

Decision-Making Support for Necessity/Optionality/Contraindication of Vaccination against COVID-19 Considering Legal Norms

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Abstract

The conducted review of known methods and systems showed that there are currently no tools for decision-making support for necessity/optionality/contraindication of vaccination against COVID-19. The paper models the process of decision-making support for necessity/optionality/contraindication of vaccination against COVID-19, which is a theoretical basis for the formation of questionnaires for gathering information about the person who plans to be vaccinated, for organizing the analysis of this person's answers, as well as for decision-making support for necessity/optionality/contraindication of vaccination against COVID-19. Questionnaires for determining the necessity/optionality of vaccination against COVID-19 and for determining the contraindication of vaccination against COVID-19 were developed taking into account the current legal norms of Ukraine, as well as rules for analyzing the answers to questions of questionnaires for determining the necessity/optionality of vaccination against COVID-19 and the answers to the questions of questionnaires for determining the contraindication of vaccination against COVID-19. The developed rules make it possible to form a set of work's categories of the person, for whom the necessity/optionality of vaccination against COVID-19 is determined, and a set of medical diagnoses-contraindications of a person, for whom a contraindication of vaccination against COVID-19 is determined, which are grounds for making a decision about the necessity/optionality/contraindication of vaccination against COVID-19. The scheme of process of decision-making support for necessity/optionality/contraindication of vaccination against COVID-19 has been developed, according to which a person who plans to be vaccinated can automatically and free of charge determine the necessity/optionality of vaccination against COVID-19, as well as the possibility/contraindication of vaccination against COVID-19 based on the legal norms in force in Ukraine, i.e. can independently make a reasoned decision regarding vaccination against COVID-19.

Keywords

Necessity of vaccination against COVID-19, optionality of vaccination against COVID-19, contraindication of vaccination against COVID-19, decision-making support.

1. Introduction

Today, health care decision-making by both doctors and patients requires considerable attention, because the health care industry has high risks and stakes, and the health and life of the patient

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depends on the decision made. When making medical decisions, there is a lack of time, high dynamics of the course of diseases, high cost of medical errors, etc. Medical errors cause tens of thousands of deaths in hospitals each year. Medical errors threaten the quality of health care, increase health care costs, and threaten a crisis in the health care industry. Even simple medical decisions can affect the subsequent quality of life of patients and the success and speed of their recovery. Most often, decision-making comes down to the experience of a medical worker who has to take into account a lot of different factors, often insufficient or imperfect information under strict time constraints and psychological pressure [1-3].

The problem of providing the automated support for decision-making in the field of health care is becoming more and more urgent with the increase in the information load on the doctor and the development of computer technologies. Clinical decision support systems provide decision makers with the functionality to use a variety of information to inform decision making. Exactly clinical decision support systems that can help alleviate the pressure felt by healthcare professionals, minimize the potential for medication errors, and help provide effective care regardless of the current workload of the healthcare facility. The clinical decision support system significantly saves money, time and reputation of the medical institution and its employees [1-5]. But the clinical decision support system is the most difficult to design and implement, because when designing such a system, information from two or more subject areas should be taken into account (at least the field of information technology, the field of health care, and often also the field of medical law, etc.) [6, 7].

Since the beginning of 2020, the health care industry has faced a serious challenge - the COVID-19 pandemic, which is causing considerable mortality in the population, as well as destroying the economies of countries around the world. Vaccination against COVID-19 has become the most effective tool for containing the pandemic. For August 10, 2022, 67.2% of the world population has received minimum one dose of a COVID-19 vaccine, but only 20.2% of people in low-income countries have received minimum one dose [8]. High speed of vaccine manufacturing and accelerated approval, poor and weak laboratory testing of vaccines, lack of clinical trial data on vaccine safety and efficacy, unwell feeling of many people after receiving the vaccine, unknown long-term health effects of vaccination, uncertainty about efficacy against various strains of COVID-19, inadequate information and representation of vaccination in social networks are factors that inhibit vaccination of the population and make it difficult to make a decision about the necessity/optionality/contraindication of vaccination against COVID-19, especially for people with chronic diseases, despite even a high mortality rate from COVID-19.

When making a decision on the necessity/optionality/contraindication of vaccination against COVID-19, it is important for Ukrainians to understand that for people of certain professions, vaccination against COVID-19 is mandatory in accordance with the order of the Ministry of Health of Ukraine dated 04.10.2021 No. 2153, registered in the Ministry of Justice on 16.12.2021 under No. 1624/37246 (categories of employees, for whom vaccination is mandatory, are defined by the authors in [9]). For everyone else, vaccination is optional but desirable, again given the high mortality rate of people from COVID-19. In addition, when making a decision about the necessity/optionality/contraindication of vaccination against COVID-19, Ukrainians should know the medical contraindications on vaccination against Covid'19 established by the current legislation of Ukraine (medical contraindications are also defined by the authors in [9]).

Therefore, when making a decision about the necessity/optionality/contraindication of vaccination against COVID-19, a person can independently study the relevant legislative acts and make such a decision or turn to a family doctor, who must again be familiar with the norms of the law and take responsibility for making a decision about necessity/optionality/contraindication of vaccination against COVID-19. The third way is the use of a clinical decision-making support system about vaccination against COVID-19, the concept of which is proposed by the authors in [9], which provides a conclusion about the necessity/optionality/contraindication of vaccination against COVID-19 on the basis of existing legal norms and thereby contributes to independent decision-making by a person and reducing the burden on the family doctor (at least eliminating the need for the family doctor to study the current legal norms regarding vaccination). Based on the truthful answers of the person, who plans to be vaccinated, to the questions of the system about the profession and place of work of the person planning to be vaccinated, about his medical history, the proposed system forms conclusions about the mandatory or optional vaccination, about the possibility or contraindications to vaccination.

The main task in designing the clinical decision support system about vaccination against COVID-19 is the formation of questionnaires to gathering the information about a person who plans to be vaccinated, as well as the analysis of this person's answers to the questions of the questionnaires, on the basis of which the decision about necessity/optionality/contraindication of vaccination against COVID-19 is made. This research is dedicated to the solution of such task.

2. Review of the Known Methods and Systems

Let's review the known methods and systems for decision-making support for necessity/optionality/contraindication of vaccination against COVID-19.

ProMES is the Covasim-based multiagent pandemic simulator, which evaluates and compares strategies for reducing Covid-19 transmissions (vaccinations, tests, combinations of nonpharmaceutical individual and state interventions). This tool is a part of data/knowledge intensive decision support system, preventing the spread of the coronavirus [10].

In [11] the general linear and logistic regression methods researched factors (demographic characteristics, health-related characteristics, knowledge about vaccination against COVID-19, and determinants of decisions to vaccinate), associated with vaccine acceptance and vaccine hesitancy respectively. COVID-19 vaccine acceptance groups were defined and multivariable models were constructed.

The study [12] proposes a decision support system that integrates geoinformatic systems, simulation methods, analytics to develop a tool for priority-based distribution of COVID-19 vaccines in a large urban setting.

In [13] Bayesian network is developed for combination and effectively communication of evidence on the risks versus benefits of the AstraZeneca vaccine, for consolidation of evidence on benefits and risks of the AstraZeneca vaccine, on the assessment of risk of developing from Thrombosis and Thrombocytopenia Syndrome after AstraZeneca vaccine. This model can be used as a decision-support tool for generating the vaccination scenarios based on sex, age, community transmission rates, virus variant. It is useful for individuals, doctors and researchers for assessing the different health outcomes.

Paper [14] develops a multi-criteria decision support system for analysis of the previous studies about similar virus infections and available data about COVID-19 and for ranking the main approaches and alternatives in confronting the pandemic of COVID-19 considering the feasibility, sustainability, and success rate of possible approaches.

Shared decision making and use of patient decision aids help patients overcome vaccination against COVID-19 hesitancy. In [15] an overview of shared decision making and use of patient decision aids is conducted and the effect of shared decision making interventions on vaccine uptake is determined - significantly increase of the decision confidence and decrease of the decisional conflict.

Authors of [16] propose the shared decision-making, based on tools associated with patient decision aids, which help patients make an informed choice about vaccination with Comirnaty from Pfizer-BioNTech in France, but such instruments can easily be extended to the population of any other country.

In the paper [17] the decision support system is presented that focuses on the capacity planning of the process of vaccination against COVID-19 in the Netherlands based on the Dutch national vaccination priority list, and is ideally suited for providing the support in the dynamic of process of vaccination against COVID-19.

The paper [18] proposes the prototype of multi-criteria decision support model based on goal programming that can effectively support vaccination plans considering minimizing the risk of spreading the disease and the number of fatalities.

Paper [19] develops a tool for decision support to improve vaccine against COVID-19 uptake among HCWs in the early phase of vaccination rollout on the basis of multifactorial influences underpinning a decision on vaccination, that features use of platform for sharing of experience, provides plans and communications in case of unforeseen situations and positive outlook associated with vaccination.

The main contribution of the study [20] is proposition of a machine learning algorithm Hierarchical Priority Classification eXtreme Gradient Boosting for administration and priority classification of vaccination against COVID-19, for the prediction of priorities of COVID-19 vaccine.

Authors of [21] proposes a decision support system used multi-agent programmable modeling environment NetLogo. This system is based on the adoption of artificial intelligence techniques, simulation of the different vaccination strategies, use of genetic algorithms for evolving the best vaccination criteria and for provision of suggestions about more effective policies.

The paper [22] develops community-oriented COVID-19 vaccination program RapidVax based on Health IT and big data analysis, which provides security of data gathering, quality of data and validations of rule, preserves privacy, customizes interactive user interfaces, visualizes outcomes, and generates reporting, and supports the vaccination task efficiently.

In the paper [23] the particle-based SEIR epidemic simulator is proposed as a tool for modeling the effective immunization outcomes and for assessing the impact of different vaccination strategies on viral propagation based on the prioritization of certain age groups or randomly vaccinating individuals across all age groups.

Authors of [24] implemented optimized decision-support system for ambulatory care for four case studies: problem of positioning centers for vaccination against COVID-19 and emergency doctors, the out-of-hours pharmacy planning problem, and the route planning of patient transport services.

In the paper [25] the decision-making supporting system is proposed as an epidemiological prediction tool including vaccination against COVID-19 and restrictions on population migration both within the country and between countries.

The conducted review of known methods and systems showed that there are currently no tools for decision-making support for necessity/optionality/contraindication of vaccination against COVID-19. Although the known methods and systems have considerable potential for the field of health care and in the fight against the COVID-19 pandemic, these methods and systems do not take into account the legal norms of any country and do not ensure the formation of a conclusion about the necessity/optionality/contraindication of vaccination against COVID-19 on the basis of existing legal norms.

3. Modeling the Process of Decision-Making Support for Necessity/Optionality/ Contraindication of Vaccination against COVID-19

In order to form questionnaires for gathering the information about a person who plans to be vaccinated and for analyzing this person's answers to the questions, it is necessary to first model the process of decision-making support for necessity/optionality/ contraindication of vaccination against COVID-19.

Let $RPFQS$ is a set of work's categories of the person, for whom the necessity/optionality of vaccination against COVID-19 is determined (such a set may consist of one element or be empty).

In order to form a conclusion about the necessity of vaccination against COVID-19, it is a mandatory condition to belong to the categories of employees who are subject to mandatory vaccination, defined in [9], therefore *the criterion of necessity of vaccination against COVID-19* will have the following form:

- if $RPFQS = \emptyset$, then vaccination against COVID-19 is optional;
- if $RPFQS \neq \emptyset$, then vaccination against COVID-19 is necessary.

Taking into account the defined in [9] categories of employees who are subject to mandatory vaccination, *the set of categories of employees, who are subject to mandatory vaccination*, has the following form:

$$PFQS = \{cebe, lsae, erie, lge, hcie, uioe\}, \quad (1)$$

where *cebe* – central executive authorities' employees, *lsae* – local state administrations' employees, *erie* – educational and scientific institutions' employees, *lge* – local self-government bodies' employees, *hcie* – healthcare institutions' employees, *uioe* – communal enterprises', institutions' and organizations' employees.

Taking into account the developed criterion of necessity of vaccination against COVID-19 and the set of categories of employees, who are subject to mandatory vaccination (formula (1)), let's perform

modeling the process of decision-making support for necessity/optionality of vaccination against COVID-19.

If $RPFQS$ is a set of work's categories of the person, for whom the necessity/optionality of vaccination against COVID-19 is determined (such a set may consist of one element or be empty), then *the general rule for making a decision on the necessity/optionality of vaccination against COVID-19* is as follows:

$$\begin{aligned} & \text{If } RPFQS = \emptyset \\ & \text{then vaccination against COVID - 19 is optional,} \\ & \text{else vaccination against COVID - 19 is necessary.} \end{aligned} \quad (2)$$

Let $RCIQS$ is a set of medical diagnoses-contraindications of a person, for whom a contraindication of vaccination against COVID-19 is determined (such a set may consist of one element or be empty).

In order to form a conclusion about contraindication of vaccination against COVID-19, the presence of medical contraindications defined in [9] is a mandatory condition, so *the criterion of contraindication of vaccination against COVID-19* will look like this:

- if $RCIQS = \emptyset$, then vaccination against COVID-19 is possible;
- if $RCIQS \neq \emptyset$, then there are contraindication on vaccination against COVID-19.

Taking into account the available medical contraindications to vaccination against COVID-19 defined in [9], *the set of contraindications to vaccination against COVID-19* has the following form:

$$CIQS = \{ails, cdhs, macp, pgnt, lctn, vcid, tbif, hidv, \\ ttcp, mcpc, opct, opic, imdy, arar, aics\}, \quad (3)$$

where *ails* – an acute illness with an increase in temperature above 38.0 °C, *cdhs* – COVID-19 in history, *macp* – treatment with monoclonal antibodies or convalescent plasma, *pgnt* – pregnancy, *lctn* – lactation, *vcid* – recent administration of vaccines against other infectious diseases, *tbif* – tuberculin test or interferon- γ release blood test, *hidv* – human immunodeficiency virus, hepatitis C virus, hepatitis B virus, *ttcp* – thrombosis and/or thrombocytopenia, *mcpc* – myocarditis and/or pericarditis, *opct* – oncopathology with allogeneic or autogenous transplantation or cell therapy, *opic* – oncopathology with a course of intensive cytotoxic chemotherapy, *imdy* – immunodeficiency, *arar* – allergic and/or anaphylactic reaction to vaccine components in history, *aics* – autoimmune conditions.

Taking into account the developed criterion of contraindication of vaccination against COVID-19 and the set of contraindications to vaccination against COVID-19 (formula (3)), let's perform *modeling the process of decision-making support for contraindication of vaccination against COVID-19*.

If $RCIQS$ is a set of medical diagnoses-contraindications of a person, for whom a contraindication of vaccination against COVID-19 is determined (such a set may consist of one element or be empty), then *the general rule for making a decision about contraindication of vaccination against COVID-19* is as follows:

$$\begin{aligned} & \text{If } RCIQS = \emptyset \\ & \text{then vaccination against COVID - 19 is possible,} \\ & \text{else there are contraindication on vaccination against COVID - 19.} \end{aligned} \quad (4)$$

The scientific novelty of the paper is the model of the process of decision-making support for necessity/optionality/contraindication of vaccination against COVID-19 is conducted, which is a theoretical basis for the formation of questionnaires for gathering information about the person who plans to be vaccinated, for organizing the analysis of this person's answers, as well as for decision-making support for necessity/optionality/contraindication of vaccination against COVID-19.

4. Questionnaires for Determining the Necessity/Optionality/Contraindication of Vaccination against COVID-19 and Rules for Analyzing the Answers to Questions of Questionnaires

Taking into account the results of the conducted in [9] analysis of the legal norms of vaccination against COVID-19, as well as modeling the process of decision-making support for necessity/optionality/contraindication of vaccination against COVID-19, let's develop questionnaires for gathering the information about a person, who plans to be vaccinated, and let's describe the process of forming the sets of work's categories of the person, for whom the necessity/optionality of

vaccination against COVID-19 is determined, and of medical diagnoses-contraindications of a person, for whom a contraindication of vaccination against COVID-19 is determined.

Questionnaire for determining the necessity/optionality of vaccination against COVID-19:

1. Are you an employee of central executive authorities?
2. Are you an employee of local state administrations?
3. Are you an employee of educational and scientific institutions?
4. Are you an employee of local self-government bodies?
5. Are you an employee of healthcare institutions?
6. Are you an employee of communal enterprises, institutions and organizations?

Each of the questions in the questionnaire for determining the necessity/optionality of vaccination against COVID-19 requires "yes" or "no" answer.

Rules for analyzing the answers to questions of questionnaire for determining the necessity/optionality of vaccination against COVID-19:

1. If the answer "yes" is chosen to the first question of the questionnaire for determining the necessity/optionality of vaccination against COVID-19, then the element *cebe* is put in the set *RPFQS*
2. If the answer "yes" is chosen to the second question of the questionnaire for determining the necessity/optionality of vaccination against COVID-19, then the element *lsae* is put in the set *RPFQS*
3. If the answer "yes" is chosen to the third question of the questionnaire for determining the necessity/optionality of vaccination against COVID-19, then the element *erie* is put in the set *RPFQS*
4. If the answer "yes" is chosen to the fourth question of the questionnaire for determining the necessity/optionality of vaccination against COVID-19, then the element *lge* is put in the set *RPFQS*
5. If the answer "yes" is chosen to the fifth question of the questionnaire for determining the necessity/optionality of vaccination against COVID-19, then the element *hcie* is put in the set *RPFQS*
6. If the answer "yes" is chosen to the sixth question of the questionnaire for determining the necessity/optionality of vaccination against COVID-19, then the element *uioe* is put in the set *RPFQS*
7. If none of the six questions of the questionnaire for determining the necessity/optionality of vaccination against COVID-19 is answered in the affirmative ("yes" answer), then the set *RPFQS* remains empty

Questionnaire for determining the contraindication of vaccination against COVID-19:

1. Do you currently have an acute illness with an increase in temperature over 38.0 °C?
2. Do you have COVID-19 in history?
3. Are you being treated with monoclonal antibodies or convalescent plasma?
4. Are you currently pregnant?
5. Are you currently lactating?
6. Have you had a recent administration of vaccines against other infectious diseases?
7. Have you recently had a tuberculin test or a blood test for the release of interferon- γ ?
8. Do you have human immunodeficiency virus, hepatitis C virus, hepatitis B virus?
9. Do you suffer from thrombosis and/or thrombocytopenia?
10. Do you suffer from myocarditis and/or pericarditis?
11. Do you have oncopathology with allogeneic or autogenous transplantation or cell therapy?
12. Do you have oncopathology and are on a course of intensive cytotoxic chemotherapy?
13. Do you have an immunodeficiency?
14. Do you have a history of allergic and/or anaphylactic reaction to vaccine components?
15. Do you have autoimmune conditions?

Each of the questions in the questionnaire for determining the contraindication of vaccination against COVID-19 requires "yes" or "no" answer.

Rules for analyzing the answers to questions of questionnaire for determining the contraindication of vaccination against COVID-19:

1. If the answer "yes" is chosen to the first question of the questionnaire for determining the contraindication of vaccination against COVID-19, then the element *ails* is put in the set *RCIQS*
2. If the answer "yes" is chosen to the second question of the questionnaire for determining the contraindication of vaccination against COVID-19, then the element *cdhs* is put in the set *RCIQS*
3. If the answer "yes" is chosen to the third question of the questionnaire for determining the contraindication of vaccination against COVID-19, then the element *macp* is put in the set *RCIQS*
4. If the answer "yes" is chosen to the fourth question of the questionnaire for determining the contraindication of vaccination against COVID-19, then the element *pgnt* is put in the set *RCIQS*
5. If the answer "yes" is chosen to the fifth question of the questionnaire for determining the contraindication of vaccination against COVID-19, then the element *lctn* is put in the set *RCIQS*
6. If the answer "yes" is chosen to the sixth question of the questionnaire for determining the contraindication of vaccination against COVID-19, then the element *vcid* is put in the set *RCIQS*
7. If the answer "yes" is chosen to the seventh question of the questionnaire for determining the contraindication of vaccination against COVID-19, then the element *tbif* is put in the set *RCIQS*
8. If the answer "yes" is chosen to the eighth question of the questionnaire for determining the contraindication of vaccination against COVID-19, then the element *hidv* is put in the set *RCIQS*
9. If the answer "yes" is chosen to the ninth question of the questionnaire for determining the contraindication of vaccination against COVID-19, then the element *ttcp* is put in the set *RCIQS*
10. If the answer "yes" is chosen to the tenth question of the questionnaire for determining the contraindication of vaccination against COVID-19, then the element *mcp* is put in the set *RCIQS*
11. If the answer "yes" is chosen to the eleventh question of the questionnaire for determining the contraindication of vaccination against COVID-19, then the element *opct* is put in the set *RCIQS*
12. If the answer "yes" is chosen to the twelfth question of the questionnaire for determining the contraindication of vaccination against COVID-19, then the element *opic* is put in the set *RCIQS*
13. If the answer "yes" is chosen to the thirteenth question of the questionnaire for determining the contraindication of vaccination against COVID-19, then the element *imdy* is put in the set *RCIQS*
14. If the answer "yes" is chosen to the fourteenth question of the questionnaire for determining the contraindication of vaccination against COVID-19, then the element *arar* is put in the set *RCIQS*
15. If the answer "yes" is chosen to the fifteenth question of the questionnaire for determining the contraindication of vaccination against COVID-19, then the element *aics* is put in the set *RCIQS*
16. If none of the fifteen questions of the questionnaire for determining the contraindication of vaccination against COVID-19 is answered in the affirmative ("yes" answer), then the set *RCIQS* remains empty

Therefore, questionnaires for determining the necessity/optionality of vaccination against COVID-19 and for determining the contraindication of vaccination against COVID-19 were developed taking into account the current legal norms of Ukraine, as well as rules for analyzing the answers to questions of questionnaires for determining the necessity/optionality of vaccination against COVID-19 and the answers to the questions of questionnaires for determining the contraindication of vaccination against COVID-19. The developed rules make it possible to form a set of work's categories of the person for whom the necessity/optionality of vaccination against COVID-19 is

determined, and a set of medical diagnoses-contraindications of a person for whom a contraindication of vaccination against COVID-19 is determined, which are grounds for making a decision about the necessity/optionality/contraindication of vaccination against COVID-19 according to rules (2) and (4).

5. Decision-Making Support for Necessity/Optionality/Contraindication of Vaccination against COVID-19

Process of decision-making support for necessity/optionality/ contraindication of vaccination against COVID-19 is represented on Fig. 1.

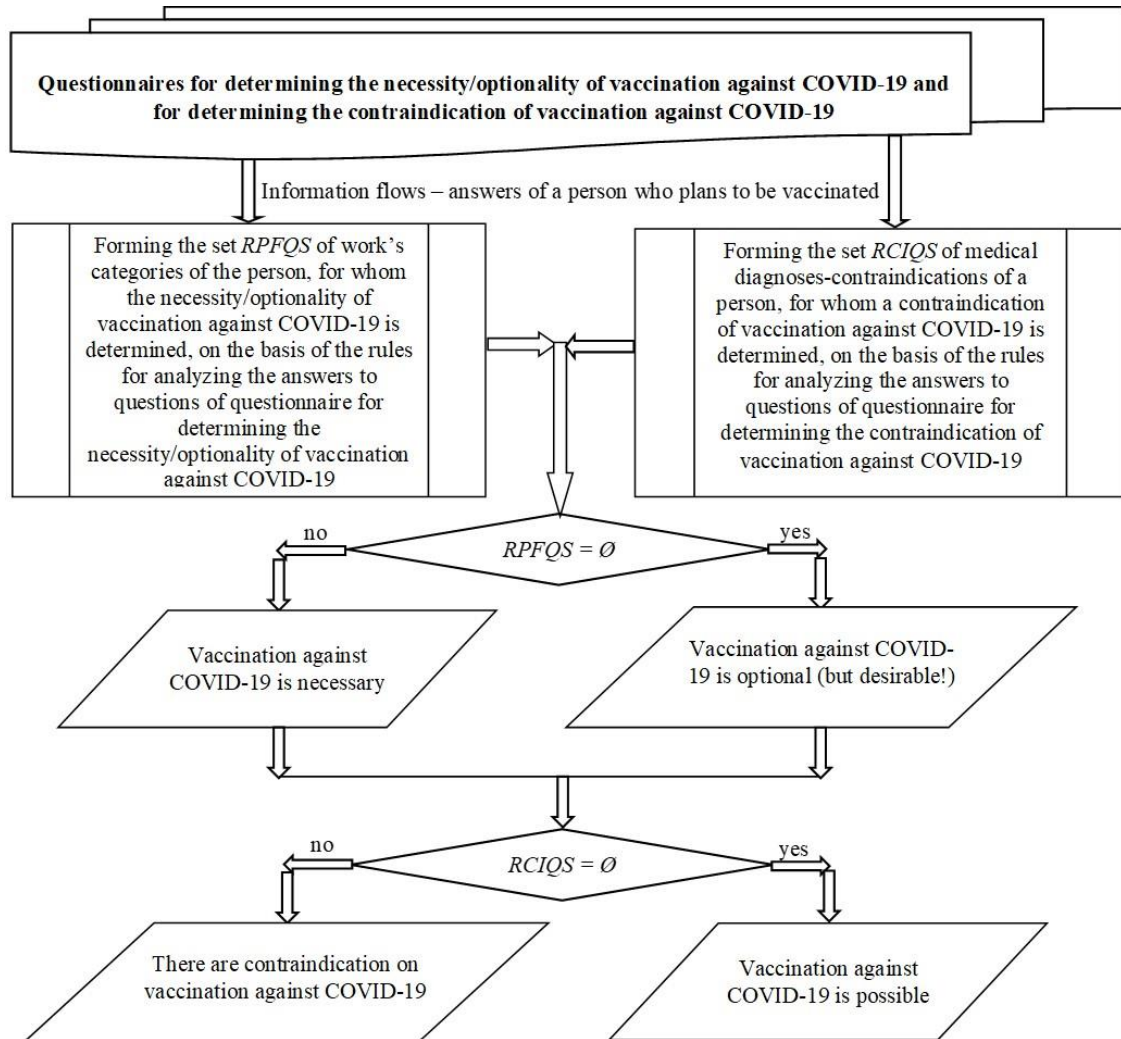


Figure 1: Scheme of process of decision-making support for necessity/optionality/contraindication of vaccination against COVID-19

Therefore, the main source of information for making a decision about the necessity/optionality/contraindication of vaccination against COVID-19 is the questionnaires for determining the necessity/optionality of vaccination against COVID-19 and for determining the contraindication of vaccination against COVID-19. The information streams are, respectively, the answers of a person, who plans to be vaccinated, to questions of questionnaires. In the process of analyzing the answers of a person, who plans to be vaccinated, to the questions of the questionnaire, forming the set *RPFQS* of work's categories of the person, for whom the necessity/optionality of vaccination against COVID-19 is determined, on the basis of the rules for analyzing the answers to questions of questionnaire for determining the necessity/optionality of vaccination against COVID-19, as well as forming the set *RCIQS* of medical diagnoses-contraindications of a person, for whom a

contraindication of vaccination against COVID-19 is determined, on the basis of the rules for analyzing the answers to the questions of questionnaire for determining the contraindication of vaccination against COVID-19.

Next, it is checked whether the set $RPFQS$ of work's categories of the person, for whom the necessity/optionality of vaccination against COVID-19 is determined, is empty. If the set $RPFQS$ is empty, then a decision is made about optionality of vaccination against COVID-19, if the set $RPFQS$ is not empty, then a decision is made about the necessity of vaccination against COVID-19.

The next step is checking whether the set $RCIQS$ of medical diagnoses-contraindications of a person, for whom a contraindication of vaccination against COVID-19 is determined, is empty. If the set $RCIQS$ is empty, then the decision is made about the possibility of vaccination against COVID-19, if the set $RPFQS$ is not empty, then the decision is made about the contraindication of vaccination against COVID-19.

So, the scheme of process of decision-making support for necessity/optionality/contraindication of vaccination against COVID-19 has been developed, according to which a person who plans to be vaccinated can automatically and free of charge determine the necessity/optionality of vaccination against COVID-19, as well as the possibility/contraindication of vaccination against COVID-19 based on the legal norms in force in Ukraine, i.e. can independently make a reasoned decision regarding vaccination against COVID-19. The currently presented scheme of process of decision-making support for necessity/optionality/contraindication of vaccination against COVID-19 is based on the current legal norms of Ukraine, but it can be adapted to the legal norms of any other country by analyzing these legal norms, supplementing or changing the questionnaires for determining the necessity/optionality of vaccination against COVID-19 and for determining the contraindication of vaccination against COVID-19, as well as supplementing or changing the rules for analyzing the answers to questions in the questionnaires for determining the necessity/optionality of vaccination against COVID-19 and for determining contraindication of vaccination against COVID-19.

The developed rules for analyzing the answers to questions of questionnaire for determining the necessity/optionality of vaccination against COVID-19, rules for analyzing the answers to questions of questionnaire for determining the contraindication of vaccination against COVID-19, and the formalization of the process of decision-making support for necessity/optionality/contraindication of vaccination against COVID-19, which provides the conclusions about the necessity/optionality/contraindication of vaccination against COVID-19, are also the scientific novelty of this paper.

6. Results & Discussion

Let's consider the example of decision-making support for necessity/optionality/contraindication of vaccination against COVID-19. Two people, who plan to be vaccinated, gave truthful answers to the questions of questionnaires for determining the necessity/optionality of vaccination against COVID-19 and for determining the contraindication of vaccination against COVID-19.

Person1 gave the following answers to the questions of the questionnaire for determining the necessity/optionality of vaccination against COVID-19: 1) No; 2) No; 3) Yes; 4) No; 5) No; 6) No.

Person1 gave the following answers to the questions of the questionnaire for determining the contraindication of vaccination against COVID-19: 1) No; 2) No; 3) No; 4) No; 5) No; 6) No; 7) No; 8) Yes; 9) No; 10) No; 11) No; 12) No; 13) No; 14) Yes; 15) No.

Therefore, considering the given answers, the sets $RPFQS_1 = \{erie\}$, $RCIQS_1 = \{hidv, arar\}$. Since the set $RPFQS_1 \neq \emptyset$, a decision is made about the necessity of vaccination against COVID-19. At the same time, since the set $RCIQS_1 \neq \emptyset$, a decision is made about contraindication of vaccination against COVID-19. Person 1, after analyzing the received conclusions, decided to postpone vaccination against COVID-19.

Person2 gave the following answers to the questions of the questionnaire for determining the necessity/optionality of vaccination against COVID-19: 1) No; 2) No; 3) No; 4) No; 5) No; 6) No.

Person2 gave the following answers to the questions of the questionnaire for determining the contraindication of vaccination against COVID-19: 1) No; 2) No; 3) No; 4) No; 5) No; 6) No; 7) No; 8) No; 9) No; 10) No; 11) No; 12) No; 13) No; 14) No; 15) No.

Therefore, considering the given answers, the sets $RPFQS_2 = \emptyset$, $RCIQS_2 = \emptyset$. Since the set $RPFQS_2 = \emptyset$, a decision is made about optionality of vaccination against COVID-19. Since the set $RCIQS_2 = \emptyset$, a decision is made about possibility of vaccination against COVID-19. Person 2, after analyzing the received conclusions, decided to undergo vaccination against COVID-19.

As the conducted in Section 2 analysis showed, the known methods and systems do not take into account the legal norms of any country and do not ensure the formation of a conclusion about the necessity/optionality/contraindication of vaccination against COVID-19 on the basis of existing legal norms. Instead, we proposed a solution, according to which a person who plans to be vaccinated can automatically and free of charge determine the necessity/optionality of vaccination against COVID-19, as well as the possibility/contraindication of vaccination against COVID-19 based on the legal norms in force in Ukraine, i.e. can independently make a reasoned decision regarding vaccination against COVID-19.

The proposed scheme of process of decision-making support for necessity/optionality/contraindication of vaccination against COVID-19 was tested on the data of 580 real patients (the information was provided by the family doctor of the outpatient clinic of family medicine of the southwestern district of Khmelnytskyi), correct conclusions about the necessity/optionality/contraindication of vaccination against COVID-19 were obtained on all test data, which gives reasons to assert 100% veracity of the work of the proposed solution.

7. Conclusions

The main task in designing the clinical decision support system about vaccination against COVID-19 is the formation of questionnaires to gathering the information about a person who plans to be vaccinated, as well as the analysis of this person's answers to the questions of the questionnaires, on the basis of which the decision about necessity/optionality/contraindication of vaccination against COVID-19 is made. This research is dedicated to the solution of such task.

The conducted review of known methods and systems showed that there are currently no tools for decision-making support for necessity/optionality/contraindication of vaccination against COVID-19. Although the known methods and systems have considerable potential for the field of health care and in the fight against the COVID-19 pandemic, these methods and systems do not take into account the legal norms of any country and do not ensure the formation of a conclusion about the necessity/optionality/contraindication of vaccination against COVID-19 on the basis of existing legal norms.

The scientific novelty of the paper is the developed model of the process of decision-making support for necessity/optionality/contraindication of vaccination against COVID-19, which is a theoretical basis for the formation of questionnaires for gathering information about the person who plans to be vaccinated, for organizing the analysis of this person's answers, as well as for decision-making support for necessity/optionality/contraindication of vaccination against COVID-19.

Questionnaires for determining the necessity/optionality of vaccination against COVID-19 and for determining the contraindication of vaccination against COVID-19 were developed taking into account the current legal norms of Ukraine, as well as rules for analyzing the answers to questions of questionnaires for determining the necessity/optionality of vaccination against COVID-19 and the answers to the questions of questionnaires for determining the contraindication of vaccination against COVID-19. The developed rules make it possible to form a set of work's categories of the person for whom the necessity/optionality of vaccination against COVID-19 is determined, and a set of medical diagnoses-contraindications of a person for whom a contraindication of vaccination against COVID-19 is determined, which are grounds for making a decision about the necessity/optionality/contraindication of vaccination against COVID-19.

The scheme of process of decision-making support for necessity/optionality/contraindication of vaccination against COVID-19 has been developed, according to which a person who plans to be vaccinated can automatically and free of charge determine the necessity/optionality of vaccination against COVID-19, as well as the possibility/contraindication of vaccination against COVID-19 based on the legal norms in force in Ukraine, i.e. can independently make a reasoned decision regarding vaccination against COVID-19. Such scheme was tested on the data of 580 real patients, correct

conclusions about the necessity/optionality/contraindication of vaccination against COVID-19 were obtained on all test data, which gives reasons to assert 100% veracity of the work of the proposed solution.

The scientific novelty of the paper is also the developed rules for analyzing the answers to questions of questionnaire for determining the necessity/optionality of vaccination against COVID-19, rules for analyzing the answers to questions of questionnaire for determining the contraindication of vaccination against COVID-19, and the formalization of the process of decision-making support for necessity/optionality/contraindication of vaccination against COVID-19, which provides the conclusions about the necessity/optionality/contraindication of vaccination against COVID-19.

The currently presented scheme of process of decision-making support for necessity/optionality/contraindication of vaccination against COVID-19 is based on the current legal norms of Ukraine, but it can be adapted to the legal norms of any other country by analyzing these legal norms, supplementing or changing the questionnaires for determining the necessity/optionality of vaccination against COVID-19 and for determining the contraindication of vaccination against COVID-19, as well as supplementing or changing the rules for analyzing the answers to questions in the questionnaires for determining the necessity/optionality of vaccination against COVID-19 and for determining contraindication of vaccination against COVID-19.

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