DETERMINING AND MONITORING OF THE THERAPY PROCEDURES BY APPLICATION OF THE ARTIFICIAL INTELLIGENCE METHODS RELEVANT FOR ACQUIRING OF THE QUALITY EXCELLENCE IN THE PROCESSES OF THE MEDICAL TREATMENT

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Abstract: *In this paper, short retrospection of the multi criteria mathematical models and fuzzy expert systems from available literature for support of the decision processes in medical treatment is presented. The significance of the application of methods and techniques of artificial intelligence, primarily the theory of fuzzy sets in modeling of clinical uncertainties and ranking of the possible solutions is demonstrated. Special attention is focused to possibility of the application of medical expert systems in the process of determination and monitoring of the optimal therapy procedure for individuals. Summary of the possibilities for application of the medical expert systems in the republic of Serbia is presented.*
Key words: *therapy procedure, rank, fuzzy set*

1. INTRODUCTION

Many results of the researches performed in the domain of medicine and information science point that the medicine in XX1 century will be significantly different from the medicine of XX century. The tasks of the contemporary medicine are: (1) improvement of the quality of health care on the individual level and (2) rationalization of the medical treatment expenses. The first task comprise following problems: diagnostic improvement, determination and monitoring of the optimal therapy procedure on the individual level, determination of the risk of illness complication, improvement of the medical staff work organization, improvement of the relation physician – patient etc. Quality of the solution for the first problem is quantitatively non-measurable and that is why it is hard to estimate the success of the obtained solutions of the problems that are comprised by the first task. Quality of the improvement of the health care from the aspect of the patient can be presented quantitatively by: (a) the time needed for the patient to be brought into good enough health condition for working and social tasks and (b) duration of the good health period. The solution of the second task depends on the obtained solutions for the improvement of the quality of the health care.

Such defined tasks can be treated as problem situations – they are highly interactive, very complex, dynamic and multi significant control problems [14]. It is obvious that the scientific base of the contemporary systems of health care is to comprise medicine based on data, using of the clinical guides and paradigms that require to be expanded in order to include the model of the cooperation with provider, users and organizational perspectives. In this paper, only one of the problems was treated that exist in the problem of the improvement of the health care quality – choice and monitoring of the optimal therapy procedure on the individual level.

The question, why the authors focus their attention only to that problem, can be posed. Optimal therapy procedure on the individual level can improve the quality of medical treatment on one side, and on the other to lower the treatment expenses which is very significant. Therapy procedures for every illness are prescribed in clinical guides, and the physician is obliged to apply the legal clinical guides. The question is, which therapy procedure to choose for the medical treatment of the patient from the more than one available therapy procedures. At the first sight, the posed task may seems simple, although it is very complex task and besides knowledge it requires from the physician the great mental effort as the each patient is treated individually. Every therapy procedure is judged according to many criteria whose importance is not equal in general. On the other side, external influences on physicians cannot be neglected as for instance, that day the

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physician is overloaded with work, not concentrated for some reason and similar. Presented facts by itself illustrate the complexity of the discussed problem.

The task of therapy procedures management on the individual level becomes more complex as in medicine exists a lot of imprecise and uncertain information such as individual interpretation of the patient's own health condition, etc. Medical entities such as symptoms, signs, test results, illnesses, diagnoses, suggestions of the therapy procedures and prognostic information can be adequately described by the artificial intelligence techniques. Methods which are most frequently used for modeling of the clinical uncertainties are modeling and simulations, neural networks, theory of the fuzzy sets and robots. In the following text theory of fuzzy sets in the modeling of clinical uncertainties are described.

Theory of fuzzy sets and fuzzy logic is efficient method for treating the uncertain and imprecise data of any kind. It has such characteristics that enable researchers to provide the high rationality when modeling the uncertain, incomplete and fuzzy data that exist in clinical practice. The basic aim of the fuzzy sets theory and fuzzy logic is exploitation of the tolerance that exists in imprecise, vague or partially truth data for obtaining the more robust and cheaper solutions [19]. The advantages of the fuzzy approach to modeling of uncertainties, comparing to other techniques and methods of the AI are many. As the most important advantage is that the expert knowledge is represented by the natural language which is the most suitable for communication as it was improved and optimized for centuries. From the point of view of mathematics, expert knowledge is represented by the linguistic variable, which is quantitatively described in the theory of fuzzy sets [19]. On the University of De Montfort in the Great Britain, in the centre for computational intelligence, fuzzy based approach is described, for computer supported medical diagnostics in the clinical context [11]. Possibility for using the fuzzy cognitive maps in the process of establishing the diagnose is presented. Method of satisfied constraints is especially used in those cases when the sporadic uncertainty occurs within the patients symptoms. In addition, in this way it is allowed for intensity and duration of the symptoms to be described by the fuzzy numbers. Model was tested on a large enough number of patients so that the obtained results clearly show the advantages of the usage of the fuzzy modeling in differential diagnostics.

Quality solutions of the problem situations can be obtained only through synergy of different knowledge that would mean that it is necessary to develop and apply methods of artificial intelligence (AI medical systems): mathematical models in which uncertainties exist and medical expert systems (MES) that contain the knowledge of the many experts.

Physician's experience in the developed world shows that the usage of the AI medical systems for tasks of the contemporary medicine has significant benefits.

Numerous factors exist that have bad influence on the implementation of the AI medical systems [18]: (1) The degree of the organization of the medical institution and interested in management staff to finance this activity, (2) lack of investments, (3) lack of leadership among the physicians, (4) lack of knowledge in this area which can be obtained through the system of medical education, and (5) lack of professional societies and also (6) lack of maintenance and control of the AI medical systems in health care institutions from the informatics support staff, etc.

This paper is structured in the following way: Section 2 presents fuzzy models for the choice of the optimal therapy procedure on the individual level, section 3 presents some developed ES, attention is particularly focused on fuzzy ES for the complex clinical problems, section 4 contains brief conclusions.

2. FUZZY MODELS FOR DETERMINATION OF THE THERAPY PROCEDURES - SHORT RETROSPECTION

Some developed multi criteria fuzzy models are shortly described in this section that can be used for determining of the rank for possible therapy procedures for the each patient separately.

Tadić et all [16] have developed fuzzy mathematical model that is the basis for the development of the fuzzy ES for the choice of the optimal TP in the sense of simultaneous multi criteria, with their importance taken into account also. The importance of the criteria does not depend on patient, and it is determined by the team of physicians. In this paper, the importance are described by the linguistic expression which is modeled by the triangular fuzzy numbers. The shape of the distributional function for fuzzy numbers is determined by the dialog with physicians. In this paper, general criteria are discussed that are applicable for every illness, efficiency, price and undesired effects that TP can produce. Values of the criteria can be crisp – price of the drugs and uncertainties such as side effect and efficiency of TP. Procedure was developed for evaluation of the equivalent price for the

considered TP. TP where ranked by the evaluated prices and ordered into monotonic decreasing order. Developed model is flexible and changes can be easily incorporated into model. In addition, the simulation can give the dependence of varying the rank of TP caused by the changes of input data (number and kind of criteria and TP, values and importance of criteria, etc. In the paper [17] multi criteria fuzzy model was developed for ranking of the possible TP. Therapy procedures can be defined so that the only one medicament is used, or more medicaments can be used. Every medicament is determined in the sense of considered criterion: drug price, efficiency and undesired effects of the medicament. In the paper, the relative impotencies of the criteria are in the matrix of the relative relation of importance for each pair of the considered criteria. Matrix elements are linguistic statements that are modeled by the triangular fuzzy numbers. For each level of the distribution function of possibilities of given fuzzy numbers, vector for importance is obtained. In other words, vector of the importance is described by the discrete fuzzy number. Discrete step is determined in advance. Efficiency of the medicament and undesired effects are described by the linguistic statements and modeled by the continuous fuzzy numbers. The price of the each medicament (optimal dose) is crisp. The procedure was developed for assigning the evaluation to each medicament in the sense of all three considered criteria simultaneously, respecting their importance. Value of the evaluation is described by the discrete fuzzy number. In the procedure of comparing the discrete fuzzy numbers, the optimal therapy procedure is obtained, which is defined like this: it is the TP or medicament whose evaluation value is greater than the evaluation values of all other TP or medicaments. Developed model is supposed to be the one of the possible models on which is based the development of the ES for choice of the optimal therapy procedure for medical treatment of the chronic mass non contagious illnesses that is developed by the project TP 23007 financed by the Ministry for Science of the Republic of Serbia.

3. EXPERT SYSTEM FOR DETERMINING OF THE OPTIMAL THERAPY PROCEDURES - SHORT RETROSPECTION

Application of the ES in the field of the medicine started in early seventies of the XX century. In the literature there are papers that describe the significance of application of the ES in various clinical cases [2,13,15] showed that the usage of the clinical systems for decision support in medicine alleviate medical practice which is based on data from the evidence that further enables the essential improvement of the quality of the health care, and the more rapid development and application in the medical practice of these systems is recommended. Expert systems that contain the knowledge of the many experts are the great help in the processes of making decisions. The advantages of the using of expert systems in the decision processes in the medicine can be stated in the following way:

1. Development of the expert systems that are used as support in making clinical decisions enables cheap dissemination of the expert knowledge :which are on different geographical locations (it is not always possible, and it is certainly very expensive to consult the expert that is dislocated.
2. Formalization of the medical expertise enables the physicians to have better insight of the level of their own knowledge, testing of the artificial intelligence in the real world domain suggests where.

Based on the data from the evidence it is known that the medicine ES where in the first place developed for the help in the decision making processes in medical diagnostics. Some of the best-known medical ES are: Dombal's System For Acute Abdominal Pain [4], INTERNIST-I [12] , MYCIN [3], ONCOLIN [3], DXplain, QMR-Qyick Medical Reference [3], HELP [1].

From now on, the developed expert system is presented, that is especially used for finding the optimal solution of the problems discussed in this paper.

Expert System For Therapy Procedures Evaluation [8] is supposed to help in the choice of optimal therapy procedure for medical treatment of the high blood pressure of the older persons. It was developed on the University of Maryland in Baltimore. The prevalence of the high blood pressure of older people is very high. In addition, it is known that the high blood pressure presents the additional risk of appearing of the many other illnesses. Therefore, the proper treatment of the patients especially older, enables the prevention of the possible complications that can arise as the consequence of the existence of that non-contagious illness, and to make the possible consequences as less as possible. By using of the developed expert system, it is possible to determine the optimal therapy for medical treatment of the high blood pressure for the older population between ages 65 and 85. For determining of the optimal therapy, it is required to take into account the following factors: age, sex, life style, living place, physiological and

patophysiological changes, the presence of the conjoined illnesses, using of the many medicaments, especially for treatment of the high blood pressure. As the inputs, the developed expert system uses patient characteristics, the state of the illness risk factors, relevant laboratory values and the used therapy. Expert system has on the disposal the set of recommendations for appropriate therapies on the individual level (the therapy is based on approximately 200 rules. Using the developed expert system it is possible to have better insight into medical treatment expenses.

3.1 FUZZY EXPERT SYSTEMS

In [10] analyzed and evaluated DSS and ES which are used as the support for clinical decisions as well as possibilities to improve the integration and enable the greater accommodation of these systems in today's system of the health care. These authors came to the following conclusions: tools that are used in the clinical decision systems are formulated according to technical availability, and in that way their use is limited, and especially their integration with contemporary systems for health care. Therefore, the development of the new systems for clinical decision support is necessary.

In the following text, some of the best-known fuzzy ES for medical treatment support are shortly described.

1. **Medical expert and knowledge-based system** was developed in 1987. on the medical University of Vienna in the department for medical statistics and computer science [6]. That ES was based on medical knowledge, current medical and administrative data for the each patient. Application of the developed ES suggests the ranking of the individual TP for the patient rapid medical treatment. Modeling of the patient data, medical knowledge, and procedures for conclusions in this ES is based on the application of the fuzzy set theory and fuzzy logic.

On the basis of these research results, a large number of computer applications in medicine was developed.

All developed computer programs were tested in the first place at the Vienna General Hospital, and in the other institutions also. It should be also noted that developed ES are applied in the medical ambulances and that researchers have good cooperation with commercial partners that further distribute the developed prototypes that are based on this ES.

2. **Medusa** is fuzzy ES for medical diagnostics of the acute abdominal pane. It was developed on the University of Dortmund in Germany, on the department for computer sciences [9]. The idea to develop this fuzzy ES is based on the fact that the diagnostics of the acute abdominal pane presents many clinical problems. In addition, the medical knowledge in this field is characterized by the large uncertainties and inaccuracies. These facts, naturally point to the idea of the development of fuzzy ES in which the fuzzy logic is implemented implicitly.

3. **A fuzzy expert shell-z-III** [5] was developed for the project "An Expert Computer System on Medical Consultation and Management" which was financed by the Research Grants Council with amount of 310000 HK$. Z-III is modularly structured fuzzy ES that consists of the three modules. ABVAB-ES which calculates the diagnose preference and chooses the best diagnose, INDUCE 36-is used for making the decision of premature birth with pregnancy older than 36 weeks, it can be important consultant system as it carefully follows all risk factors for mother and the baby during the pregnancy and makes decisions using the compromise.

And ESROM which is used as an aid for decision when to start the birth; ESROM has the three aims (1) Diagnose – to decide when the membranes should be broken (2) Discovering of the infections – to determine when the infection of the fetus begun and (3) Management – to decide on when the fetus is to be born.

4. APPLICATION OF THE AI SYSTEM IN SERBIA

Application of the information technologies in the Republic of Serbia until the year 2000 was mainly out of date, "on paper", applied in fragments and non coordinated. Since the year 2002 within the Ministry of health of the Republic of Serbia, Sector for international cooperation and project coordination was founded, that cooperates with the World Bank and European Union. The basic aim of this Sector is starting the projects that are supposed to enable the development of informational technologies in the health sector of the Serbia.

It can be said for our country, that the application of the informational technologies is still on the beginning, and by that is still meant the development of the databases (health institutions, employed in the health sector, insured persons, electronic health care documentation of the patients).

If the application of the ES in the area of medicine in our country is compared with developed countries, the great difference is clearly visible. On medical faculties in our country still there are no organizational parts (departments, desks, laboratories, centers, etc) in which the medical information systems would be developed,

as for instance on Stanford university in the Great Britain, Medical faculty on Harvard, Medical faculty, Medical faculty of Vienna, etc.

In addition, the cooperation of the medical and technical faculties (departments for information technology and soft computing) in our country is not on satisfactory level. There are many trials, on individual level, for some medical problems to be quantitatively described, and to find solutions using mathematical modeling. Authors of this paper are of the opinion that it is sensible to develop expert systems in all domains of their usability, in the first place in the domain of management of therapy procedures on the individual level.

The development of the expert system that is used in the process of determining the diagnosis has many difficulties. For instance, medical equipment that are used in the process of diagnosis determining are in the most cases of the foreign origin, and often have built in software for reading and writing of the working signals. Medical equipment of the previous generation is not equipped with software that enables the physician to make more accurate diagnose, and there is a question whether it is justified to develop software solutions for such equipment. On the other side, there is a question whether there is a legal solution concerning the human rights of the patients and physicians if the diagnose is determined by the expert system and after some time it turns out that the diagnose was wrong. These are the two basic reasons that explain the presented attitude of the authors.

5. CONCLUSIONS

On the basis of the all presented, it can be concluded that there is no argue whether the ES should be applied for medical purposes, but with what rate it should be performed. Decisions that the physician is supposed to make, supported by the ES, have significantly less influence of the subjective opinion and attitudes of the physician and it can be said that those decisions are therefore more accurate. That further implicates the quality improvement of the individual patient health care which is the final goal of the modern medicine.

It is evident that many questions can be posed, that are supposed to be the subjects of further researches. When and to what extent should be the ES applied in various areas of the patients medical treatment, then, is it justified from the expenses point of view, to first implement ES in specialized health care institutions, or in institutions for the primary health care. Is it economically justified to develop ES for many illnesses simultaneously, or to firstly treat the illnesses that are most frequent within the certain population? It is the attitude of the authors that it is economically justified to develop ES for the selection of the therapy procedures for the treatment of chronicle mass non contagious illnesses, that the authors do within the project TP-23007 financed by the Ministry of Science of the Republic of Serbia.

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