

Intelligent Information Technology for Supporting the Medical Decision-Making Considering the Legal Basis

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Abstract

Decision support systems (DSS) and information technology (IT) for medicine considering the legal basis allow free and automated verification of all essential terms of contracts and provide recommendations for the contract's conclusion or its non-conclusion. Current decisions to support medical decision-making considering the legal basis showed that none of the known decisions meet all the necessary criteria. Therefore, an actual problem for Ukraine is the development and implementation of intelligent information technology for supporting the medical decision-making considering the legal basis, which is the aim of this study. The developed intelligent information technology for supporting the medical decision-making considering the legal basis provides support for decision-making on the possibility of using reproductive technologies (possibility of surrogacy and/or in vitro fertilization), the possibility of donation and transplantation, the possibility of concluding contracts for therapeutic services and contracts for dental services, general contracts for medical services. In addition, intelligent information technology to support medical decision-making based on the legal basis automates the semantic parsing of contracts and draws conclusions about the possibility or impossibility of concluding a contract, as well as provides a request stating the reasons for impossibility to conclude a contract (for example, indicating missing essential conditions), if it was concluded that such a contract cannot be concluded.

Keywords

Decision-making, contract for the provision of medical services, conclusion about the possibility/impossibility of concluding the medical services contract, intelligent information technology for supporting the medical decision-making considering the legal basis.

1. Introduction

The implementation of the new information technologies in all human activity's areas in order to automate routine work, reduce manual labor and minimize the human factor is the strategic goal of Ukraine's information society [1]. Today, medical information technology must meet 4 requirements: efficiency, safety, novelty and economic benefits [2].

Today, decision-making processes in the field of medical services are cumbersome, complicated and non-transparent [3]. The productivity of health workers is significantly increased due to the successful implementation and use of decision support systems (DSS) and information technology (IT) [4]. Today in Ukraine there is a problem of development of medical software, IT and DSS. Successful implementation of medical software, IT and DSS provide doctors with new information on the specialty, increase the efficiency of doctors, increase the productivity of medical resources and strengthen the integration of Ukrainian medicine into the medical space of Europe [5, 6]. Intelligent or

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intellectualized systems and technologies facilitate medical decision-making and are promising tools in the era of "evidence-based" medicine [7]. Paper [8] discusses DSS for support doctors in decision-making and for improving the health care's quality and safety. The review [9] showed that advanced clinical decision support is the prospect direction for the next 10 years. Joint decision-making involves different types of agents with the requirement that they can sufficient possibility to make the appropriate decision [10]. Intelligent IT can guide doctors in decision-making, reaching a diagnosis, and improving contract. It can reduce healthcare costs by decreasing medical errors and providing more dependable predictions [11].

The most important and complicated is the task of developing the multidisciplinary medical IT and DSS (e.g., IT and DSS for the medical law domain, because many patient health problems have a legal basis [12]), because in requirements for such IT and DSS the software development standards and standards in medicine and law need to be considered, preventing to losses of information owing to different understandings of information needs and contexts [13].

Service contracts are the most common type of contract of civil law. The contract for the medical services' provision (therapy, transplantation and donation, the reproductive technologies' use, dental services) is the most common legal basis for the medical services' provision. A contract for the medical services' provision is an agreement whereby doctor (or clinic) at the patient's request must relevantly serve the patient (restore and maintain his health) and the patient must pay a certain amount of money specified in the contract for the services provided to him. Implemented and used medical IT and DSS can substantially increase the correctness of the contract from the point of view civil and medical law [4].

The modern therapist makes decisions by integrating several medical specialties; especially this problem has been exacerbated with the introduction of insurance medicine in Ukraine, when the physician must know the standards of diagnosis and standards of treatment of therapeutic diseases. This problem is faced by therapists daily and repeatedly, especially when using innovative medical technologies [14]. Therefore, nowadays the issue of therapeutic contract's concluding needs a lot of attention. The therapeutic contract is an agreement whereby doctor at the request of the patient in accordance with health legislation provides a therapeutic service, which is creation and treatment of the etiology, pathogenesis and clinical manifestations of internal organs' diseases, their diagnostics, prophylaxis and rehabilitation, and the patient must pay a certain amount of money specified in the contract for the services provided to him, unless else provided by contract or law.

Nowadays, transplantation of human organs and (or) tissues is an effective and in many cases the only means of saving lives and restoring health. According to the Law of Ukraine "On the use of transplantation of anatomical materials to humans" [15], transplantation is a special treatment method which involves transplanting to a recipient of an organ or other anatomical material from a person or animal. Transplantation is the transfer (engraftment) of human cells, tissues or organs from the donor to the recipient in order to restore their function(s) in the body [16]. Donation is the voluntary transfer of blood and other human organs to help other people heal and recover [15]. There are 2 types of donation: posthumous (if the consent of the person given during his life or the consent of family members given after person's death is available) and lifelong if the consent of the donor is available). According to the Law of Ukraine "On the use of transplantation of anatomical materials to humans" [15], transplantation activities should be based solely on the Unified State Information System for Organ and Tissue Transplantation (USIST). Direct work with data on donors and patients in the system will be semi-automatic. According to the authors, USIST can and should be fully automated in terms of the decision-making on the possibility of donation and transplantation considering the civil law basis to minimize the influence of the human factor in making such important decisions.

Nowadays, almost 15% of Ukrainian families are infertile. The only way of overcoming infertility for many families is the reproductive technologies' using. Reproductive technologies are modern high-tech methods of infertility treatment, during of which some or all stages of conception and development of embryos carried out outside the body, in particular, fertilization of the egg outside the body, implantation of embryos and pregnancy in case of impossibility of these processes naturally [17]. The particular importance has two types of reproductive technologies - in-vitro fertilization and surrogacy. If such conditions exist, then the issue of concluding a contract for in vitro fertilization or surrogacy is very important. In vitro fertilization contract is an agreement according to which the doctor (clinic) at the patient's request must serve the patient with appropriate medical services,

applying the assisted reproductive technologies, when the eggs are fertilized with sperm outside the body, and the patient agrees to pay for the procedure, as it was agreed by the contract's parties. According to the Order of the Ministry of Health of Ukraine №787 [18], surrogacy is the artificial egg's insemination with the following placement of the embryo in another woman's uterine cavity (surrogate mother). Thus, the being of surrogacy is the transplantation of the fertilized egg into the body of a woman, which is genetically alien for future child, who bears and gives birth the child not for herself, but for a family who cannot have children for medical reasons.

Today, dental services are the popular medical service in Ukraine. Applying for dental services is second after therapeutics services [19]. Today, the issue of concluding the dental services' contract needs more attention. The dental services' contract is an agreement whereby the dentist at the patient's request, according to the health care legislation, provides a dental service, preventing the disease of the teeth, the oral cavity, gums, maxillofacial area, their diagnostics, and treatment, and the patient must pay this services if other don't specify by the dental services' contract [20].

Therefore, the conclusion of a contract for the provision of medical services, in particular, verification of the existence of all significant conditions in the contract, is becoming increasingly important - with the purpose of ensuring the safety both the doctor providing the service and the patient receiving the service, as the lack of significant conditions in the contract leads to serious problems and legal conflicts. To date, there is no single form of contract for the provision of various medical services in Ukraine. The legislative acts have no norms, which give the definition and regulate the procedure for concluding the medical services' contracts. Resulting, many medical services' contracts have aggravating conditions for the patient, offer illegal methods of dispute resolution, and have no characteristics for individualizing the medical services. These disadvantages often lead to adverse legal consequences for both the patient and the clinics, which continue to use contract models that have obvious legal limitations. Of course, every clinic cannot hire a lawyer for preparing the medical services' contracts. Multidisciplinary medical DSS and IT for the medical law domain allow free and automated verification of all essential conditions' existence in the contract and the provision of advice on the conclusion of the contract or not.

So, the development and using the intelligent information technology (set of processes, methods, and tools for accumulating, processing, and transmission of the primary information with the purpose of obtaining information product with new quality [21- 23]) for supporting the medical decision-making considering the legal basis is *an urgent problem* for Ukraine.

2. State-of-the-art

Let conduct state-of-the-art on known decisions for support of the making the medical decisions based on legal grounds. We are interested in whether the known methods and tools support decision-making on the using reproductive technologies' possibility (surrogacy and in vitro fertilization) – *criterion 1*, on the donation and transplantation possibility – *criterion 2*, on the possibility of concluding therapeutic services' contracts – *criterion 3*, dental services' contracts – *criterion 4* and general medical services' contracts – *criterion 5*. In addition, we are interested in whether known tools automate parsing the contracts and drawing conclusions about the possibility or impossibility of concluding a contract – *criterion 6*, whether these tools provide a request, what exactly is missing in the contract for its conclusion, if a conclusion about the impossibility of concluding the contract is drawing – *criterion 7*.

Results of the conducted state-of-the-art are represented in Table 1.

Effective method of imputation of missing data through SGTM neural-like structure [21]	no	no	no	no	no	yes	yes
Ontology-based approach for the information sufficiency's evaluating in the surrogate motherhood contract [35]	yes	no	no	no	no	yes	yes
Different models of support of the clinical ethics [36]	no	no	no	yes	yes	no	no
AMBOSS: Method of legal assessment to make decisions by the patient's [37]	no	no	yes	no	yes	no	no
Portal of Medical Data Models [38]	yes	no	yes	no	yes	yes	no
Information technology for filling the patients' dynamic consent [39]	no	yes	yes	yes	yes	no	no
Technology for legal support providing for healthcare staff [12]	no	no	no	no	no	no	yes
System for collection, collation, analysis, distribution and reaction for serious adverse events and reactions in unrelated HPC donors [40]	no	yes	no	no	no	no	no
Global Database on Donation and Transplantation [41]	no	yes	no	no	no	yes	no
Kidney Allocation System [42]	no	yes	no	no	no	yes	no
Korean Organ Transplantation Registry (KOTRY) [43]	no	yes	no	no	no	yes	no
Donor Advocacy Team (DAT) program [44]	no	yes	no	no	no	yes	no
National Subsystem of donation and transplantation in Mexico [45]	no	yes	no	no	no	yes	no
Polish organ transplantation management system [46]	no	yes	no	no	no	yes	no
French national information system for coordination and administration of organ transplant [47]	no	yes	no	no	no	yes	no
Intelligent agent for support of decision making on civil law regulation of contract for the provision of in vitro fertilization [48]	yes	no	no	no	no	yes	yes
Decision-making about conclusion of medical services' contractual obligations [49]	no	no	no	no	yes	yes	yes
Information technology for the dental services contract's legal	no	no	no	yes	no	yes	yes

regulation [50]								
Supporting the decision-making about the donation's and transplanted's possibility considering the civil law grounds [51]	no	yes	no	no	no	yes	yes	
Decision making process on civil law regulation of contracts for the provision of therapeutic services [52]	no	no	yes	no	no	yes	yes	

The conducted state-of-the-art on known decisions for support of the making the medical decisions based on legal grounds showed, none of the known solutions satisfies all 7 criteria in the complex. Therefore, developing and implementing intelligent information technology for supporting the medical decision-making considering the legal basis, which would meet all the above 7 criteria simultaneously is *the purpose of this study*.

3. Intelligent information technology for supporting the medical decision-making considering the legal basis

On the basis of the modeling the information flows in the medical decision-making process considering the legal basis and the investigation of information flows in the process of evaluating information, which is available for medical decision-making considering the legal basis, conducted by the authors in [21, 48-52], and theoretical principles of information technology in the form of the methods for decision-making support, which were presented in [21, 48-52], the block diagram of intelligent information technology for supporting the medical decision-making considering the legal basis (set of processes, methods, and tools for accumulating, processing, and transmission of the primary information with the purpose of obtaining information product with new quality [21, 22]) is developed and presented in Figure 1.

Intelligent information technology for supporting the medical decision-making considering the legal basis gives the support for decision-making on the possibility of using reproductive technologies (the possibility of surrogacy and/or in vitro fertilization), the possibility of donation and transplanted, the possibility of concluding therapeutic services' contracts, dental services' contracts and general medical services' contracts. In addition, intelligent information technology for supporting the medical decision-making considering the legal basis automates the semantic parsing of contracts and drawing conclusions about the possibility or impossibility of concluding a contract, as well as provides a request indicating the reasons for impossibility of concluding a contract (for example, indicating the missing significant conditions in the contract), if it was concluded that it is impossible to conclude such a contract.

Figure 1 showed that the proposed intelligent information technology for supporting the medical decision-making considering the legal basis consists of:

1. Parsing the appropriate medical services' contract (for example, using an intelligent agent for parsing natural language documents, which was developed in [53])
2. Method of decision-making in the field of legal regulation of surrogacy [21]
3. Method of decision making on civil law regulation of contract for the provision of in-vitro fertilization [48]
4. Method for supporting the decision on the possibility of donation and transplanted on the basis of civil law [51]
5. Method of decision making process on civil law regulation of contracts for the provision of therapeutic services [52]
6. Method for legal regulation of the dental services contract [50]
7. Method of decision-making about conclusion of contractual obligations in the field of medical services [49]

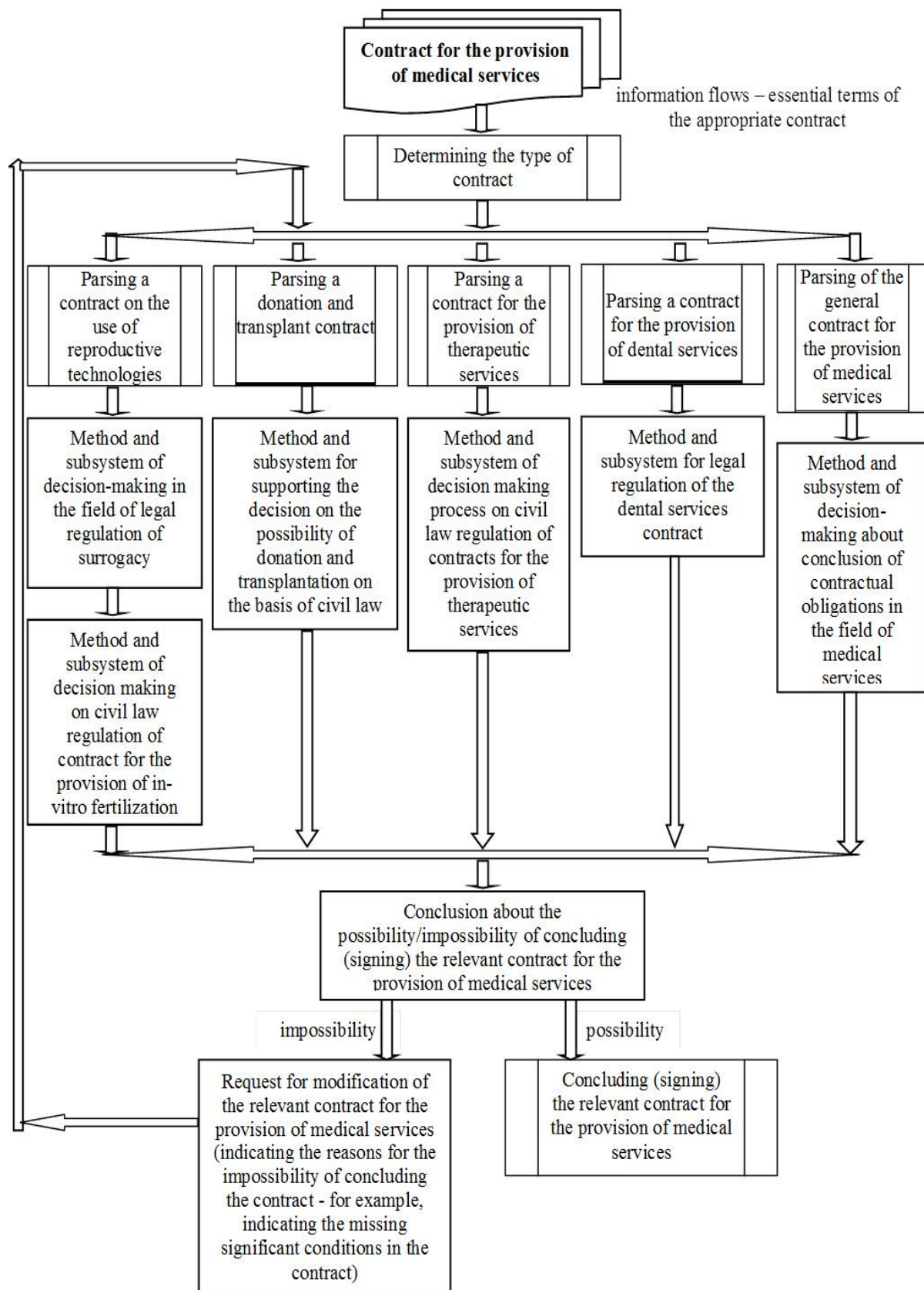


Figure 1: Intelligent information technology for supporting the medical decision-making considering the legal basis

Obviously, the main purpose of the developed intelligent information technology for supporting the medical decision-making considering the legal basis is the automation (minimization of the human factor impact and simplification of the implementation) of the contracts' parsing and drawing the conclusions about the possibility or impossibility of concluding the contracts of reproductive technologies (surrogacy and/or in vitro fertilization), of donation and transplantation, therapeutic services' contract, dental services' contract, and general medical services' contract.

4. Results & discussion

Let consider the functioning of the developed intelligent information technology for supporting the medical decision-making considering the legal basis.

For example, the input of the developed information technology is the medical services' contract. It was determined that this is a contract for the provision of in-vitro fertilization. Developed intelligent information technology for supporting the medical decision-making considering the legal basis conducted a semantic analysis (parsing) of the provided contract for the provision of in-vitro fertilization, as well as processing the contract using the method of decision making on civil law regulation of the contract for the provision of in-vitro fertilization, which was developed by the authors in [48]. Resulting in the analysis of the contract, a set of significant conditions, which are absent in the analyzed contract, was formed. The set of missing significant conditions has the form: $MC = \{ \text{"indications for in-vitro fertilization"}, \text{"woman's age"}, \text{"woman's legal capacity"} \}$. It is not empty, so intelligent information technology for supporting the medical decision-making considering the legal basis forms conclusion on the impossibility of concluding the appropriate medical services' contract, and a request for addition of the in-vitro fertilization contract (indicating the absence of significant conditions in the contract). Thus, the developed information technology helped to avoid concluding the incorrectly executed contract, which have no significant conditions, and could lead to negative effects for one or both parties.

The developed intelligent information technology for supporting medical decision-making considering the legal basis gives the opportunity to verify the correctness of the structure and content of the appropriate medical services' contract. Such verification allows the unmistakable (from the point of view of legal basis) decisions on the possibility/impossibility of concluding the contract, minimizing the subjectivism influence and the human factor, and eliminating the need to pay for legal services by the clinics.

5. Conclusions

The conclusion of the medical services' contract, in particular, verification of the availability of all significant conditions in the contract, is becoming increasingly important, with the purpose of ensuring the safety of both the doctor providing the service and the patient receiving the service, as the lack of significant conditions in the contract leads to serious problems and legal conflicts. Many contracts for the provision of medical services of various kinds contain aggravating conditions for the patient, offer non-legal method of dispute resolution, and do not contain characteristics that individualize medical services. These shortcomings can lead to unfavorable legal consequences for both the patient and the medical organizations, which continue to use such models of contracts, which have obvious restrictions on the legal side. Of course, not every clinic can afford to hire a lawyer to prepare contracts for the provision of medical services. Multidisciplinary medical DSS and IT for the field of medical law are designed to provide the possibility of free and automated verification of the existence of all significant conditions in the contract and provide advice on whether or not to conclude the contract. The conducted state-of-the-art on known decisions for support of the making the medical decisions based on legal grounds showed, that none of the known solutions meets all the necessary criteria in the complex. Therefore, the current problem for Ukraine is the design and implementation of intelligent information technology for supporting the medical decision-making considering the legal basis, which is why this study is devoted.

The proposed intelligent information technology for supporting the medical decision-making considering the legal grounds provides support for decision-making on the possibility of using

reproductive technologies (on the possibility of surrogacy and/or in-vitro fertilization), on the possibility of donation and transplantation, on the possibility of concluding contracts for therapeutic services, contracts for dental services and general contracts for medical services. In addition, intelligent information technology for supporting the medical decision-making considering the legal basis automates the semantic parsing of contracts and drawing conclusions about the possibility or impossibility of concluding a contract, as well as provides a request indicating the reasons for impossibility of concluding a contract (for example, indicating the missing significant conditions in the contract), if it was concluded that it is impossible to conclude such a contract.

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