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BLOCKCHAIN TECHNOLOGY IN THE PROCESS OF SELLING PHARMACEUTICAL PRODUCTS

Oleg A. Malafeyev (a), Ahad O. Qodirov (b), Irina V. Zaitseva (c)*, Svetlana N. Yuldasheva (d), Alexandra S. Selezneva (e), Artur T. Breider (f)
*Corresponding author

(a) Saint-Petersburg State University, Faculty of Applied Mathematics and Control Processes, Universitetskaya nab., 7/9, St. Petersburg, 199034, Russia, malafeyevoa@mail.ru
(b) Saint-Petersburg State University, Faculty of Applied Mathematics and Control Processes, Khalturina street, 15, apartments 416, St. Petersburg, 198504, Russia, ahadkadirov@gmail.com
(c) Russian State Hydrometeorological University, Institute of Information Systems and Geotechnologies, Voronezhskaya Street, 79, St. Petersburg, 192007, Russia, irina.zaitseva.stv@yandex.ru
(d) Saint-Petersburg State University, Faculty of Applied Mathematics and Control Processes, Khalturina street, 15, apartments 210, St. Petersburg, 198504, Russia, yuldasheva_1966@inbox.ru,
(e) Stavropol branch of the Moscow Pedagogical State University, Stavropol, 355042, Russia, shuraselezneva@mail.ru
(f) Federal state budgetary military educational institution of higher education «Military Medical Academy named after S.M. Kirov» of the Ministry of defense of the Russian Federation, Saint Petersburg, Russia, brey2803@gmail.com

Abstract

This article discusses a mathematical model for the implementation of pharmacological products using Blockchain technology. In addition, the current problems of the shadow drug market (corruption, resale) are analyzed and practical solutions are given to eliminate them. Blockchain technology, due to its decentralization, is one of the best solutions today. This is due to confidentiality, the immutability of the hash function, the speed of transactions within the technology. The integration of the hybrid Blockchain will allow using distributed registries more deeply - entering data into the Blockchain about transportation, about the conditions of logistics activities, about expiration dates, etc. Tracking can be done using marking matrix codes (Data Matrix), which are now implemented by the Information Monitoring System drug movement. The operator is the Center for the Development of Advanced Technologies (CDAT), which is already using Blockchain technologies to compile marking codes. In addition, the article presents a schematic representation of the industrial sale of medicines using Blockchain technology. The strengths of its introduction into the sales structure are shown. All this distinguishes Blockchain technology from other current trends.

Keywords: Blockchain technology, decentralization, hash-function, implementation model

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1. Introduction

In this article, the authors consider a mathematical model of Blockchain technology, which describes the interaction between manufacturers of medical pharmacological products, consumers and regulatory authorities. This technology allows you to clean the market from the secondary resale of medicines and reduce corruption in the sector.

In the considered mathematical gamma-model, a large finite number of independently operating manufacturers of medical products post on the website the prices of the medicine they offer. More precisely, the manufacturer of the drug posts the price of a smart contract for the production of this drug. At the same time, each of them has its own cost of production of this drug product. After that, the consumer of the drug opens his personal account and selects a medical drug with a minimum cost. More precisely, he chooses a smart contract for the production of the drug with a minimum price. In this case, the manufacturer of the goods pays the price of the previous competitor. The following theorem holds (Nemnyugin et al., 2020).

Theorem. In the game described above, there is a situation of equilibrium in pure strategies. The equilibrium strategy of the manufacturer is the choice of its price equal to the cost.

2. Problem Statement

Today, the Russian pharmaceutical industry has faced many unresolved issues. The most relevant are:

i. secondary resale of drugs;
ii. corruption in the health sector.

These issues are still an acute socio-political problem and create a shadow market. The modern shadow drug market is a socio-economic phenomenon in society, characterized by a mismatch between the personal interests of the pharmaceutical company and the legal requirements for it on the part of society. In order to reduce such illegal trends, the state gave entrepreneurs three years to go to the online-cash registers. 2019 is the last stage of the reform of federal law No. 54 "On cash registers." Until July 1 online-cash registers are set by entrepreneurs who have not done this before (Zaitseva et al., 2020b).

Online - cash register is a control cash registers (CCR) of a new type, it meets three main requirements:

i. It is listed in the State Register of cash registers;
ii. A fiscal drive is installed in the case, which stores sales information in an encrypted form;
iii. The cashier sends sales information to the fiscal data operator (FDO). This organization transfers information from cash desks to the tax office.

When companies began switching to online cash registers, tax authorities predicted that it would be impossible to deceive new equipment. This means that organizations will not hide a penny of revenue.

Three years passed, and it became clear that the online equipment is really “smart” and can do a lot, but the system can still be outsmarted. Pharmacologically, companies have learned to bypass the cash

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desk program and transmit information about only a part of transactions, print receipts identical to real ones on printers, and reduce the memory of equipment (Qodirov & Mkrtchyan, 2020).

Tax authorities have promised that with the transition to online - cash registers there will be less cash audit. Indeed, the number of inspections has halved, but they are almost always fined.

The following are ways to bypass CCR:

- Health organizations are flashing the settings so that the cashier does not transfer all the punched checks to the tax office, but, for example, one out of five. The remaining four are “clones” of the original with the same number and fiscal attribute. Cashiers issue these checks to customers, but do not send tax service.
- Pharmacy institutions are trying to circumvent the new rules with typewriters and old cash registers - check falsification. This method was told by inspectors of the Tomsk region at nalog.ru/rn70/ in the News section of February 20. If the buyer does not check the check through a special application or on the tax website, he may not notice the substitution.
- Pharmacies are engaged in resale. In practice, this happens as follows. A pharmacy institution “punches” a drug through a working online cashier (for example, in the amount of X rubles). Further, it is written off from circulation. And after a while, it resells it to the buyer, releasing at the price of X + Y rubles. The check issued to the buyer is invalid, since it is no longer carried out through the online cashier. Because of this, the tax service receives information about the amount of X. The amount of Y is - sheltered from taxation (Baicherova et al., 2020).

In conclusion, I would like to say that the capacity of the wholesale secondary sales market, according to experts, is 15 percent of the total market, which in monetary terms reaches 500 billion rubles. These are huge funds that the state budget does not receive (Feller, 2017).

In addition, conducting shadow activities leads to monopolization of the market, worsens the competitive advantages of “white” players and negatively affects the entire infrastructure of the market.

3. Research Questions

In course of the study the following questions were raised:

i. What is the role of Blockchain technologies in managing the pharmacological process?
ii. How cost-effective is it to use Blockchain technologies in the healthcare system?
iii. What is the Russian experience in maintaining a centralized drug database?
iv. What is an example of the successful experience of using Blockchain technologies in pharmacology?

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4. Purpose of the Study

Presumably, the solution of the above questions will help to understand the economic and administrative attitude towards Blockchain technologies in the Russian Federation. In addition, the developed methodology will contribute to the development of distributed registries in the country's pharmacological industry.

5. Research Methods

In this section, the authors use universal scientific research methods, as well as methods of statistical, comparative and complex analysis. These methods make it possible to identify the strengths and weaknesses of the use of Blockchain technologies in the pharmacological industry of the Russian Federation.

5.1. The Choice of a Solution System

Today, those information technologies that are used in the Russian Federation to reduce the shadow pharmacological market are centralized. In other words, information processing in such systems occurs through a single information processing center. In this regard, when using such centralized software technologies, there is no talk of transparency and the absence of corruption risks.

It should be noted right away that the algorithms used by modern information technologies are not clear to users. Moreover, they are closed from them. In addition, behind each information technology based on centralized processing of information, there are people who are not without the very inconsistency between the personal and the proper.

However, undoubtedly, existing information technologies are designed to reduce the shadow market. The practice of public relations shows that these technologies work and there are already tangible results of their work. In particular, the launch of the State Services information portal allowed many citizens to receive remote access to various public services and reduced the influence of a local official in providing them.

Despite this, it is necessary to understand that the use of existing software solutions does not completely solve the problems of the shadow pharmacology market. So, in Russia it is not the first year that the information product - State Information Technology of the Russian Federation “Vybory” has been used in the processing of information during election campaigns (Bondar et al., 2019).

However, its use does not save Russian society from problems associated with violation of the rules of the electoral law. The voting procedure itself remained the same as before the introduction of GAS "Vybory" technology. And the vote counting process is still similar to the black box model. Namely, the operation algorithms of the system are not clear not only to voters, but also to members of election commissions.

Consequently, the solution to mitigate the shortcomings of centralized information processing systems is to build a decentralized system technology, namely, Blockchain (Durakova et al., 2020).

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Blockchain technology is an information processing algorithm that is based on a peer-to-peer protocol. A peer-to-peer network is understood as "a multitude of nodes (computers, smartphones, etc.), combined into a single system and interacting using the P2P protocol (Qodirov & Chistyakov, 2021).

This protocol provides the ability to create and operate a network of peer nodes.

In P2P architecture, client software is a program that provides its own functionality. As well as the functioning of the data transfer protocol. In other words, client software itself is both a client and a server. In addition to peer-to-peer network architecture, blockchain technology is based on algorithms unidirectional hashing and consensus technology (Dai, 2022).

Unidirectional hashing is a mathematical algorithm for converting information into a string of a given length. The output string resulting from the hash is a number and is called a hash or hash sum (Figure 1).

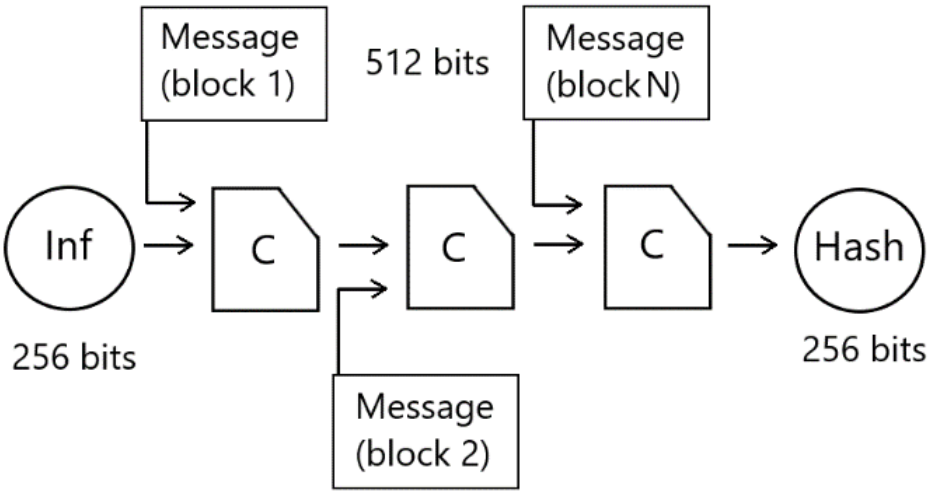

Figure 1. Schematic representation of a hash function transformation structure

The hashing process in Blockchain technology ensures the immutability of the data registry, copies of which are stored on all nodes of the peer-to-peer network. Thus, hashing protects the registry from making unauthorized changes to it. Any attempt to change any part of the data at the end of the information stream will be noticed thanks to the stored hash pointer at the beginning of this information array. A visual representation of the continued operation of Blockchain technology is presented in Figure 2 (Merkle tree) (Avila et al., 2019).

Consensus technology is a set of rules for making changes to the registry. In other words, this consensus technology ensures that the peer network accepts only registry changes agreed upon by the network itself. None of the network nodes individually can affect the functioning of the system and making changes to the data registry.

We can say that Blockchain technology ensures the reliability of the registry with information and the impossibility of making changes to it "retroactively". As well as the impossibility of making changes to it unauthorized by the network and its participants and the independence of the network from any particular node.

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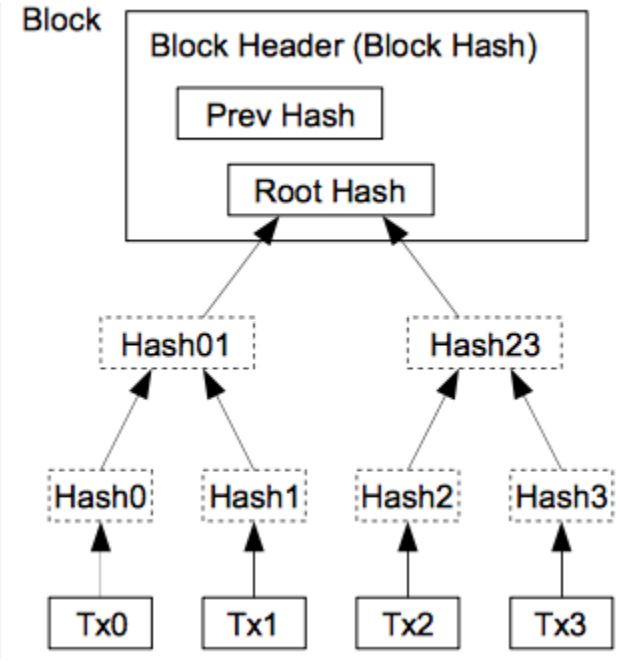

Figure 2. Schematic representation of the immutability of information in Blockchain technology

Thus, Blockchain technology is a decentralized information processing system. This technology can independently, regardless of specific individuals, based on mathematical algorithms and using cryptography methods, be able to provide its own functionality. Moreover, the functionality of the technology is aimed at solving the problems of the shadow pharmacological market. Therefore, thanks to this feature, as well as the availability of this information to any user, it becomes possible to implement Blockchain technology and its ideas. These ideas can improve existing information technologies, as well as make the purchase and sale of medicines truly "transparent" (Malafeyev et al., 2020a).

5.2. Solving the Problems of the Russian Market of Pharmacology

According to the authors, secondary resale and bypassing the CCR is possible because the buyer himself has been removed from the sales chain. But by creating a unified system of the buyer, the pharmacy institution and the supervisor, these problems can be solved. The system itself must be built on Blockchain technology. By a supervisor, authors understand the tax service and the insurance agent.

Using this function, based on Blockchain technology, the healthcare system will receive a tool for tracking the sale of medical products (Qodirov & Smykalo, 2019).

A schematic representation of the sales tracking chain is shown in Figure 3.

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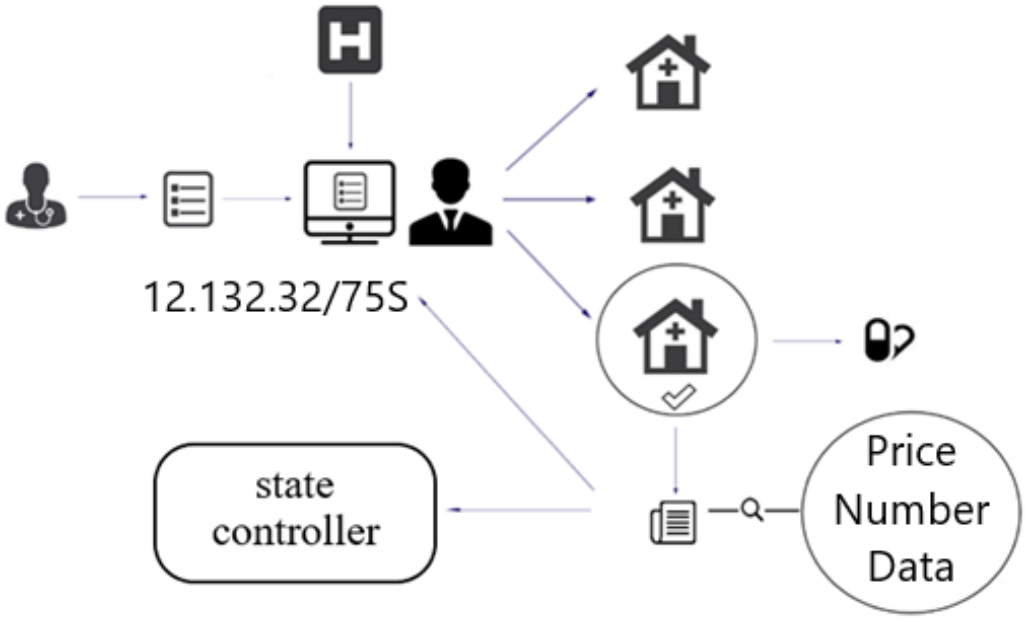

Figure 3. Drug sales tracking model

This system works as follows.

The doctor, having prescribed a course of treatment for his patient, writes him an electronic prescription (through his personal doctor's office). The prescription is displayed in the personal account of the patient. Each patient and each doctor have his own personal account. All personal data is hashed by the system and protected from third-party use. The patient's personal account is attached to his INILA (Insurance Number of Individual Ledger Account). The doctor's personal account is identified by the network administrator. After receiving the prescription, the patient goes to the pharmacy. Using his key-card with a private access code, he, applying it to the scanning device, shows the pharmacy his prescription. The pharmacy gives him the prescribed drugs and sends a check (indicating the drugs received, the number of items, the total amount payable, etc.) to his personal account. And also, to the personal address of the supervisor (in this case, the Federal Tax Service and the service insurer) (Bayer et al., 2020).

This information can be viewed in the user account by the user himself, his attending physician and the supervisory authority. Documentation of the work of the technology for the implementation of pharmacological preparations is presented in Figure 4 (Zaitseva et al., 2020c).

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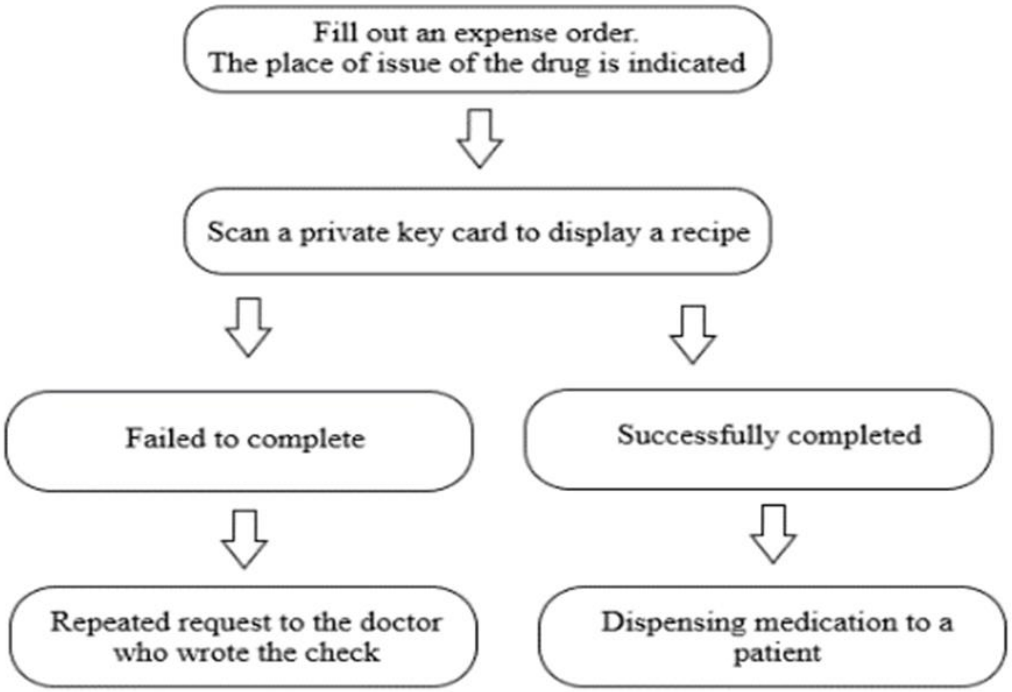

Figure 4. Dispensing of a drug by a medical institution

As a result, we get a transparent system. The pharmacy will not be able to resell its products again, as it sends an information receipt to the user (and also duplicates it to the supervisory and insurance), where the exact price is indicated. This information can be viewed by both the supervisor and the patient himself, which means:

- Once the check is issued, it is duplicated by Blockchain technology to the patient's personal account. From personal account, via SMS, comes duplication of information to the patient on the phone.
- If the SMS did not come, then there is no duplicate check in the personal account and the supervisor. So - the sale is unauthorized (Arzimbekov et al., 2020).
- If the SMS arrived, the transaction went through the tax service and there is no secondary resale. There is no rise in price of products, which is beneficial for the patient;
- If the price is shown below paid, the user will notice the forgery and will be able to contact the law enforcement authorities (Haber & Stornetta, 2017).
- If the price is indicated exactly the one paid by the user, then the pharmacy, in case of paying taxes at a lower price, risks being identified in a forgery, since the supervisor has access to the electronic check. And this will lead to the fact that these frauds with secondary resale will be minimized.
- The system will allow the doctor to track the course of treatment prescribed to the patient. The doctor will be able to see in real time whether the patient is buying the medicines prescribed to him and whether he should follow the course (Back, 2018).

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5.3. The Mathematical Description of the Proposed Medical Project Based on Blockchain Technology

Non-cooperative game G in normal form with a finite set of agents - manufacturers of the drug A, B, C,... defined by the sets Sa, Sb, Sc. . . strategies of agents - manufacturers of a medicinal product and their payoff functions Πa (sA, sB, sC...), Πb (sA, sB, sC...), (sA, sB, sC...). . . determining the winnings of players A, B, C,... respectively, in an arbitrary section (situation) (sA, sB, sC ...), where the section (or situation, or profile) is a certain set of strategies sA from Sa, sB from Sa, sC from Sc, etc., a situation (s_A, s_B, s_C, ...) is called a Nash equilibrium if none of the agents producing the medicine can win by changing this situation, or, in other words, if the s_A strategy is the best answer to the set of s_B strategies, s_C,. . ., s_B strategy - the best answer to the set of strategies s_A, s_C,. . ., etc (Malafeyev et al., 2020c).

In the language of formulas, this means that Pa (s_A, s_B, s_C,...) ≥ Πa (s_A, s_ B, s_ C,...).

We now turn to a formalized model of multi-agent interaction between agents - manufacturers of a drug.

There are n drug manufacturers of applicants for a license to sell a medicinal product who make proposals (without telling each other) to the state structure issuing licenses, that is, each of the agents - manufacturers of the medicinal product i (for i = 1,. ., n) places an application for a license with a specified license price (a positive number) on the Internet, say vi. The winner is the agent - the manufacturer of the drug, the number of which will be the largest of all vi, but he does not pay the indicated price, but the highest bid of the remaining (Huang et al., 2020).

For simplicity, suppose that no draws are excluded (i.e., situations where the two highest bets are equal are not considered). We will show that to tell the truth (in this case, it means for each of the agents - manufacturers of the drug i that he sets the real price ti, that is, the price that he is willing to pay for the license) is a (weak) dominant strategy. In particular, the only Nash equilibrium is formed in the case when each of the agents - manufacturers of the medicinal product tells the truth. To this end, we compare agents - manufacturers of the drug - i with other strategies vi. We must consider two cases.

Case 1. Suppose that the agent - the manufacturer of the drug i wins the license at the rate ti and that the second highest rate that he has to pay is u ≤ ti.

If he had made a bet vi ≥ u, he would have won at the same price, and if his bet had been vi <u, then he would have lost the license and received a lower payment than with ti.

Case 2. Now, let the agent - the manufacturer of the drug i lose (payout is zero) with a bet in ti, and suppose that the maximum bet was h> ti.

Then if the agent - the manufacturer of the drug i made a bet vi ≤ h, he would lose anyway, and nothing would change. By setting vi> h, he would have won the license, but would have to pay h> ti, that is, more than he would like, that is, his payment would become negative and, therefore, again worse than with ti. Q.E.D.

If you set the condition that the agent, the manufacturer of the medicine, who made the highest bid, also wins, but he has to pay the amount that he has named for the license, then in this case telling the truth is not the dominant strategy (Malafeyev et al., 2020b).

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Recall that the agent s2 strategy is strictly dominated by the s1 strategy of the same agent (or s1 is strictly dominated by s2), if it is always more profitable for an agent to use s1 no matter what other agents do. By analogy, the concept of lax dominance is defined.

6. Findings

After conducting a comprehensive analysis of the state coordination of the pharmacological structure, the authors came to the conclusion that the Russian Federation, represented by the authorized Government, regulates health care by several parameters, influencing or determining their key indicators. Among them are quality standards for pharmacological products, health insurance, licensing of medical institutions, as well as direct and indirect support for the institution of entrepreneurial activity in the pharmacological system.

Today, the state structure is an active participant in the healthcare complex, simultaneously acting as both a supplier of up-to-date market information and a buyer of medical services. And also as a customer, analyst, regulator, planner and employer of the healthcare system. In addition, the state is an active participant in the digital market, acting as a source of technological equipment and technological support for society. The principles that guide the state when regulating pharmacological activity, in modern socio-economic formations, reflect the high-tech directions of the industry development and are based on the following indicators (Zaitseva et al., 2020a):

- the country's pharmacology infrastructure aims to ensure that every member of society has fair and full access to medical services to maintain their health at a high level;
- the state actively supports and develops the digitalization of Russian healthcare (electronic pharmacological prescriptions, secondary prescriptions, display of prescriptions in the patient's medical history, their duplication in the insurance and supervisory authorities, etc.), improves the infrastructure for the interaction of individual medical institutions (development of telemedicine, biomonitoring, tracking, etc.);
- the state is actively in need of a digital solution that will clear the market of low-quality pharmaceutical products and reduce the illegal drug market.

As the most reliable strategic solution for the above issues related to ensuring the security of interaction between a pharmacological institution and the state, the authors of this article propose to use Blockchain technology. Blockchain technology is a system for transmitting data (both financial and information exchange) through a decentralized continuous and peer-to-peer chain of transaction blocks. Blockchain protocols will reduce the falsification of electronic checks (smart contract system), remove "bad" players from the market and increase the overall competitiveness of the market.

7. Conclusion

As a result, combining the doctor, the patient, the pharmacy, and the supervisor in a single information field, the society, the doctor, and the patient will benefit. In addition, the system will be able

to identify substandard pharmacological institutions. And institutions that have nothing to hide will whitewash their reputation.

Creating a unified information system based on Blockchain technology will solve the problems of the shadow market for the secondary resale of medicines, which will positively affect the entire healthcare infrastructure.

For Russian society, this will lead to increased competition in the market, a decrease in the monopolistic trend, an increase in the tax base and the identification of low-quality players.

In addition, this technology can be integrated into the EAEU countries, thereby increasing sales of Russian manufacturers in unoccupied markets. This will increase the overall level of competition in the market and will have a beneficial effect on the system as a whole.

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