. And it is something we are looking to do. But I think it's going to take a bit of time because we are a startup. We want to make sure that we are established before, you know, kind of pursuing cooperation with this
25	Tugce
26	So, we can say you are planning but not started yet.
27	The Interviewee 3
28	That's right.
29	Tugce
30	Okay. And does your company collaborate with universities?
31	The Interviewee 3
32	No.
33	Tugce
34	Does your company collaborate with public or private research institutes or laboratories?
35	The Interviewee 3
36	Not as far as I'm aware. No. We did have a collaboration with University Malta a while ago. Oh, you really test me on. I'm trying to think we did have some sort of collaboration. I think about a year ago with University Malta to... to help with development ...developing a product. But it wasn't successful. So, we just pursued... We just got the collaboration in place, but we didn't actually end up pursuing it as well.

37	Tugce
38	Can I ask that? What was the reason of to be unsuccessful?
39	The Interviewee 3
40	Because blockchain in its nature is quite an exploratory phase. Universities and public research institutes look at trying to explore the technology to its maximum potential, whereas with business you do need to at some point look at a cost benefit analysis because indeed if we're investing in a certain project, we need to be able to see the clear returns and how we... how the money's going to be generated. What kind of cash flows we're looking at. So, it is a conflict of priorities, I believe.
41	Tugce
42	Okay. And does your company cooperate with governmental institution?
43	The Interviewee 3
44	We are cooperating with a bank with the National West Bank. They're not West Bank. We are being incubated by them. A departure... a division of ours is being incubated, incubated by them. So that... I don't think that. I don't know if it's not West Bank, a governmental institution, but I think that's it. It's a government backed body, or a government backed grant.
45	Tugce
46	So, how your company attends innovation activity in health care?
47	The Interviewee 3
48	So, we have a two-pronged approach. We very much look at, you know, what is the technology that is available? How can we maximum benefit from it? So, we've looked at blockchain to start off with and you know, we've been invested heavily in blockchain and looking at how blockchain can benefit specifically the pharmacy area. Because that's my background. My business partner is from ... He's from more of a biomedical sciences background. So, we like to look at, you know, these are technologies available. Where can we play with in healthcare? That's kind of the way that we go about innovation. And obviously, the second part is looking at where the problems that happen within healthcare. You know, problems I have faced when I during my career and my colleagues and we look at which technologies could potentially benefit or solve some of these issues. You know, things now that kind of criminal like 5G, Internet of Things, all these kinds of buzzwords. Looking at how can we actually create value from applying them within healthcare?
49	Tugce
50	So, do you make any collaboration for product development with pharma industry. Any company in this industry? Or did you transfer any technology for other companies?
51	The Interviewee 3
52	So, we develop we primarily develop products on our own. For example, with one of our first products, which was called xxxxxx, we trailed there and actually rolled out in some pharmacies like ...there's a pharmacy called xxxxxx, The xxxxxxx Pharmacy Group, there's xxxxxx Pharmacy Group. These are based in the north of England region. And these guys obviously took on the products. They trailed it to give us feedback. And it was a bit of an iterative process of trying to fine tune it. So, yeah, so we do... we do focus primarily on working within our own means and within our own structures using stakeholder feedback to try, you know, find key areas of development, try to find problems that haven't been sold for pharmacies and trying to develop something for them specifically. So that's obviously what we've... what we've pursued with our first products.
53	Tugce
54	Okay. And did you start or initiate to innovate new products or service for healthcare? And if you say yes, could you please explain what it is and how you started?
55	The Interviewee 3

56	Yes, we again, black and blue patient. Blue patient was a new product or a service,I am not sure. I think it's a product classified as a product, which was a algorithm based product that tried to incorporate technology within the patient pharmacist consultation. So, the product, the idea behind the product was that the patient that a pharmacist would conduct some physical examinations on the patient and they would input basic, you know, physical examination results into this algorithm and it would use NHS data to try and give the pharmacist areas where the consultation should be driven. So, for example, the pharmacies would conduct a blood pressure test, would input the blood pressure scores. They would conduct some weight and height measurements. And there would be, you know, analyzed by the algorithm. Give them a BMI, very, very simple things. But idea would be that it would incorporate technology within the consultation. And this data can be recorded locally for the pharmacy. I can see a kind of progression of the fact that the patient returning to the pharmacist and, you know, receiving repeat consultations. So that was you know, that was kind of the first product that we released here.
57	Tugce
58	Did you know? Did you produce these products themselves or you cooperate with any other companies?
59	No. We produced this. We produced this ourselves. So, this was the first part of I mentioned in the last question. So, we actually received feedback from the pharmacists, which wasn't a kind of, you know, a formal arrangement or, you know, a business a business transaction. It was, you know, how did you guys find it? You know, one of our community engagement managers was in the pharmacy. Seeing how the pharmacist found it in terms of user research, etc. So, it was primarily developed in-house.
60	The Interviewee 3
61	And what is the role of blockchain companies in the product development process in healthcare ?
62	The Interviewee 3
63	Well, that's a big question.
64	Tugce
65	You can think like for pharmaceutical industry actually, especially because they use your own data, for example. So, there's some clinical trials or something.
66	The Interviewee 3
67	I think its test.it is pushing the barriers. So, you know, from the things that you provided that, you know, attending brainstorming sessions. Definitely. I do not buy the rest because really the key issue from what I've seen is that, you know, people work in silos. So, people work in their own little groups and they believe they have an idea because of something they've read. But when you go into practice, you know, doctors or pharmacists or dentists, they're far away from thinking about these programs. So maybe if there were opportunities to bring these two together. This is where the blockchain companies and other technology companies would... you know specifically for this question, blockchain companies can really look up and, you know, figure out where does blockchain help within the healthcare system. You know, I've been repeating this in my professional meetings as a pharmacist where, you know, for example, we don't have clear access to patient data in a pharmacy. You know, we have to rely on something called the summary care record, which is just a snapshot of what the patient data is that's available to the GP. And you go to the dentists, they don't have barely any patient database, however, records they have for their patients. So, I think at some point, you know, medical chain and the owner you know, you spoke the interviewee 1 and... you know, a few years ago we're pursuing an idea around, you know, wearable technology. So, for me, I think blockchain companies have the responsibility to attend these meetings and attend these stakeholder focus groups and really showcase how blockchain can improve healthcare and solve some of the real problems that faced. I wouldn't be sure about, you know, in both of my roles, which I don't use blockchain for clinical trials or market research is primarily for patient data or drug data.
68	Tugce
69	And Could you explain what is the difference between your chain-based information companies and traditional information companies? What kind of dynamic capabilities do they have in sense of innovation?
70	The Interviewee 3

71	Maybe, maybe mentality like wave noise from wives are from wives. You know, my experience with dealing with some of these companies in general has been there is definitely a more, you know, to use a word dynamic mentality to words data within blockchain based information companies. If I understood this correctly, you know, blockchain companies do generally because of the nature of the technology, try to test new boundaries. A changed business models. They look at how can the patient become the center of their data compared traditional information companies, which a bit more of a safeguard. They believe that they have the responsibility to collect the data. Keep it safe. Keep it in a centralized. Blockchain companies really do common try to disturb that and return data back to its original owners, I guess.
72	Tugce
73	So how you help researchers or developers or also innovators to find partners? Because, you know, in also your company, I think it's kind of platform which different stakeholders can find to each other. Right?
74	The Interviewee 3
75	Not really, not because of the stage that my company is in. We don't necessarily. We have had inquiries, but again, we quite weak. We're still quite a young, smaller staff. You know, we were only consistent altogether, maybe of 20, 20 individuals, 22 employees. So, we focused primarily on finding the problems, developing the solutions and then training them and seeing okay with this work. Great. Then, you know, kind of split off and start working on developing this as a full company and so on. So, we don't necessarily deal too much with, you know, partners and strategic partnerships and that kind of thing.
76	Tugce
77	Yeah. So you are... You create your own applications then.
78	The Interviewee 3
79	That's right.
80	The Interviewee 3
81	Okay. So then I skip actually many of these questions then now because you don't also really have partners with the universities and... Yeah. So. Okay... So maybe I can ask that. What kind of challenge you face during innovation process?
82	The Interviewee 3
83	The challenges I think are meeting expectations with reality. You know, I think there is a big problem with. What people think technology can do and what technology can actually do. And that's been one of the biggest problems for me as a healthcare professional, as somebody who leads this health tech company when I meet with other health care professionals. They have one of two different perspectives on this kind of work either. The first one believes that I should be able to solve every single problem in one product and using one technology. And that's not the case. And the others, unfortunately, don't believe at all in the technology and say that, you know, it's just a scam or it's just a get rich quick mechanism, which is obviously, you know, both are far away from ..from the truth, which is that there is a technology here that can definitely help patients directly with the care that they receive. You know, by facilitating pharmaceutical trials, clinical trials, by facilitating the flow of information. But there doesn't need to be a bit of a raincheck or a sense check on. Guys, we need to just allow this technology to develop organically and try, utilize... utilize it the best we can. In the pockets of areas where technology is and not trying to, you know, use blockchain to...I don't know. So, I've had some crazy, crazy proposals of our using blockchain to solve to help with surgeries and different things and do to you kind of have court based on them. Like, no, we need to be a bit more realistic, maybe even like.. some of these quick wins, you know, showing how blockchain can be used in real life. And that will kind of increase people's belief in the technology and also allow people to understand better how technology should be used.
84	Tugce
85	So, what kind of data is collected in your blockchain?
86	The Interviewee 3

87	Mainly prescriptions. So, prescription data
88	Tugce
89	But, Is it possible to any other data to collect in your network or only limited prescriptions?
90	The Interviewee 3
91	We did try to do. We did have a collaboration with an organization a while ago. I'm talking about 18 months ago. To also have auditory prescriptions. So when somebody goes to you know, somebody has difficulty hearing and they go to an odontologist, they obviously. Right. They also have a prescription of some sorts. And there was a... an attempt to try to incorporate that as well as we do hope eventually an idea to amalgamate the two...amalgamate two products together where patients would have a segment for their prescriptions on this platform. But also, the health data that is collected by the pharmacist. So, you know, the blood pressure, the blood sugar levels, the breathing, the heart rate, etc.. But currently, it's just prescriptions.
92	Tugce
93	Okay. How do you motivate patients and other stakeholders to share their data to use in the research process? Maybe you don't do this, but
94	The Interviewee 3
95	Yeah, we primarily use trial data. There's not a lot of it is not real patient data in simulations.
96	Tugce
97	Do you think blockchain technology has a limitation in sense of data movement among parties?
98	The Interviewee 3
99	Yeah, of course. I think not all of it is technology based. Some of it is psychological, behavioral psychology based. So, people believing that the technology will do what it does. So, you know, stay safe. There's also an aspect of doctors sometimes don't necessarily want the patient to have all the data that they have access to. They believe that, you know, this could... for example, open up issues where the patient sees some data and they actually go out and start Googling their symptoms or Googling some issues on the prescription, etc. I think is, yes.... So, I think that all aspect that you have to develop an interface for each person. So, you know, because in our business model, idea we have the pharmacies, we have the patient, we have the doctors. You can also, in addition to that, have potentially the regulator being involved the CCD, which is the clinical commissioning groups being involved. So, each of them has their own agenda when they're looking at the prescription and looking at the whole network. So, the doctors obviously want to write a prescription and be assured that there won't be any tampering with any of the data on that. The patient wants access to be able to choose which pharmacy they want to dispense, subscription on, etc. The pharmacy obviously wants to make sure that they receive exclusion and they are paid for whatever they are dispensing. But then you've got people in the clinical commissioning groups who don't certainly care about the individual patients who care more about which drugs are being prescribed in the local area. So, I think the biggest limitation is the whole interface of it. You know, you're ...you are introducing new stakeholders to the group that you need to think about.
100	Tugce
101	So, do you make any collaboration with other industries in order to improve blockchain and smart contract ?
102	The Interviewee 3
103	Not really, no. No.
104	Tugce
105	So, could you share your opinion how blockchain technology address problem in healthcare today? Especially, you can think the corona virus situation today.
106	The Interviewee 3

107	I think is accessibility to data. That is, you know, the world is moving towards the reason why we are having such a good response, I think, to Corona virus, even though, you know, on the surface it may look. But, you know, I think in generations to come, they'll look back on this this pandemic and realize that actually the numbers of people who I hope because of the actions that have been taken are minimized. You know, people, the patient are dying. It was a lot less than what could have been if people didn't have access to information. And I think because of social media and whatnot, we have a lot of access information. One area that's not yet accessible is patient data. And I think, in fact, some of the you know, I keep up today with the news and I see that, you know, for example, they say that Hydroxy calorically could be a potential remedy, this potential vaccines being developed in Japan and Korea. The issue that I think health confessionals face is that there's not a transparency of information between them and this is where blockchain can really come in. If you have the ability to share patient information between, you know, epidemiologists and between, you know, virologists and between people who can really make a difference across not just cities and medical practices, but also across countries. I think this is where blockchain will really find its feet especially. Who knows?
108	You know, And, you know, this is the first pandemic for a hundred years. But, you know, very soon we might find that this could potentially open up a whole new area where there are more pandemics, for example. Some people are theorizing. So blockchain does have an opportunity there to be able to transfer information safely and efficiently.
109	Tugce
110	So also, I want to ask, how blockchain technology can help mitigate the social damage and how affects people's social lives?
111	The Interviewee 3
112	I don't see how. Again, you talk about blockchain in the area of information technology. So, for example, you know, we release a sort of ...more up to date... because I think that the biggest. I don't know, but I don't think blockchain will be able to affect people on the micro level. So, you know, people go into the shops and going, however, web blockchain potentially might have a benefit is where people, for example, travel. So if you're traveling abroad, some countries might start, especially when travel restrictions in east. I know, for example, in the states, then they might start introducing checks. Where has this person had coronavirus? Have they not had coronavirus yet? You know, are they currently carrying coronavirus? You know, who knows? So potentially blockchain might help with these kinds of checks or somebody goes to the doctor. You know, they provide them with a certain confirmation that they have had coronavirus and they are now immune to it. For example, blockchain can be used to as a kind of framework to spread this information so that people on the other side that are relying on this information can be assured that this information has not been tampered with. There isn't any source fraud within that. There is a clear chain of command between the test and then the result and the confirmation. But in terms on the micro level, within cities and within people's interactions, you know, I personally can't see blockchain having an effect.
113	Tugce
114	OK, especially when you think your business models and your business, how these kinds of platforms reshape the collaboration in health care. Why do you think? What kind of product after that can be emerged?
115	The Interviewee 3
116	I think that in the next period, once we are out of this, I think there's gonna be a real hunger for making sure that we never put in this position again where, you know, people locked in doors and they can't move. You know, I think generally speaking, the world coronaviruses has in a way brought the world close together because this issue has faced everybody. You know, when you look at the economies, the majority of the economies across the world have crashed because of it. When you look at society and from a community perspective, many, many countries, I think really stuck there, 30 percent of the world right now is on a global lockdown. So, I think in a way, it will encourage more cross collaboration internationally, bringing the best and brightest from each country to help and solving problems. And I think, again, blockchain will be crucial in ensuring that the information that is being provided to the people, especially from healthcare perspective, is, you know, genuine and transparent and valid.
117	Tugce
118	Do you want to add any comments or any additional information which is important for you?

119	The Interviewee 3
120	I don't think so. I think you've covered the majority. Again, to give you a bit of context around where my answers are based from. You know, our company is very much a young startup, you know. Well, again, we don't have more than 20 employees in the company. As leaders of the company, as the executives, myself and the CEO, we are from healthcare backgrounds. He's a lot more, you know, in the kind of the business end and I'm more in the making sure we are kind of solving real life problems. And as you can see it and we pretty much focus on products, we don't necessarily focus on expanding blockchain itself and expanding the technology. We look at taking that technology and pretty much taking a perspective of translational research. How can we apply that technology on the ground? So, I hope the answers have provided any sort of benefit
121	Tugce
122	And I think it can be. So thank you. Thank you so much, for help.
123	Thank you very much. Stay safe.

Appendix 4. Transcript of interview with Partner 1

1	Tugce
2	I want to ask you, could you please introduce yourself and your company?
3	The Interviewee 4
4	Sure. All right. Well, Tugce it's wonderful to be speaking to you. It's really exciting. We talked to someone in Kaunas again. I think I mentioned in my email thread. I've actually been a count of three times, not a lot, but three times on different trips and used to work with team over there frequently, including I actually got to do a presentation to you. So, it's really good to have that reconnection. My name's The Interviewee 4. I'm the chief technology officer with Empiric Health. Empiric Health is a U.S. based company, Delaware Corporation, that was spun off from Intermountain Health Care System. Intermountain is a large twenty-four hospital system, primarily in Utah. A couple other states, they are really well-known historically for their innovation. They spin off different companies frequently based on things that they have done and tried out in their environment. Over the last five years, about five years ago they started a cost management program that was really around unwarranted clinical variation in surgical services. So, they were very specifically looking at things driving cost and quality outcomes in surgery. Looking at decisions surgeons make around supplies and instrumentation, medications, etc. They had really good success with that. They reported savings over a three, four-year period and around 90 million dollars US. And as a result, they... they made the decision to spin off empiric health. Again, that was done about three years ago, February Twenty seventeen specifically. Our mission is to take that methodology, that approach and the accompanying analytics out into the marketplace. Empiric now has about five or six other clients, also typically larger hospital systems strictly in the US market at this point. We do two to three-year types of service consulting engagements, but we go in. We start by getting a lot of data from the clients. We get data out of the EMR, out of the EHR. We also get data from their supply chain system. We bring that together into an analytics platform where again, we're specifically looking for various. Part of that platform includes a blockchain. I'll come to that in just a moment. But just to kind of wrap up the history, when I joined the company back in October of twenty seventeen, the technology buildout work had just started. I was brought into kind of guide and steer that one of our partners is how we got introduced as Firm 1. They're based in Denver. Firm 1 is we use them primarily as a kind of a leapfrog opportunity that had a lot of the platform already built out that knew we needed. They had a robust data repository that included a health care type of model. They already had a lot of the analytics types of tools that we wanted on top of that. And so, we engaged with them to do a custom build out at the analytics stack. And again, the blockchain piece was part of technology stack. So, the course about a year, we worked with them to do that. In 2018, we implemented platform. Actually, we did the initial implementation first quarter twenty eighteen. So, there's really less than six months from start to go until we were working with it. So, that that's sort of the history and again, identify as one of our key partners. One other a couple of other perspectives. I will mention that for us as a health care startup, we knew the one we were going to be intentionally trying to scale rapidly. We knew that we were going to be working with a lot of detail, patient data. We knew that we wanted to really try to take a best practice approach from the beginning in terms of security and data management. And... under the U.S. HIPA and high-tech regulations in Europe, it's the GDPR. There's a lot that a lot of gray areas. But what we wanted to intentionally do was try to figure out industry best practice and

	do that just from day one. So, part of that meant that we were we made a decision consciously to be fully cloud-based. We wanted to make sure the analytics stack met all of the appropriate information security criteria, even though we were a small company, we're still a small company that ultimately people the company. So, we've been very intentional about that. So for us, one of the first key points of how blockchain impacted us as an innovation company is the extra layer of security that it brought. One of the things I'll elaborate on is that for us, blockchain really was not a strategic part of the business plan. It was a benefit that was more foundational in nature. We wanted to have a stack that was just as tightened up as possible from a security standpoint. And so therefore, having a stack that embedded in the layer already had a blockchain piece there. That extra protection, immutability, encryption, that was just a plus that we wanted when we recognized that that was a capability, we could... we could have kind of for free because it went along for the ride. So, for us, that was one of the first pieces. A second piece is that, as I mentioned, we plan and still are working very hard to scale quickly in our clients. We see a great deal of value in being able to provide benchmarking across clients on cost, quality outcomes and surgery and to make it really easy for a client to be able to see how they stand nationally compared to other hospital systems for given type of procedure. And that for surgeons to see how they compare to other surgeons nationally and the approaches that we use Ram Liddick standpoint, that's not really out there in the market. So, we feel like one that could be a big differentiator to its big value proposition we bring to the table and with the blockchain. That means we then can leverage things like smart contracting and some of the other capabilities to set up an environment where it's easy for clients to participate in that kind of program. So those were really the two big aspects as one, the extra security. And then to that kind of future looking piece, which was a little more strategic in nature. Let me pause there and I'll let you get some questions. Yeah.
5	Tugce
6	Okay. So, I can ask my first question. you have already answered some piece of these questions. But I want to ask, could you explain what kind of relationship your company are in with Firm 1? You are saying they're your partner to create a kind of platform, right? Yes.
7	The Interviewee 4
8	Yes. And ...we have an ongoing relationship with them. They are basically a hosting and administration type of company, of course. Now, originally, they were also a software development partner. But we now, as we've grown without our software engineers, but they continue to… to really be the main... the basically our virtual data center and administrator for our platform.
9	Tugce
10	And ...what is your specific role in this relationship?
11	The Interviewee 4
12	t was the chief technology officer. I don't have a whole lot of data involvement, the ultimate responsibility for the relationship, the contract, the services, what... what we decide to keep in-house versus having them put in. So that falls on me sort of strategic nature of it. And then just as senior level that the general relationship management, I meet regularly with their chief technology officer, some of their other company executives. In the early days, three years ago, I was really the first technology hire in the company. So I was also the product manager, the primary QI and testing resource on our end and was even running the sprint backlog. Product produced. But as we've got people, we've got a product management capability and again...
13	Tugce
14	What is your company's benefits gained from this partnership? What is your company's main motivation in getting involved in this relationship with Firm 1?
15	The Interviewee 4
16	Well, let me start with the second question first. In the... when the company was first formed in February 2017, there was a review of the technology in approach that Intermountain had used to do the work they had done when they developed this approach, this methodology. It was largely based around an enterprise data warehouse and using Tableau to do various reporting mechanisms. Was pretty quickly determined that would not scale and it really wouldn't be viable in a commercial market. We're bringing multiple customers. It wouldn't be a good multi-tenant type environment for the repository. It just wouldn't. It needed to be redone, refactored rebuilt from the ground up. The CEO of Empiric was hired in July of that year and he quickly realized, yeah, we're going to have to rebuild that. Firm 1 was brought in to say, OK, we need to do this and

	we need to do it quickly. And because they already had many of the key foundational components, including the blockchain. But some of the other things I mentioned earlier, we realized that by bringing them on we could really get a functioning stack, a functioning product very quickly. And in fact, that's what happened. We managed to get from their involvement actually up and working on... on a viable platform and under six months. So the initial choice was that speed to an MVP speech, a useful type of product. Now, the ongoing strategic piece of this is as a small company. It's good to have a partner that can kind of flex up and down with you as your needs change. So they were able to add or reduce up and down on soft engineering resources that also provide a great depth of knowledge on information security, which also relates to blockchain fees. So as a small, innovative company, it's good to have a partner who can help. You know. Really you're not relying on trying to go out and hire a bunch of people that they want
17	Tugce
18	And ...What do you think your partner's main motivation was. That's mean Firm 1's.
19	The Interviewee 4
20	Yes, for them although they had a couple of small clients that really did not have a big ongoing client base at the time that we contracted with them. So, we provided to them kind of a cornerstone client and an anchor client, if you will, to want a steady stream of income is always nice. But also, we were the first ones to really use multiple aspects of their technology stack. So, they really had a chance to. Basically, we were their big initial beta user of the stack. So, they got that much.
21	Tugce
22	So, what is the role of blockchain technology in this process and how blockchain technology affect your service and products?
23	The Interviewee 4
24	Yeah. So, again the blockchain piece for us right now primarily acts as an additional layer of security. One of the nice things about the way Firm 1 platform out, which is different than most blockchain vendors. And when we talk about blockchain in general, I do want to differentiate between what first is done versus what's done the rest of the market. Firm 1 is very clever, and that the way that you work with the data and the blockchain has been surfaced SAPI that looks just like a data API.So it's very easy to just treat it as if it's a database and not have to worry about all the blockchain specifics that are going on underneath. They've really managed to make that a little bit more of a black box site. So, for us, it's just part of the foundation and gain that encryption benefit. There's the audit piece of that as well. There's some aspects of what we do that we do sort of surface up the audit trail chain, if you will, into the user interface. So, that's one area where we see it a little bit in the UI. Again, of the strategic or looking pieces what I want to be able to do from benchmarking perspective to create more than an open environment where clients can just simply self-contract then and then begin to participate in the benchmark environment, leveraging the blockchain capabilities
25	Tugce
26	So, we can say that security is the most important part of using this technology for your business. Right?
27	The Interviewee 4
28	For our business model right now. Yeah, the security is probably the most important part. But again, as we go forward in the next six months to a year, two years, maybe, I expect that that will shift more to that, making a little bit more of an open environment for clients to feel committed to benchmark.
29	Tugce
30	And then according to your experience, could you say what's kind of challenge you face during this partnership? And if it's possible, could you share some example for us?
31	The Interviewee 4
32	Well, let me give you two examples. One example is for me coming into it, blockchain was actually new technology for me. I'm certainly aware of it, but I hadn't done any hands-On type of work or business experience where we were using blockchain to leverage it prior to coming in third. So for me, there is a little bit of a learning curve. And it was not clear to me in the first couple of months what the real benefits would

	be for us and whether it was going to be more trouble than it was worth. That was one of my initial concerns, is that it could just be unnecessary overhead. Performance was a concern. And I... you know, I had heard really bad stories about how bad performance could be in blockchain tax environments. None of that panned out. So for me, one of the challenges was my own learning curve and that's where they were actually really good partner because they all kind of bring me along to a better understanding of it while helping address some of my concerns. Like we...we very intensely did some things to ensure that performance was not force, that things were architected in such a way that the blockchain is on or off. We just really couldn't tell from user experience point of view. So that was one challenge. The second challenge is certainly for the first two years. Firm 1 was, as I said, both an administrator, host of the platform for us and also a software development partner. They did great on both, but sometimes we had put a whole lot more time and thought into the software development piece because they basically were our outsourced soft engineering team. So that meant a lot of direct interaction, not just at a high level, but down in the weeds with their software engineers as well. And I really wouldn't say that was a challenge. It wasn't a problem. It was more just a little bit different type of relationship with a vendor than I might normally have. And that kind of environment, because we were trying to do and manage both of aspects.
33	Tugce
34	Did you create any product or service by using this blockchain technology?
35	The Interviewee 4
36	Our core analytics platform that I talk about, the primary tool that we put out in front of our end users is called ProComp and that is the custom UI built largely by Firm 1, but also now our own engineers. It has several modules or components within it that really focus on looking, at identifying and understanding that unwarranted clinical variance. So, we can go into the tool and we can say for a given type of procedure or all the cases are very similar. Which surgeon has higher costs, which surgeon has more site infection rate, higher side infection rate? And then start to understand why that platform lets just dig into the details and get to that web based, browser based. We can do it on mobile, but most of the time it's really intended for use by or nurses sitting at the client that are really trying to engage with the surgeons of understanding its differences.
37	Tugce
38	Does your aims is decreasing the cost of surgical operations, or not?
39	The Interviewee 4
40	And there's really been kind of a shifting focus in our early days. Our focus was primarily what are the costs that happen within the walls that are so young to us? The supplies and instrumentation, everything that's used by the surgeon is charged out basically to the patient or their insurance company. And it's interesting, the different choices surgeons make to do the exact same procedure can result in very large differences in their costs. And so, helping understand those and helping surgeons figure out. "Wait! I don't really have to use that foreign dollar device when there's a $50 device that does exactly the same thing." Open them under standard that’s the primary focus. But we also bring in quality and outcomes measures. So, we're looking at things like how did the patient do after the surgery and making sure that any those changes don't have a negative impact on the patient on the other end. The now we're starting to get a little broader. We're starting to look at what happens 90 days after the surgery that kind of...
41	Tugce
42	Yeah, what's kind of values you create for your customers?
43	The Interviewee 4
44	So, our... our business model is really more consulting model at this point. So, what we're typically doing with the tool with software is preparing content to share with the surgeons in a consulting type environment. Frequently that means one of our people getting up in front of a roomful of their surgeons and doing presentation and saying 8 percent of you use this particular device, 20 percent of you use a much more expensive device. Let's have a conversation around why those differences exist and see if those changes can.
45	Tugce
46	And now I want to talk about the data which you recorded. What kind of data is collected in your chain?

47	The Interviewee 4
48	Yeah. So, the data we bring into the platform is the data from the EMR that is really about what happened in surgery and the patients stay in the hospital. There's about 300 and some odd different data elements we bring in routinely. We also integrate the data from supply chains such as the supply costs and manufacture's some info, we were just talking about. One of the other things though that we included in the chain. Beyond that. So, part of it is we're bringing that data in and then that goes into the chain and that way we've got a nice plan, not a trail. That what we brought in from the client this month is, in fact, what also changed from last month, for example. But the other thing we do in the platform is we apply a set of business rules to figure out which surgical cases are very similar.
49	The Interviewee 4
50	So, in other words, how cases grouped together in what we call cohorts and the cohorts are defined based on rules surgeons come up with. And this was done in a mountain. They developed about through 250 of them, three hundred now. So, there's different cohorts and the rules are run against the discrete data for each surgical case. And the assignment of those and the rules that went into the court definition are also attached on the chain. And so that way that also becomes basically a high-end audit trail for us to be able to go back and look and go. The way we group these cases today is the same or different from how we group them six months ago. And if it's different, here's where, who and ... follow the chain back and understand one.
51	Tugce
52	How do you motivate patients and other stakeholders to share their data to use in the research process, if you do this?
53	The Interviewee 4
54	Yeah, it's actually with our business model. We don't have to go to patients directly. The data is coming from the hospital. I will share with you one of the challenges we have. Although the hospitals, as they contract with it... with us, they understand they're going to have to share the data. It's really hard to get some of this data out. (giggling) It's not supported by standard electronic data interface CDI types of standards. The data we need is not, for example, combine with an HL7 backs. What we finally ended up doing is having to write our own custom queries from the big EHR. So, for Cerner and Epic, the two large EMR companies in the US, we have our own set of extraction queries, we had to write. And then we turn around and provide those to the client. Then they used to get us the data. So, it's less about getting them persuaded to share as it is enabling them to be able to ship.
55	Tugce
56	How they managed to data movement in research networks ?
57	The Interviewee 4
58	Right now, our data, our platform is all strictly within the domain of the client engagements. So we've not opened it up outside of that at this point. As we get into more of that benchmarking, I can see that we would open it up and create more of a benchmarking, searchable benchmarking community that would include researchers and include other stakeholders that are not strictly existing service clients. So we're not there yet. That that's somewhere. I think that in one or two years we'd probably be more into that model.
59	Tugce
60	Do you think Blockchain technology has a limitation in the sense of data movement among parties. If, Yes. What kind of improvement is necessary?
61	The Interviewee 4
62	Yes. There's probably two or three things that we mentioned about it that are potential friction, points of friction. One is there is still performance issues. Trying to really move transactions through and into a blockchain is not very resource intensive and it's not necessarily a simple problem to solve. Right. So that's one friction point. Another I wouldn't call it maybe a friction point is something that folks like Firm 1 is starting to solve is blockchain just as a simple technology without being coupled to a content framework, is tough to leverage If you're a small innovating company. Right? And so, to have a domain knowledge already

	a framework you can start with that is coupled to the blockchain. So, for example, for us already having a data dictionary mapped out, that is a health care data model relevant for us where we have it defined. We have a sort of standard definitions for patients encounters, surgical cases, all the other components that then with the API and the Firm 1's framework is already there. We don't have to reinvent the wheel, if you will, and is automatically attached to the blockchain capabilities. That for us was one of the big saving graces for doing this. And I think for other vertical applications that leverage blockchain, I think that's going to need to be a necessary piece. I think the blockchain vendors, technology producers are going to need to partner up with content frameworks in order to really get the benefit there out into the industry.
63	Tugce
64	And now, as you know, that all the world is fighting with Covid 19. And so, what do you think? Could you share your opinion how blockchain technology address problems in healthcare today, especially when you think the fighting with Covid-19? And what is your opinion about that?
65	The Interviewee 4
66	Well, if I go from the very general, I do think blockchain makes it much easier to do what it was designed to do, share data to do distributed transactions that don't require a central authority to do so. You know that role distributed ledger capability in the post-Cold War world. Let's talk about that for a sec. What's this is all over. I think people are going to realize that we need better ways and better...better ways of sharing data related to epidemiology specifically. That is, you know, in the U.S., for example, the way that a lot of this information gets out is previous to this seasonal flu, for example, gets reported to the CDC, the Centers for Disease Control. They then turn monthly. We distribute numbers. Eventually they got where they would do it little more frequently, but it was a very go to a central authority type of process. And then there's data munching and things that happen and reporting that comes out of that central authority that introduces timelines. So I think a more distributed type of ecosystem that could leverage blockchain where participants sign up to say, OK, I want to be part of the covid-19 reporting system or let's think ahead covid-20 or 21. That... that is something you just sign up for and then you're leveraging the blockchain with a content framework type of API to report that. And then I think that becomes a lot easier. The distributed capabilities would help diminish the impact of like a bad actor on skewing data, for example. But that could be something that's truly a global ecosystem. And that would mean whether it's whoever, you know, government issues aside, if you've got health care agencies and China. signed up and reporting, then you get that data out there real time is things tend to spread across from one country to the next. You have better, more Real-Time visibility of that. It's me that that's... that's where. I can see a real opportunity and I think people hopefully will wake up to the need to do that coming out of this.
67	Tugce
68	So actually, you answered this one. But how blockchain technology help are used in order to develop drug, vaccine or treatment? Do you think it can help?
69	The Interviewee 4
70	Yeah, I really do. And actually, although it's not something we're... we're not doing anything in that nature ourselves. But if you look at what Firm 1 does, one of their verticals that they're going after is the pharmaceutical research, where patients can sign up as individuals to say, hey, I want to participate in this trial or this program or this research study and any of their health care providers where their data is in the ecosystem, is automatically unlocked, if you will, for the pharmacy through the Smart contract. That... that to me is is another great use for this and taking that epidemiological type of ecosystem one step further, then if you've got that same data and then could attach it to the patient records and the patient involvement, patient's getting to get paid to participate in those programs. And that's something that, again, is not easy to do in current climate
71	Tugce
72	and... how blockchain technology help mitigate social dimension damage to people's life. Do you think it can help to create some products?
73	The Interviewee 4
74	Well, I think we've already hit on two of them. The idea of a global epidemiological blockchain based system or ecosystem that that I think could be a tool allowing direct individual spatial and studies that might be associated with that. That would help. I think... I would probably struggle to find an example past that specific

	health care. I do think, though, that this may bring up some more questions about blockchains use in financial transactions. I think the financial landscape is going to change a bit after this as well. This is a rogue global economic head and a lot of ways and globally, it's not just one region or one country, it's everybody. So I'm not quite sure where that might go. I know that the blockchain, bitcoin type of virtual currencies have a bad reputation and we're not doing well, a consumer type of market in terms of being a a medium for actual transactions. It was more speculation driven. I'm not sure if that will get better or not, but I think it's going to be different.
75	Tugce
76	And what does your expectation about products, application or social innovation after also these pandemics?
77	The Interviewee 4
78	One of the things we're saying that we're trying to understand ourselves is that because our clients, for example, are large hospital systems, they're having to rethink all of what they're doing. The services, contracts, vendors that they're working with, they're having to reprioritize projects. So there ...there will be a change in the health care marketplace. And I think a lot of companies will go out of business. A lot of them will have to dramatically change their business. I think they'll also be a lot of room for new innovative startups. But we're going to have to understand what the new needs are that are not the same as what the old needs were. So for us, we still think being able to look at and understand cost quality outcomes, the variance that happens in surgery, that we don't see that going away. That still for us is going to be a big deal. But part of what we're looking at is rather than doing a lot of our people directly to the client to go into the room with surgeons and have the meetings and have the Face-To-Face conversations to how do we do that same thing, but do it remotely, either through a platform or through teleconferencing with a case may be. So there's going to be a lot of that. So, for example, a specific example, telehealth, we are seeing a lot of big changes and there are a lot of telehealth companies out there already. But this is going to be a big boost for them. And so they will probably be a whole lot better off coming out of this situation.
79	Tugce
80	So probably these kinds of products which is related to telehealth can increase. Do you wanna add anything which is important for you and I didn't ask?
81	The Interviewee 4
82	Yeah, I guess I'll come back to sort of a theme. And that is that...for blockchain to really will be widely used in health care and healthcare innovation. I think it needs to become easier to use and it has to become a little bit more of the inherent technology stack and you sort of choose to turn on or use certain features or not, you know, not much different than having. If you think about a technology stack of architecture, you've got operating system, you've got maybe a database layer, you've got application layers. Blockchain is just not a layer in there. That to me is when it can start to become more usable and more useful, more predominant out of the market. Now, that's not to diminish some of the value of the capabilities that it brings, but it's got to be easy first. And then after it becomes easy, then we can start to leverage some of the other pillars. Okay.