Decision Support System Regarding the Possibility of Using the Reproductive Technologies Taking into Account Civil Law

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Summary

The review of known methods and decision support systems regarding the possibility of using the reproductive technologies showed that currently there are no methods and decision support systems regarding the possibility of using reproductive technologies taking into account civil law. Although the analyzed methods and systems have great potential for use in different contexts, these methods and systems do not take into account the civil law requirements of any country. The paper has developed a decision support system regarding the possibility of using the reproductive technologies taking into account civil law, which automatically and free of charge determines the possibility/impossibility of surrogate motherhood or in vitro fertilization. If it is determined that surrogate motherhood or in vitro fertilization is impossible, the sufficiency of the information in the analyzed contract is evaluated, and the reasons for the impossibility of surrogate motherhood or in vitro fertilization are presented to the user.

Keywords:
Reproductive technologies, contract on the provision of reproductive technologies, semantic analysis (parsing) of natural language contracts, support for decision-making regarding the possibility of using the reproductive technologies.

1. Introduction

Reproductive technologies are modern high-tech methods of treating infertility, in which some or all stages of conception and early development of embryos are carried out outside the body, in particular, fertilization of an egg outside the body, implantation of embryos and carrying a pregnancy in case of the impossibility of these processes naturally [1, 2].

Today, there are a large number of types of assisted reproductive technologies used in the treatment of infertility in the world. The following types of assisted reproductive technologies are used in Ukraine [2, 3]: in vitro fertilization; intrauterine insemination; donation of gametes or embryos; surrogate motherhood; transfer of gametes, zygotes or embryos to the fallopian tube. Two types of reproductive technologies are of particular importance - in vitro fertilization (fertilization of the egg is carried out outside the woman's body, after which the donor material is artificially introduced into the woman's genital tract) and surrogate motherhood (the transfer into the surrogate mother's body of a human embryo conceived by a marriage couple, by wife and donor, by donors).

Currently, decision-making processes regarding the possibility of use of reproductive technologies are time-consuming, complex, ambiguous for patients, and often for doctors as well [4, 5]. A decision support system can facilitate the decision-making process regarding the possibility of use of reproductive technologies, which can become an effective tool capable of providing doctors with the necessary information, as well as speeding up the integration of Ukrainian medicine into the European medical space [4, 6, 7]. A properly designed and implemented decision support system can reduce medical errors and costs, and provide more reliable decisions.

Even more important and challenging is the development of cross-disciplinary decision support systems, in particular decision support system regarding the possibility of using the reproductive technologies that take into account civil law requirements, since many medical problems have legal roots, which can have a lasting impact on health of patients [8]. It is the use of such a cross-disciplinary decision support system can significantly increase the legal correctness of the performed procedure with using the reproductive technologies, protect the doctor and the patient from legal collisions, provide an opportunity for a quick and free verification of the fulfillment of all essential conditions for the possibility of using this or that reproductive technology from a legal point of view, and also provide recommendations regarding further use or non-use of reproductive technology.

Therefore, the development of decision support system regarding the possibility of using the reproductive technologies taking into account civil law is currently *an urgent task*, the solution of which is devoted to this study.

2. Review of Known Methods and Decision Support Systems regarding the Possibility of Using the Reproductive Technologies

Let's review the known methods and decision support systems regarding the possibility of using the reproductive technologies.

In the paper [9], the requirements for the register of the reproductive technologies are formed. The electronic passport of the woman's reproductive health is the basis of such register. This register is a basis for analysis of the effectiveness of the reproductive technologies' use and for making the decisions about the pregnancy likelihood.

Identifying the viable embryos for implantation is one of the most important aspects during reproductive technology using. As a rule, selection of embryo performs by visual examination via microscopy by embryologists, and their evaluations can be subjective. Use of machine learning methods for embryo selection during reproductive technology using is actual. The study [10] uses deep learning method for the morphological classification of embryos based on medical images, which significantly outperforms other methods.

Currently, the reproductive technologies are highly sophisticated technology that have a success rate of 20% and depend on a slew of factors with complex relationships. Machine learning can maximize the success rate of reproductive technologies by analysis of the large and complex datasets. The paper [11] represents a dynamic model for outcome prediction of the reproductive technologies using incremental classifier named Ensemble of Heterogeneous Incremental Classifier (EHIC) in machine learning.

The pregnancy rates, which is achieved with the reproductive technologies using, is low, because success of reproductive technologies using is based on many biological, social, and environmental features. High cost (which are not covered by any health insurance schemes) and painful process of the reproductive technologies using are the two major barriers. The decision support system for the reproductive technologies outcome prediction using machine learning techniques [12] can be used by physicians and patients before entering into the treatment by the reproductive technologies with the purpose of improving the success rate by predicting the treatment outcome, with the purpose of choice by the couples and the doctors of the decision on the next course of action (to opt for reproductive technologies, or opt for correcting the reproductive technologies, or quit the reproductive technologies).

The aim of the paper [13] is the development of the informatics tool for dealing with a medical decision during using reproductive technologies. The multiple criteria decision aiding method ELECTRE TRI-C is used for sorting or ordinal classification problems, for assigning each couple to an embryo-transfer category, for increasing the single pregnancy rate, and for minimizing multiple pregnancies.

The objective of the research [14] is the development of the computer algorithm for in vitro fertilization management and the assessment of the algorithm's accuracy in the every-day decision making during ovarian stimulation for in vitro fertilization during comparison with the evidence-based decisions. In [14] a first iteration of a highly accurate predictive analytic algorithm is developed, which work in agreement with evidence-based decisions during ovarian stimulation during in vitro fertilization. This tool offers a potential platform for optimization of the clinical decision making during in vitro fertilization.

The objective of the research [15] is determining the optimization of trigger injection time by using the machine learning causal inference model with the purpose of maximization the yield of fertilized oocytes and total usable blastocysts for given stimulated follicles for women undergoing in vitro fertilization with intracytoplasmic sperm injection. The decision is formulated as follows: either triggering on that day or waiting another day. The use of this machine learning algorithm leads to a significant increasing the number of fertilized oocytes and total usable blastocysts during in vitro fertilization with comparison of physician decisions.

Nowadays the online tools on the basis of an artificial intelligence for decision-making process across all aspects of the reproductive technologies using are rapidly developed. These tools improve outcomes and provide the transition decision-making from one based on traditional assessments toward a hybrid triad of expertise, evidence, and algorithmic data analytics using artificial intelligence. The purpose of research [16] is highlighting the evolution and describing the vision for applications of artificial intelligence during reproductive technologies using for improving the outcomes, reducing the costs, and positively impacting the clinical care.

The morphology of men sperm cells is the clinical tool for the fertility prognosis and uses for making decisions regarding the options of the reproductive technologies using. Therefore, a complete analysis of men sperm is critical in this context. The paper [17] develops, implements and calibrates the methodology for characterization and classification of sperm heads towards morphological sperm analysis with the purpose of the fertility diagnosis and prognosis. Authors of [17] propose a two-stage classification scheme combining an ensemble strategy and a cascade approach with several support vector machines for classification of the sperm heads on five different classes.

The review of known methods and decision support systems regarding the possibility of using the reproductive technologies showed that currently there are no methods and decision support systems regarding the possibility of using reproductive technologies taking into account civil law. Although the analyzed methods and systems have great potential for use in different contexts, these methods and systems do not take into account the civil law requirements of any country.

3. Decision Support System Regarding the Possibility of Using the Reproductive Technologies Taking into Account Civil Law

Before proceeding to the design and implementation of the decision support system regarding the possibility of using the reproductive technologies taking into account civil law, an analysis of the subject area of civil law governing the use of reproductive technologies should be performed, in particular, the analysis of the civil-legal grounds for the emergence of surrogate motherhood and for the possibility of in vitro fertilization with selection of mandatory conditions, without fulfillment of which the using of reproductive technologies is impossible. Such subject area analysis was performed by the authors in [18].

Taking into account the results of the analysis of the field of civil law, which regulates the use of reproductive technologies, let's develop the decision support system regarding the possibility of using the reproductive technologies taking into account civil law – Fig. 1.

From Fig. 1, it is obvious that the main source of information is the contract on the provision of reproductive technologies, which can have one of two types – the contract on the provision of surrogate motherhood and the contract on the provision of in vitro fertilization. A contract of a certain type is subjected to semantic analysis (parsing) for the purpose of finding mandatory essential conditions of a contract of a certain type (as the authors defined in [18] on the basis of the analysis of civil legal grounds valid in Ukraine for the reproductive technologies using, 36 mandatory essential conditions in the contract regarding the provision of surrogate motherhood and 27 mandatory essential conditions in the contract regarding the provision of in vitro fertilization must be ensured). As a result of the conducted semantic analysis, sets of existing and absent mandatory conditions in the specified contract are formed, which are entered in the data section of the knowledge base. The rules section of the knowledge base contains rules for determining the possibility of carrying out the procedure of surrogate motherhood or in vitro fertilization, taking into account civil law, developed by the authors in [18].

Based on the obtained sets of existing and absent mandatory conditions in the analyzed contract, each rule for a certain type of contract from the rules section of the knowledge base is checked, a certain counter is calculated and the possibility/impossibility of surrogate motherhood or in vitro fertilization is determined. If it is determined that surrogate motherhood or in vitro fertilization is impossible, the sufficiency of the information in the analyzed contract is evaluated and the reasons for the impossibility of surrogate motherhood or in vitro fertilization are presented to the user.
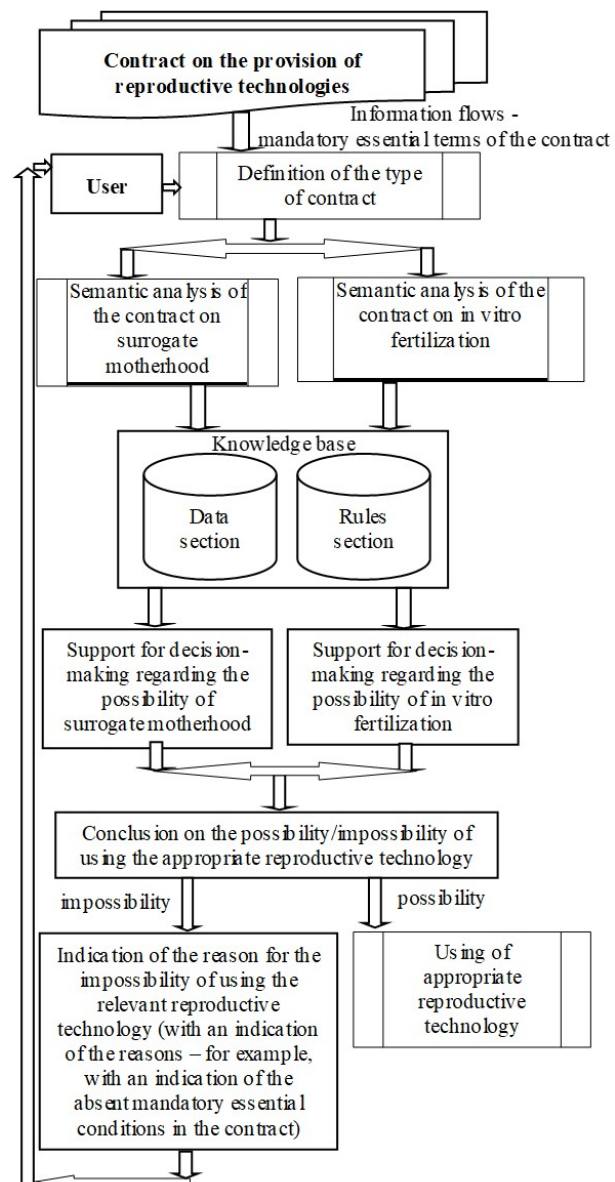

Fig. 1 Decision support system regarding the possibility of using the reproductive technologies taking into account civil law.

The method of semantic analysis (parsing) of natural language contracts on the provision of reproductive technologies consists of the following stages (based on the concept of semantic parsing of natural language specifications of software requirements developed by the authors in [19, 20]):

1) search for each mandatory essential condition for the contract on the provision of reproductive technologies of a certain type;

2) if <condition$_j$> is found in the contract, then <condition$_j$> is included in the set of existing mandatory

conditions, j=1..36 for the contract on the provision of surrogate motherhood or j=1..27 for the contract on the provision of in vitro fertilization (because, as the authors defined in [18], 36 mandatory essential conditions in the contract regarding the provision of surrogate motherhood and 27 mandatory essential conditions in the contract regarding the provision of in vitro fertilization must be ensured);

3) if <condition$_j$> is not found in the contract, then <condition$_j$> is included in the set of absent mandatory conditions;

4) verification of whether the formation of sets of existing and absent mandatory conditions is correctly completed - for a contract on the provision of surrogate motherhood, the number of elements of the set of existing mandatory conditions and the set of absent mandatory conditions together should be 36, and for a contract on the provision of in vitro fertilization, the number of elements of the set of existing mandatory conditions and the set of absent mandatory conditions together should be 27.

The method of semantic analysis (parsing) of natural language contracts on the provision of reproductive technologies is schematically represented in Fig. 2.
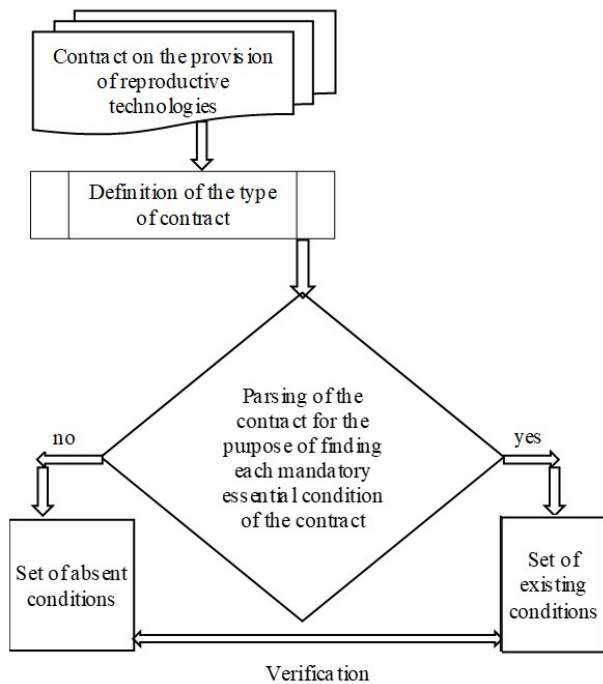

Fig. 2 Semantic analysis of the contract on the provision of reproductive technologies.

The method of supporting decision-making regarding the possibility/impossibility of surrogate motherhood is schematically represented in Fig. 3.
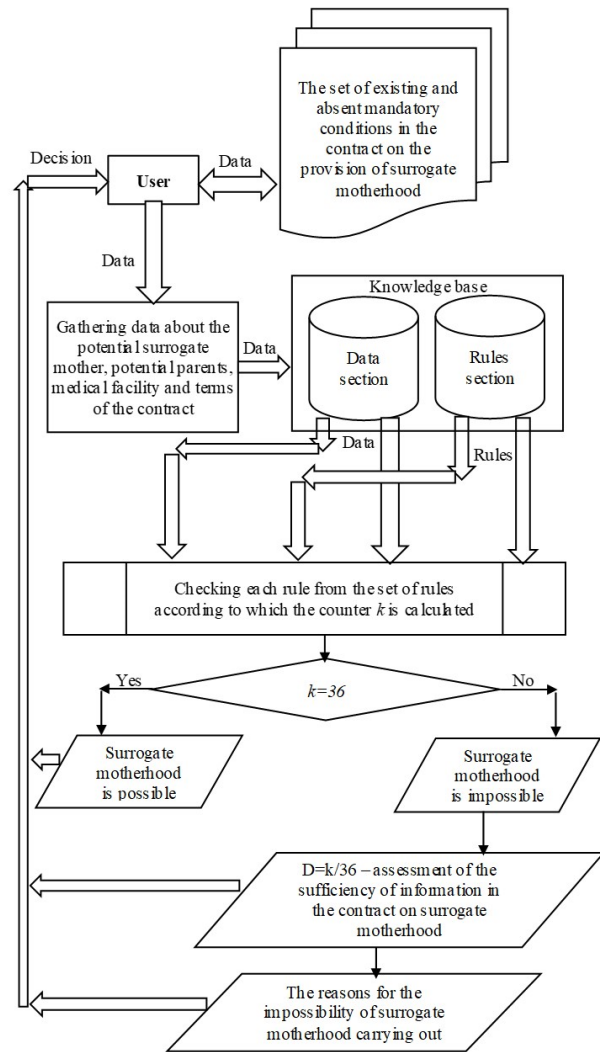

Fig. 3 Support for decision-making regarding the possibility/impossibility of surrogate motherhood.

The method of supporting decision-making regarding the possibility/impossibility of in vitro fertilization is schematically represented in Fig. 4.

4. Functioning the Decision Support System Regarding the Possibility of Using the Reproductive Technologies

Let's consider the functioning of the proposed decision support system regarding the possibility of using the reproductive technologies on the example of the analysis of one contract on the provision of surrogate motherhood and one contract on the provision of in vitro fertilization, provided by one of the clinics of reproductive medicine in Khmelnytskyi (Ukraine).
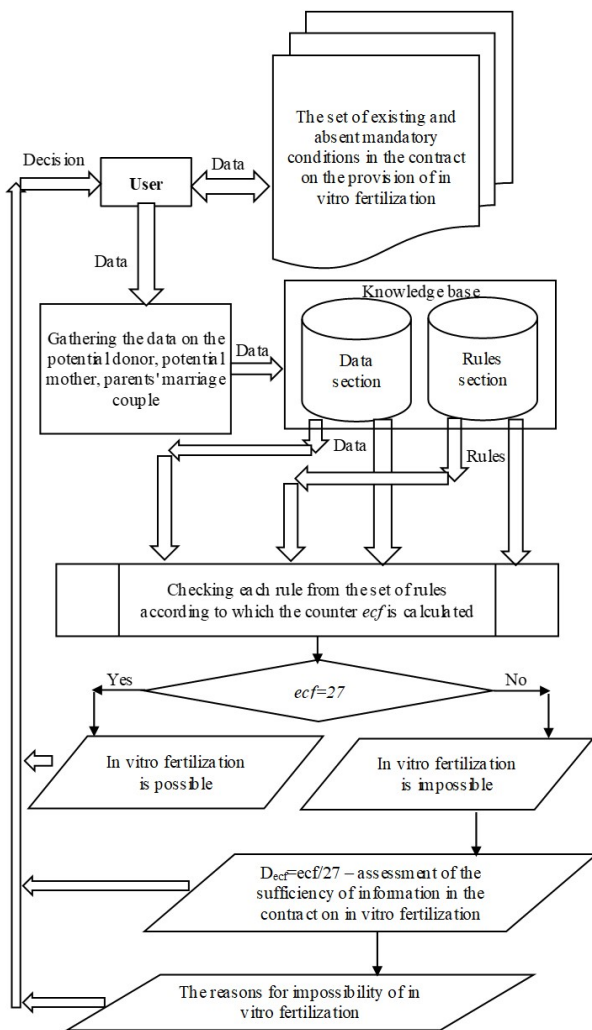
Fig. 4 Support for decision-making regarding the possibility/impossibility of in vitro fertilization.

Therefore, a contract on the provision of surrogate motherhood was submitted to the input of the proposed decision support system regarding the possibility of using the reproductive technologies. This contract on the provision of surrogate motherhood was subjected to semantic analysis (parsing) according to the developed method of semantic analysis (parsing) of natural language contracts on the provision of reproductive technologies for the purpose of finding the mandatory essential conditions in the contract of this type.

As a result of the conducted semantic analysis, a set of existing and a set of absent mandatory conditions in the contract on the provision of surrogate motherhood were formed. The set of existing mandatory conditions in the contract included the following conditions: "the potential surrogate mother is of legal age", "the potential surrogate mother is of legal capacity", "the potential surrogate mother has her own healthy child", "the potential surrogate mother voluntarily issued a written statement", "the potential surrogate mother has no medical contraindications to pregnancy and childbirth", "the potential surrogate mother complies with all the doctor's orders", "the potential surrogate mother has provided full information about her health", "the potential parents are a heterosexual couple", "surrogacy is allowed the legislation of Ukraine, whose citizens are potential parents", "potential parents are capable of legal action", "potential parents are not deprived of parental rights", "potential parents are not a party to the surrogacy contract, which was terminated due to their fault", "potential parents are not adoptive parents of another child whose adoption was canceled or declared invalid due to the fault of this marriage couple", "potential parents are not registered or undergoing treatment in a psychoneurological or narcological dispensary", "potential parents do not abuse alcohol or drugs", "potential parents have a permanent place of residence and a permanent income", "potential parents do not suffer from diseases approved by the Ministry of Health of Ukraine", "potential parents are not convicted, do not have an outstanding or unexpunged criminal record", "potential parents do not need constant external health care", "potential parents are not stateless persons", "the medical institution provided the necessary, complete and reliable information about the service", "the medical institution provided information about the service before the conclusion of the contract on the provision of surrogate motherhood", "the medical institution provided comprehensive and detailed advice on the embryo implantation procedure to the surrogate mother", "the medical institution provides medical services using modern methods of diagnosis and treatment", "the medical institution ensures participation in highly qualified medical personnel to provide services", "consequences of miscarriage", "consequences of the birth of a child with physical or mental defects", "consequences of the birth of a child with congenital anomalies", "consequences of stillbirth", "order of action in case of the birth of twins".

The set of absent mandatory conditions in the contract included the following conditions: "the potential surrogate mother is not an egg donor", "the potential parents have medical indications for surrogate motherhood", "the potential parents have a genetic connection with the future child", "the age of both of potential parents is 21 years or older", "the medical institution provided full information about possible fertilization options", "consequences of the birth of a defective child". It is obvious that the set of existing mandatory conditions in the contract contains 30 elements, and the set of absent mandatory conditions in the contract contains 6 elements, which together makes 36, that is, the formation of the sets of existing and absent mandatory

conditions for the contract on the provision of surrogate motherhood is completed correctly.

Based on the obtained sets of existing and absent mandatory conditions in the analyzed contract, each rule for determining the possibility of performing the surrogate motherhood is checked, the counter k is calculated, which for this contract is 30. Since $k<36$, surrogate motherhood is impossible. The assessment of the sufficiency of information in the analyzed contract is $D=30/36=0.83$. The user (reproductive medicine clinic) was also provided with the reasons for the impossibility of surrogate motherhood - elements of the set of the absent mandatory conditions in the contract on the provision of the surrogate motherhood.

Similarly, at the entrance of the proposed decision support system regarding the possibility of using the reproductive technologies, we will submit the contract on the provision of in vitro fertilization. This contract was subjected to semantic analysis (parsing) in accordance with the developed method of semantic analysis (parsing) of natural language contracts on the provision of reproductive technologies for the purpose of finding the mandatory essential conditions in the contract of this type.

As a result of the conducted semantic analysis, a set of existing and a set of absent mandatory conditions in the contract on the provision of in vitro fertilization were formed. The set of existing mandatory conditions in the contract included the following conditions: "the woman is of legal age", "the woman is of legal capacity", "the woman has no contraindications for carrying a pregnancy", "the woman's blood group and Rh factor are known", "the woman has undergone a clinical blood test", "the woman has undergone a coagulogram", "the woman passed tests for HIV, syphilis, hepatitis B and C", "the woman passed tests for chlamydia, toxoplasmosis, cytomegalovirus and cow rubella", "the woman has undergone a bacterioscopic analysis of discharge from the vagina, urethra and cervical canal", "the woman underwent a cytological examination of cervical smears", "the woman underwent a general gynecological examination", "the woman underwent an ultrasound examination of the pelvic organs", "the woman underwent a blood test for prolactin, anti-Mullerian hormone, lutropin, follitropin, estradiol , progesterone", "the woman does not have mental illnesses", "the length of the woman's uterus is at least 3.5 sm", "the woman does not have acute inflammatory diseases", "the woman does not have defects or deformations of the uterine cavity", "the woman does not has benign tumors of the uterus", "the woman does not have malignant neoplasms", "the blood type and Rh factor of the man-donor are known", "the man-donor has passed tests for HIV, syphilis, hepatitis B and C", "the man-donor has undergone a spermogram", "the man-donor underwent fluoroscopy of the lungs", "the marriage couple needs in vitro fertilization for medical reasons (female infertility)", "the marriage

couple gave written consent", "donor anonymity is guaranteed", "medical confidentiality is guaranteed". Not a single condition was included in the set of absent mandatory conditions in the contract. It is obvious that the set of existing mandatory conditions in the contract contains 27 elements, and the set of absent mandatory conditions in the contract contains 0 elements, which together amounts to 27, that is, the formation of the set of existing and absent mandatory conditions for the contract on the provision of in vitro fertilization is completed correctly.

Based on the obtained sets of existing and absent mandatory conditions in the analyzed contract, each rule for determining the possibility of in vitro fertilization is checked, the ecf counter is calculated, which for this contract is 27. Since $ecf=27$, in vitro fertilization is possible. After receiving such a conclusion, the clinic performed the in vitro fertilization procedure.

So, as the conducted experiments have shown, the developed decision support system regarding the possibility of using the reproductive technologies taking into account civil law can significantly increase the legal correctness of the performed procedure, protect the doctor and the patient from legal collisions, provide the possibility of a quick and free check of the fulfillment of all essential conditions for the possibility of use of one or another reproductive technology from a legal point of view, as well as provide recommendations on the further use or non-use of reproductive technology.

5. Conclusions

The development of decision support system regarding the possibility of using the reproductive technologies taking into account civil law is currently an urgent task, the solution of which is devoted to this study.

The review of known methods and decision support systems regarding the possibility of using the reproductive technologies showed that currently there are no methods and decision support systems regarding the possibility of using reproductive technologies taking into account civil law. Although the analyzed methods and systems have great potential for use in different contexts, these methods and systems do not take into account the civil law requirements of any country.

The paper has developed a decision support system regarding the possibility of using the reproductive technologies taking into account civil law, which automatically and free of charge determines the possibility/impossibility of surrogate motherhood or in vitro fertilization. If it is determined that surrogate motherhood or in vitro fertilization is impossible, the sufficiency of the information in the analyzed contract is evaluated, and the reasons for the impossibility of

surrogate motherhood or in vitro fertilization are presented to the user.

So, the developed decision support system regarding the possibility of using the reproductive technologies taking into account civil law can significantly increase the legal correctness of the performed procedure, protect the doctor and the patient from legal collisions, provide the possibility of a quick and free check of the fulfillment of all essential conditions for the possibility of use of one or another reproductive technology from a legal point of view, as well as provide recommendations on the further use or non-use of reproductive technology.

The currently developed decision support system allows determining the possibility/impossibility of surrogate motherhood or in vitro fertilization only on the basis of the current civil law of Ukraine, but it can be adapted to the legislation of any country - for this, an analysis of civil law regarding the possibility/impossibility of surrogate motherhood or in vitro fertilization of a certain country should be conducted; the rules for determining the possibility of performing surrogate motherhood or in vitro fertilization should be added or changed taking into account the analysis of the civil law of a certain country.

A promising direction of the authors' work is the implementation of the proposed decision support system in the form of a web-oriented application, available 24/7, without any registration.

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