

# Theoretical and Applied Principles of Information Technology for Supporting Medical Decision-Making Taking into Account the Legal Basis

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## Abstract

The structure and principle of application of the methodology for supporting the medical decision-making taking into account the legal basis, as well as the scheme of application of information technology for supporting the medical decision-making considering the legal basis were developed in the paper. The developed methodology for supporting the medical decision-making taking into account the legal basis provides: support for decision-making on the possibility of using the reproductive technologies, donation and transplantation, provision of therapeutic services, dental services, and general medical services; automation of semantic analysis of medical contracts; formation of conclusions on the possibility or impossibility of concluding the appropriate contract; providing a request with a list of essential conditions in the contract, due to the absence of which a decision was made on the impossibility of concluding a particular contract; guaranteeing the existence of all essential conditions in the contract, if a decision has been made on the possibility of concluding a certain contract; minimizing the influence of the human factor in making medical decisions. Experimental results of verification of medical contracts using the developed methodology and information technology showed that from 20% to 54% of medical contracts do not have all the necessary essential conditions, i.e. are incorrect and cannot be concluded without revision. Thus, the developed methodology and information technology provide an opportunity for clinics and patients to avoid signing incorrectly executed contracts without proper essential conditions that could have negative consequences for both patients and clinics.

## Keywords

Medical decision-making, contract for the provision of medical services, blockchain-based information technology for healthcare system, methodology for supporting the medical decision-making taking into account the legal basis

## 1. Introduction

Today, health care decision-making processes are time-consuming and complex [1]. The productivity of health professionals can be increased through the use of decision support systems (DSS) and information technology (IT) [2]. The use of medical IT and DSS provides doctors with up-to-date information in the field of medicine, increases the efficiency of the use of relevant medical resources, increases productivity, integrates Ukrainian medicine into the world medical space [3, 4].

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IT helps in decision-making, which is especially important in the modern era of "evidence-based" medicine [5]. IT can decrease medical errors, can provide more dependable solutions, and can reduce healthcare costs [11]. In addition, cross-disciplinary medical ITs [7-14] are very useful, but at the same time difficult to design (for example, IT for medical law, as many health problems have legal roots [15]).

One of the most important civil law institutions for the field of medical law is service contracts. The contract on the provision of various medical services (therapeutic, dental, reproductive technology services, transplantation, and donation services) is the most important and common basis for the emergence of legal relations for the provision of certain types of medical services. Again, the use of medical IT significantly increases the correctness of the contract from a legal point of view, protects the doctor and patient from legal conflicts, provides a quick and free check of all essential terms in the contract, as well as provides recommendations for the further concluding or non-concluding the contract [ 2, 16, 17].

Thus, the development of theoretical and applied principles of information technology for supporting medical decision-making taking into account the legal basis is currently an urgent problem for Ukraine.

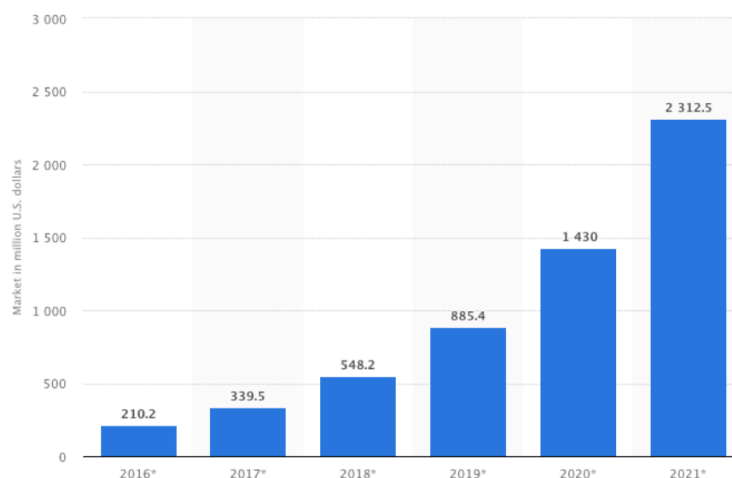
## 2. State of the Art

Currently, more and more researchers are paying attention to the problem of developing theoretical and applied principles of information technology for supporting medical decision-making taking into account the legal basis.

Thus, paper [18] discusses decision support systems designed to improve the quality and safety of health care by supporting physicians in decision-making. In [16], the authors conducted state-of-the-art on known decisions for supporting the making of medical decisions based on legal grounds based on the introduced by the authors 7 criteria, analyzed more than 30 known methods and tools and found that none of the known solutions meet all 7 criteria in the complex and cannot be fully applicable to the field of medical law.

Recently, increased attention to the technology of distributed registries has led to an understanding of the potential of blockchain technologies in the construction of information technology for the health care system. The main boom in blockchain projects in medicine is in the United States. The general picture of the use of blockchain technologies for medical IT is as follows – Figure 1.

**Size of the blockchain technology market worldwide from 2016 to 2021 (in million U.S. dollars)**



**Figure 1:** The extent of using blockchain technologies for medical information technologies [19]

Let's explore the known solutions for the healthcare industry based on blockchain technologies.

All existing projects on the use of blockchain technology in the field of health care can be divided into several areas:

1. Origin tracking – the use of a distributed registry to regulate pharmaceutical supplies and track medicines:

- The MediLedger Project [20] – an open network to regulate the supply of pharmaceuticals in order to reduce compliance costs, increase safety, improve the overall business activity of the pharmaceutical supply chain, and stop the supply of counterfeit drugs

- Prescription project [21] – use of iDIN, an online authentication service used in Internet banking, as a means of connecting to a blockchain for patients to choose their own health care provider without intermediaries, as well as to track the origin of prescriptions

2. Data storage and management – in the field of health care, the issue of information management is very important; healthcare professionals work on a daily basis with data that requires careful handling, anonymity, correct transmission, as well as special rules for granting access to medical data, a special rights management algorithm. This is the most popular area of development in medicine, so there are more than 20 solutions for the storage and management of medical data based on blockchain technology:

- Healthchain system [22] for storing personal medical records; presented in the form of graphs information about the health of patients helps professionals to improve treatment methods, attract customers, increase profits, avoid losses and reduce the cost of administrative resources

- IRYO platform [23] for storage and control by patients of electronic medical records based on the EOS blockchain, provides secure storage of health data under the full control of the patient

- CareX project [24] for making payments in the field of health care through CareX's own token; a project that solves the problem of cross-border transfers of funds in medical tourism

- SmartHealthCareToday platform [25] for storage of personal medical data, integration of EHR and PHR standards, which contain information about the patient's life, his activities, and regular measurements of medical indicators; provides health data to health facilities to improve treatment

- Accredited online program The Medical Interpreting and Translating Institute Online [26] for teaching medical translation; MiTio offers an online course available through the app and in a web version

- GlobalLabs platform [27] for blockchain-based healthcare research and development; database/catalog of researchers with a description of their capabilities for institutions interested in research and development

- Decentralized platform Clinicoin [28], which rewards participants for maintaining a healthy lifestyle; information and personal medical data are stored in the system, which allows it to track results and develop individual plans; participants receive tokens for performing "healthy" actions

- QuantH system [29] for storage and exchange of medical data based on blockchain; all-in-one solution offers a wide range of medical services

- Patientory system [30] for storage and management of medical data; access to data is opened by means of the application; Patientory connects to any HER system and allows interaction of the physicians, healthcare providers, and consumers

- Synthium Helath [31] platform for establishing business relationships between medical institutions and suppliers of medical equipment; the platform allows suppliers to expand their market presence, sell goods faster, reducing operating costs

- MedRec project [32], which creates a blockchain system for medical cards of patients; its function is to register and store medical records in a form that allows patients, doctors, health care providers, and relatives of patients to access the patient's medical record

- eHelath Estonia project [33] to create a database of Estonian medical cards on a blockchain; provides security in data storage, their transparency, ease of management of the electronic system and the life cycle of medical records

- startup Open Longevity [34] to develop a diagnostic panel for aging, ie software that allows you to collect and analyze data on health status, age-related changes in the body and based on them to create effective methods for the treatment of aging

- Mediacalchain project [35] for convenient and secure storage of patients' personal data; medical record transactions are placed in a blockchain, and then a smart contract is created, which provides time-limited access to the patient's electronic card
- BurstIQ system [36] for processing, storage, and transmission of patient medical data; a platform for easy exchange of health information with specialists, research centers, and pharmaceutical companies
- Gene Blockchain project [37] with an emphasis on the research direction of work; provides access to genetic data, which allows to find the causes of many diseases and develop techniques for their prevention and treatment
- Decentralized storage Bowhead Health [38] for personal data of users; the repository is controlled exclusively by the patient using a mobile application
- Pokitdok platform [39], which is gaining experience in the field of healthcare; with its help, you can find health care providers, get information about pricing for medical procedures
- DokChain project [40] for processing financial and clinical data in the field of health care, providing intelligent and dynamic automation of medical procedures
- HealthCombix project [41] to structure the work of medical organizations; telemedicine and possible rewards in cryptocurrency for providing data are available on the platform

3. Telemedicine (operational virtual communication with medical professionals) – projects that develop platforms through which the patient can get advice from medical professionals:

- Symptomatic platform [42] for working with big data, compatible with electronic medical cards, and provides telemedicine services via video conferencing; suitable for data management of any chronic disease
- Docademic platform [43] specializes in telemedicine and connects patients with doctors using video communication; offers recommendations for treatment and diagnosis for doctors, mass access to groups of patients
- DocCoin project [44] to connect the user through smart contracts with any medical professional in the world who can consult, prescribe treatment and prescribe medication
- TrustedHealth platform [45] for telemedicine, which is based on blockchain; the system can connect the patient to any medical professional from around the world
- PointNurse system [46], the main activity of which is telemedicine; allows nurses and members of the support team to conduct direct consultations on primary health care, to assess health, to conveniently share responsibilities

4. Diagnostics – projects in the field of the latest technologies aimed at detecting diseases using blockchain:

- SKYCHAIN blockchain-infrastructure [47], designed to deploy, train and use artificial intelligence in healthcare, as well as to make intelligent diagnostic systems more accessible to consumers, using blockchain to ensure secure transactions between key parties
- DeepRadiology system [48], which uses deep machine learning to process images obtained by radiation methods;
- IT platform eHealthFirst [49] for personalized management of medical cards based on the blockchain using artificial intelligence, machine learning, and natural language processing; provides primary diagnosis and formation on its basis of the optimal algorithm of diagnosis, treatment, and prevention

5. Using blockchain to raise funds – projects that seek funding to implement their ideas:

- SolveCare platform [50] for the decentralization of health services, which allows health care providers and insurance companies to interact with customers without intermediaries
- Luven system [51] for diagnosing cancer at an early stage and a project that supports the development of this technique;
- Health Monitor device [52] for non-invasive diagnosis of diabetes, gastric ulcer, and lung cancer;
- Elcoin project [53], which simultaneously develops medical and cosmetic equipment and a decentralized blockchain system to increase the availability of medical services, improve their quality and reliability.

The most popular area for the application of blockchain technology in medicine is data storage and management, for which the largest number of projects is developed that offer solutions for working

with big data. However, the analysis showed that such an important area as support for medical decision-making based on legal grounds is again currently out of the field of attention of developers who offer medical solutions using blockchain technologies, although blockchain technologies could be useful for the protection and management of data on the contracts concluded by the patient, as well as on the contracts proposed for the conclusion.

Given the importance and relevance of the problem of supporting medical decision-making based on legal grounds, *the goal of this research* is to design a methodology and scheme for the application of information technology for supporting medical decision-making taking into account the legal basis.

### **3. Theoretical and Applied Principles of Information Technology for Supporting Medical Decision-Making Taking into Account the Legal Basis**

In order to form the theoretical principles of information technology for supporting medical decision-making taking into account the legal basis, let's develop the methodology for supporting the medical decision-making taking into account the legal basis based on previously proposed by the authors' models and methods [16] - Figure 2. All models and methods that make up the proposed methodology are presented in detail in [16].

The integration of the developed models and methods into the methodology for supporting the medical decision-making taking into account the legal basis provides the following results:

1. Decision-making support on the use of reproductive technologies, donation and transplantation, the provision of therapeutic services, dental services, and general medical services
2. Automation of semantic analysis of contracts – on the basis of the previously developed and presented in [16] rules
3. Forming conclusions on the possibility or impossibility of concluding a contract – on the basis of the previously developed and presented in [16] methods
4. Providing a request with a list of essential conditions in the contract, due to the absence of which a decision was made on the impossibility of concluding a particular contract
5. Guaranteeing the existence of all essential conditions in the contract, if a decision has been made on the possibility of concluding a particular contract
6. Minimization of the influence of the human factor in making medical decisions

In order to form the applied principles of information technology for supporting medical decision-making taking into account the legal basis, let's develop a scheme of application of information technology proposed in [16] – Figure 3.

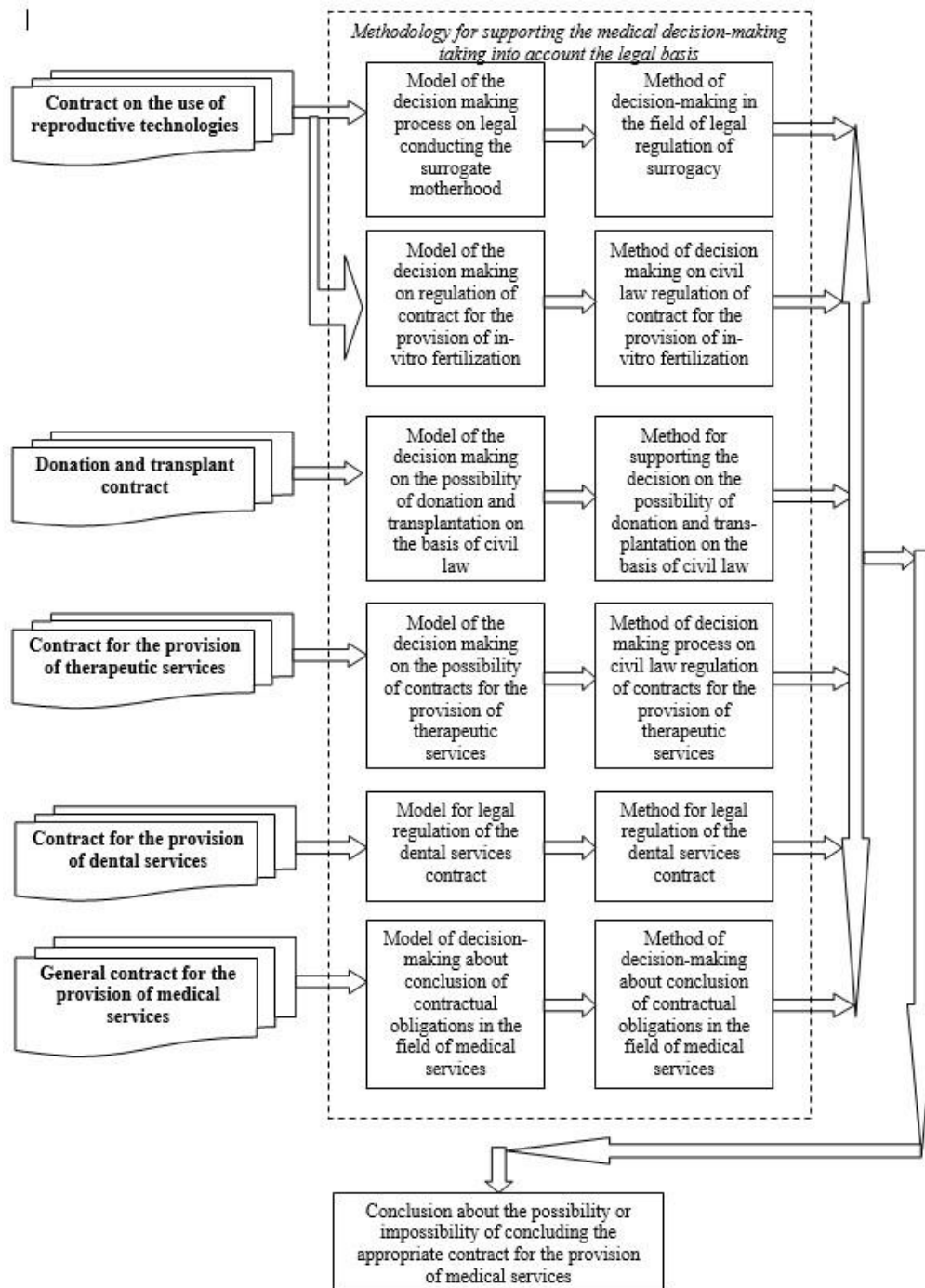
It is obvious from Figure 3 that the input of information technology for supporting medical decision-making taking into account the legal basis is the contract for the provision of medical services, and the result of processing such a contract by the developed information technology is one of two results:

1. Conclusion on the possibility of concluding a processed contract with the subsequent conclusion of this contract
2. Conclusion on the impossibility of concluding a processed contract, then IT provides a request with a list of essential conditions in the contract, due to the absence of which a decision was made on the impossibility of concluding this contract

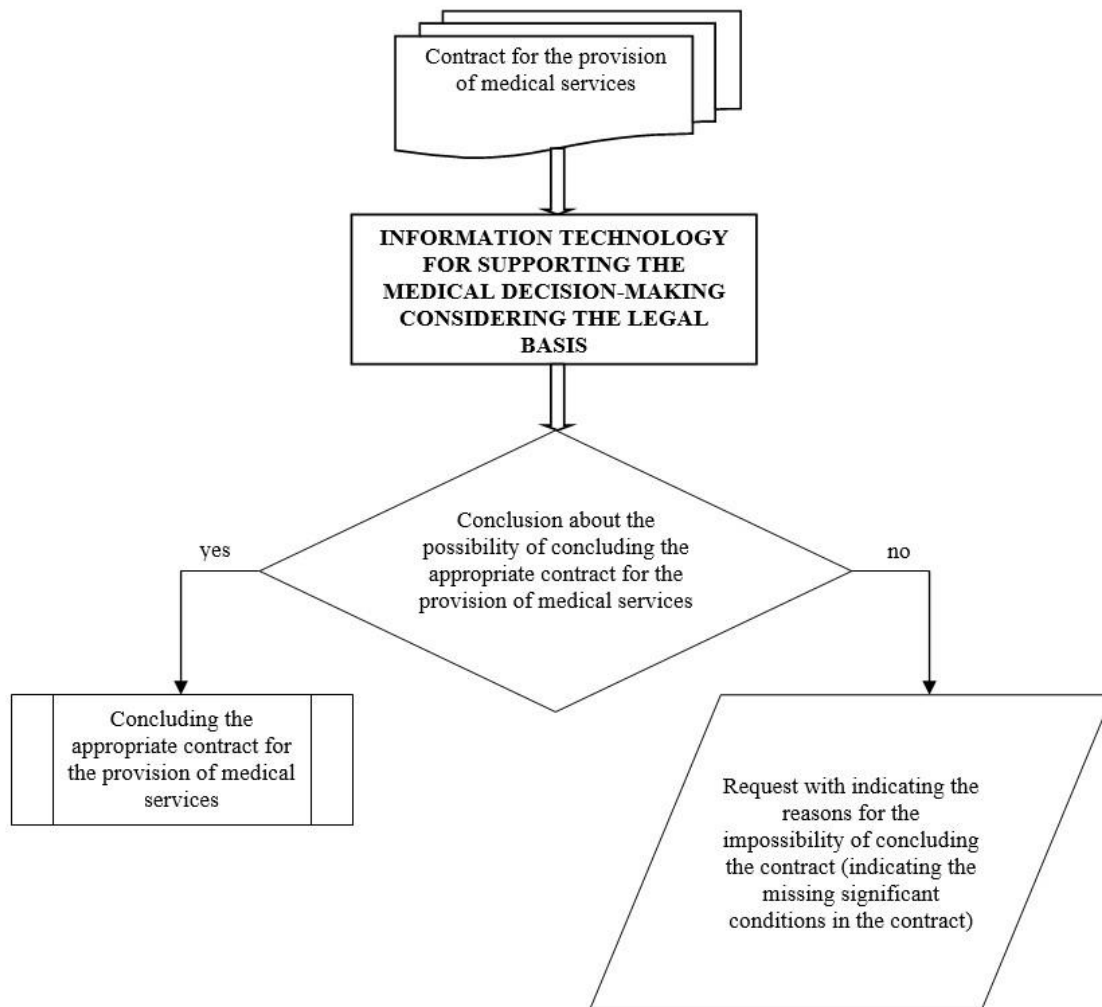
### **4. Results & Discussion**

Let's consider the application of the developed methodology and information technology for supporting the medical decision-making taking into account the legal basis. Let 2 contracts for the provision of therapeutic services are submitted at the IT input. The developed methodology and IT after processing the submitted contracts have formed the set of essential conditions that are missing in the analyzed contracts (on the basis of the previously developed and presented in [16] rules and methods). The set of missing essential conditions for the first contract is empty. The set of missing essential conditions for the second contract  $AP = \{ \text{"theoretical principles of work", "duties, rights, and responsibilities of the doctor (medical institution)", "medical history", "general clinical and$

laboratory-instrumental methods of research", "previous (syndromic) diagnosis", "functional state of individual organs and systems"} is not empty. Then the developed methodology and IT provided for the first contract a conclusion about the possibility of concluding the contract, after which the contract was concluded, and for the second contract - a conclusion about the impossibility of concluding the contract, after which a request was formed with a list of essential conditions in the contract, due to the absence of which a decision was made on the impossibility of concluding this agreement. Thus, with the help of the developed methodology and IT, the clinic and the patient avoided signing an incorrectly executed contract without proper essential conditions, which could have negative consequences for both the patient and the clinic.



**Figure 2:** Structure and principle of application of methodology for supporting the medical decision-making taking into account the legal basis



**Figure 3:** Scheme of application of information technology for supporting the medical decision-making considering the legal basis

The developed methodology and IT were used to verify 853 general contracts for the provision of medical services. As a result of this analysis (Figure 4) it was found that only 697 of the 853 contracts had all the necessary essential conditions and could be signed without revision, and the remaining 156 contracts did not have all the necessary essential conditions, so they could not be signed without revision, i.e. without the application of the developed methodology and IT, 20% of general contracts for the provision of medical services would not be correct from the point of view of civil law and could lead to negative consequences for both the patient and the clinic.

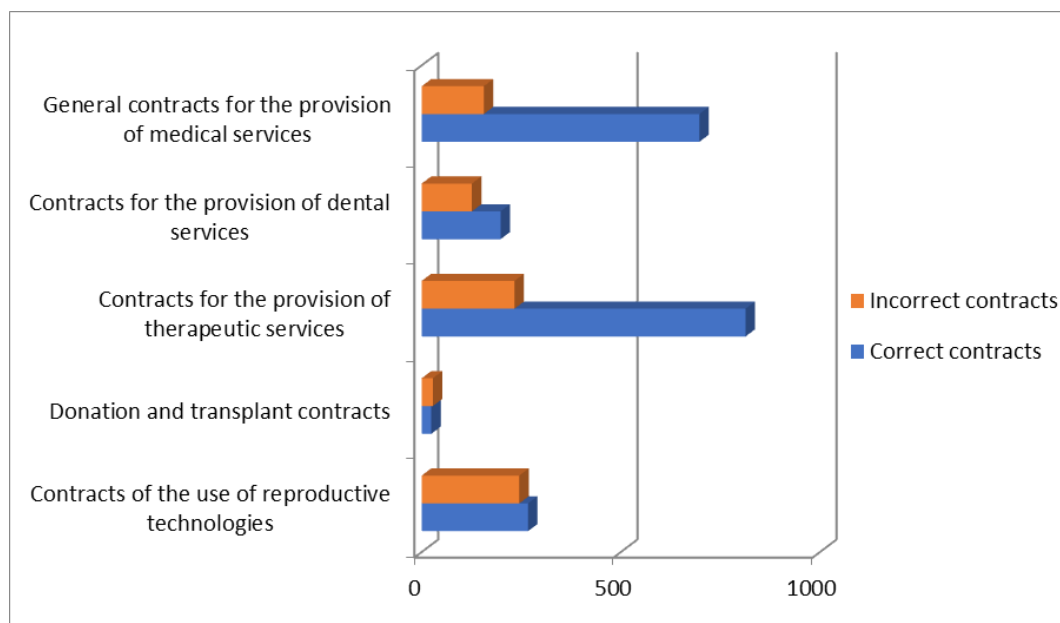
The developed methodology and IT were used to verify 324 contracts for the provision of dental services. As a result of this analysis (Figure 4) it was found that only 198 of the 324 contracts had all the necessary essential conditions and could be signed without revision, and the remaining 126 contracts did not have all the necessary essential conditions, so they could not be signed without revision, i.e. without the application of the developed methodology and IT, 38% contracts for the provision of dental services would not be correct from the point of view of civil law and could lead to negative consequences for both the patient and the clinic.

The developed methodology and IT were used to verify 1046 contracts for the provision of therapeutic services. As a result of this analysis (Figure 4) it was found that only 813 of the 1046 contracts had all the necessary essential conditions and could be signed without revision, and the remaining 233 contracts did not have all the necessary essential conditions, so they could not be signed without revision, i.e. without the application of the developed methodology and IT, 22% contracts for the provision of therapeutic services would not be correct from the point of view of civil law and could lead to negative consequences for both the patient and the clinic.

The developed methodology and IT were used to verify 52 donation and transplant contracts. As a result of this analysis (Figure 4) it was found that only 24 of the 52 contracts had all the necessary essential conditions and could be signed without revision, and the remaining 28 contracts did not have all the necessary essential conditions, so they could not be signed without revision, i.e. without the application of the developed methodology and IT, 54% donation and transplant contracts would not be correct from the point of view of civil law and could lead to negative consequences for both the patient and the clinic.

The developed methodology and IT were used to verify 512 contracts of the use of reproductive technologies. As a result of this analysis (Figure 4) it was found that only 267 of the 512 contracts had all the necessary essential conditions and could be signed without revision, and the remaining 245 contracts did not have all the necessary essential conditions, so they could not be signed without revision, i.e. without the application of the developed methodology and IT, 48% contracts of the use of reproductive technologies would not be correct from the point of view of civil law and could lead to negative consequences for both the patient and the clinic.

Thus, as shown by the results of verification of medical contracts using the developed methodology and information technology, from 20% to 54% of medical contracts do not have all the necessary essential conditions, i.e. are incorrect and cannot be concluded without revision. Thus, the developed methodology and information technology provide an opportunity for the clinic and the patient to avoid signing incorrect contracts without proper essential conditions that could have negative consequences for both patients and clinics.



**Figure 4:** The results of application of the developed methodology and information technology for medical contracts of different types

## 5. Conclusions

The paper proves the importance and relevance of the problem of supporting the medical decision-making, taking into account the legal grounds.

The structure and principle of application of the methodology for supporting the medical decision-making taking into account the legal basis, as well as the scheme of application of information technology for supporting the medical decision-making considering the legal basis were developed in the paper.

The developed methodology for supporting the medical decision-making taking into account the legal basis provides: support for decision-making on the possibility of using the reproductive technologies, donation and transplantation, provision of therapeutic services, dental services, and general medical services; automation of semantic analysis of medical contracts; formation of



conclusions on the possibility or impossibility of concluding the appropriate contract; providing a request with a list of essential conditions in the contract, due to the absence of which a decision was made on the impossibility of concluding a particular contract; guaranteeing the existence of all essential conditions in the contract, if a decision has been made on the possibility of concluding a certain contract; minimizing the influence of the human factor in making medical decisions.

Experimental results of verification of medical contracts using the developed methodology and information technology showed that from 20% to 54% of medical contracts do not have all the necessary essential conditions, i.e. are incorrect and cannot be concluded without revision. Thus, the developed methodology and information technology provide an opportunity for clinics and patients to avoid signing incorrectly executed contracts without proper essential conditions that could have negative consequences for both patients and clinics.

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