ISSN 2228-9860 eISSN 1906-9642 CODEN: ITJEA8

International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies

http://TuEngr.com

Using a Decision Tree with a Feedback Function to Select Therapeutic Tactics for Viral Infection of the Respiratory Tract in the Medical Expert System

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Paper ID: 13A8J

Volume 13 Issue 8

Received 05 January 2022
Received in revised form 19 April 2022
Accepted 05 May 2022
Available online 14 May 2022

Keywords:
Artificial intelligence, expert system, medical decision support system, COVID-19, viral infections; respiratory tract, doctor's appointment, electronic clinical pharmacologist, pharmacovigilance, therapy safety

Abstract

The Electronic Clinical Pharmacologist (ECP) is a Medical Decision Support System (MDSS). This system is based on the Unified Medical Knowledge Base (UMKB), which is updated and updated as new medicines are released and specialized publications are published in peer-reviewed biomedical scientific journals. ECP helps to reduce the risks of medical errors and complications in clinical practice. When using ECP, the number of side effects from the use of medicines decreases, the patient's admission time is reduced, the quality of medical care is improved, the costs of the medical organization for the purchase of medicines are reduced, all this is carried out due to more rational prescriptions of the doctor. The ECP takes into account the personalized approach of drug therapy. Based on Stavropol State Medical University and medical universities of the North Caucasus Federal District, a questionnaire of students was conducted among students of 3-6 courses, as well as testing of the ECP application to compare treatment standards (clinical recommendations) according to the clinical recommendations of the Ministry of Health (outpatient, inpatient treatment) and self-treatment of students and their relatives. And patterns of changes in the course of treatment were also revealed when using MDSS ECP and without it.

Disciplinary: Medicine.

Cite This Article:

Maslova, A.Y., Mishvelov, A.E., Dudusheva, M.J., Blejyants, G.A., Minaev, S.V., Shchetinin, E.V., Apaguni, A.A., … Osipchuk G.V. (2022). Using a Decision Tree with a Feedback Function to Select Therapeutic Tactics for Viral Infection of the Respiratory Tract in the Medical Expert System. *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies*, *13*(8), 13A8F, 1-10. http://TUENGR.COM/V13/13A8J.pdf DOI: 10.14456/ITJEMAST.2022.157

1 Introduction

Within the framework of the global trend of building a digital world, the state of modern society is increasingly described using the concept of "digitalization". In the messages of the President of the Russian Federation Vladimir Putin to the Federal Assembly, the issues of digitalization acquire strategic importance for the country. In November 2016, the President of the Russian Federation proposed to "launch a large-scale systemic program for the development of the economy of a new technological generation - the digital economy." Since 2017, in accordance with the Decree of the President of the Russian Federation, the "Strategy for the Development of the Information Community for 2017-2030" has been implemented. The overall goal of the process of digitalization of healthcare is to provide the maximum number of residents of the country with medical services, to ensure the availability of medical care in conditions of transport disunity, the scale of the territory and the presence of settlements with different living standards [1,2]. The approach to this goal is seen in the development of digital technologies, as well as the generalization of the best practices of their implementation in various areas of clinical medicine. The article presents the result of a review of scientific publications, regulatory documentation, as well as information sources (including foreign ones). Digital healthcare tools are considered: telemedicine technologies, mobile applications, websites and information platforms of medical organizations [3-5].

2 Literature Review

Some authors systematized their observations and forecasts about what are the main trends that will have the greatest impact on the change in the market of medical information systems (MIS), medical expert systems (MES), and the forecast of the development of digital medicine. The authors noted that one of the main drivers and development of the market is the work of the doctor and the developers of the MIS (joint work) concerning only various aspects of the patient's health and life, as a basis. As it was noted by the team, in the field of patient relationship management, the concept of Patient Relationship Management (PRM) is already beginning to be introduced into medical practice [6,7].

Other scientists have conducted research on self-medication, which is an integral part of the healthcare system, consisting of community pharmacists who consult patients treating minor illnesses using over-the-counter medications. It was noted that medical decision-making systems can contribute to the identification (including prevention) of diseases and treatment. The working group consisted of technology and medical students, clinical pharmacists, and a pharmacist-researcher. During the development of the medical decision support system, 5 tests were conducted. As a result, the article says that the system was successfully developed and tested using a simulated flu patient, and results were obtained that helped the patient [8-11].

Scientists from North Caucasus used in their study data from electronic medical records that were collected over 18 months. The data obtained from the patient were calculated using a hybrid approach (machine learning and an expert system based on special rules were used). The obtained

indicators from patients were used in a new algorithm: computerized warnings generated by the clinical decision support system (CDS), and a method for prioritizing multi-criteria queries based on the literature. The data obtained from 10,716 individual patients (133,179 prescriptions) were used to train an algorithm based on 25 functions in the development dataset. The new medical decision support system with a hybrid algorithm has improved the accuracy and reliability of prescription checks in hospital settings and also eliminated medical errors when prescribing medications [12,13].

3 The Scientific Novelty of the Development

The classifier of medical concepts (terms), which can be automatically expanded in the process of its use in clinical work, is a detailed systematized classifier of medical concepts, terms and their synonyms in Russian. It is possible to create complementarity with other classifiers of clinical terminology, including international ones (MedDRA, SNOMED), which is especially important for integration into foreign systems. The classifier allows you to formalize and index text information as much as possible during its entry into the patient's medical record. Today, the technology contains more than 2,230,000 unique concepts (terms, not counting synonyms) used in medicine. Its use will make it possible to move to a unified medical terminology and create uniform knowledge bases that can later be synchronized and combined for analysis.

Special technology for modeling medical knowledge is a hybrid technology that uses crowdsourcing and machine analysis of medical texts with the extraction of facts, this achieves a high level of accuracy of the extracted data: automatically generated data is regularly checked and supplemented by moderators manually through a crowdsourcing platform [8-11].

a) the system of modeling the medical knowledge base (certificate of state registration of the computer program No2014618583) is an automated system that uses the principles of crowdsourcing to collect medical knowledge. The system distributes tasks among experts – doctors, pharmacists and biologists, and forms a semantic network from incoming fragments of information. Information is entered into the system not only in text form in different languages but also in the form of logical connections with one or another probability. The possibility of building neural networks in the concept of fuzzy logic allows the system to combine the opinions of an unlimited number of doctors, creating a collective mind [12-15].

The system of modeling the degree of evidence and the reliability of data allows you to rank any knowledge entering the knowledge base by the source of information. In addition, the system has a tool for accounting for the reputation and authority of an expert. It is possible to store the opinions of an unlimited number of experts around one fact, as well as combine the opinions of various experts. When analyzing knowledge around a single fact, the system, using statistical analysis methods, identifies possible errors that deviate from the general opinion, then send them for moderation. In the process of clinical application, a rating of experts is formed, which is used to give an authoritative assessment of the significance of the knowledge they introduce into the

system in the future. The degree of trust and significance of an expert's opinion is directly proportional to the number of his correct answers.

b) the technology of machine analysis of medical texts with the extraction of facts. The process of machine analysis of medical texts as a whole consists of 2 stages.

- Morphological analysis of texts.
- Extraction of meaning (facts) from a medical text using medical ontologies and classifiers of medical concepts (terms).

The United Medical Knowledge Base (UMKB) is a database that combines knowledge from all fields of medicine. They are presented in the form of a semantic network, structured on the basis of medical ontologies and fuzzy logic theory. UMKB has special technologies (crowdsourcing). The expert system being developed is created based on UMKB according to the profile of differential diagnostics.

A specially developed innovative model for the representation of medical knowledge, where, unlike traditional knowledge models, lateral connections between features, principles of fuzzy logic and semantic networks are used. The presence of the module "ontology constructor" provides an opportunity to create the necessary ontologies for the formalization of knowledge in any field of medicine and biology. Thanks to this, it became possible to present complex poorly formalized medical knowledge. The model is able to describe risk factors, etiology, and the pathogenesis of the disease as accurately as possible (probability, time of manifestation and sequence of pathological signs at each stage of the disease development), methods of treatment and prevention. In the formation of pathological and compensatory mechanisms, the concept provides an opportunity to clarify a variety of conditions that affect this mechanism. For example, signs that characterize the personal characteristics of the body (gender, age, immune status, chronic diseases, etc.) [16-19]. All of this is very important for the operation of the system, in the mode of personalized and evidence-based medicine [20-26].

4 Method

At stage 1, studies were conducted on the basis of Stavropol State Medical University, at stage 2, students from other universities of the North Caucasus Federal District (the Republic of Dagestan, Republic of Karachay-Cherkessia, Republic of Ingushetia, Republic of Northern Ossetia-Alania) were connected. The project is being implemented by Stavropol State Medical University and the partner of JSC "Sotsmedika", the Skolkovo Innovation Center. The project was implemented based on the latest developments in the field of artificial intelligence of JSC “Sotsmedika” using an expert decision support system - “Electronic Clinical Pharmacologist". The Unified Medical Knowledge Base (UMKB) served as the platform of the system. Within the UMKB, a separate area is deployed, where knowledge in the field of pharmacology is presented in the form of a semantic network. This is more than a million concepts used in the industry and millions of connections between them. As well as intersystem connections with other sections of the UMKB, in particular, with pathological signs and factors that determine the personal characteristics of the body, etc.

Such a volume of formalized knowledge in this area was accumulated using crowdsourcing technology (an expert group of clinical pharmacologists, pharmacists and doctors of various specialties) in combination with the technology of machine analysis of medical texts. As a result, the Electronic Clinical Pharmacologist (ECP) Clinical Decision Support system - the system helps the doctor in prescribing pharmacotherapy, helps to reduce medical errors and complications in clinical practice. ECP is integrated into the medical information system of a medical institution, monitors medication prescriptions in the background and issues recommendations in the automated workplace of a doctor. There is also an ECP application on Android and iOS mobile platforms. Mobile versions of ECP were used in our study.

Nosology B 34 was chosen - a viral infection of unspecified localization.

A total of 44 people (1st and 6th-year students, as well as residents), aged from 17 to 23 years, took part in the study. 2 groups of subjects and a control group were created - this is the number of side effects that are removed by definitions.

Sampling by nosology.

The research materials were obtained during a sociological study using a questionnaire. The questionnaire included questions reflecting self-assessment by risk group, about sources of information related to the prevention of viral infections, about transmission routes, the possibility of the disease, severe consequences and demographic data (gender, age). The survey was conducted with the informed consent of students in compliance with ethical standards.

The questionnaire included questions on the clarification and course of the disease and concomitant diseases, the exclusion of COVID-19, drug therapy and risk assessment of complications of diseases using ECP and without it.

Figure 1 shows that 3 people (respondents) (7.5%) have chronic diseases of the bronchopulmonary system, and the same number (3 people) with diseases of the endocrine system, pathology of the cardiovascular system have 2 people (5%). 26 respondents were without chronic diseases.

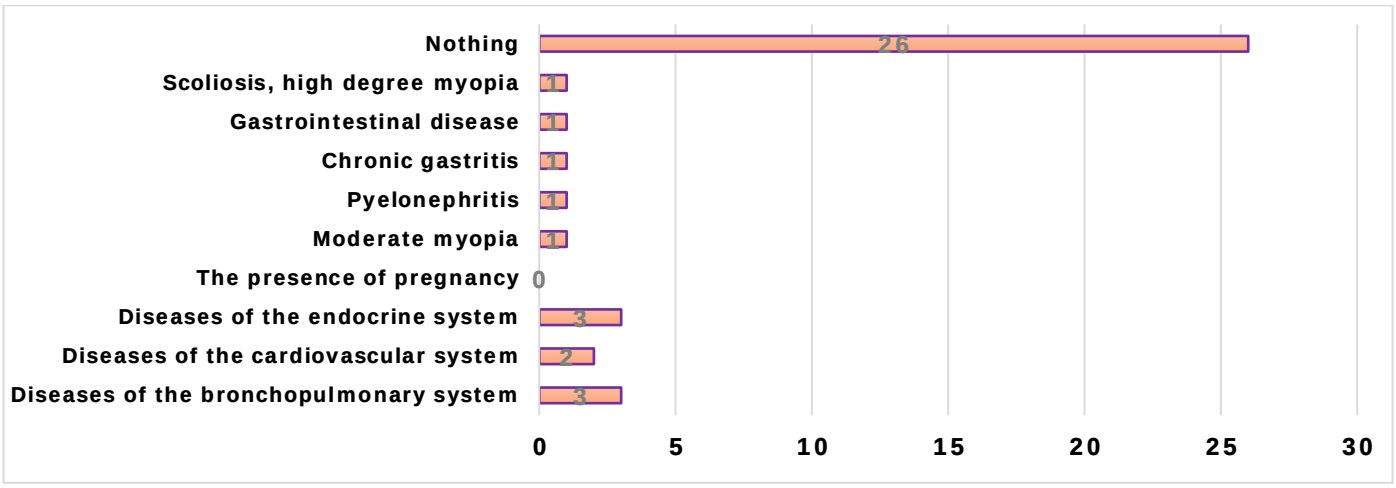

Figure 1: Distribution of chronic diseases in the anamnesis

Through the questionnaire, it was also revealed that 10 people (25%) were in contact with people diagnosed with Covid-19, and 30 people (75%) were not in contact.

During the study, it was found that 4 subjects (14.6%) out of 44 had positive PCR results for the presence of SARS-Cov-2 RNA.

5 Result and Discussion

MDSS ECP allows you to provide a "bridge" between the Internet search system and the doctor, as it allows you to immediately get objective information in one place. In clinical practice, the ECP system helps the doctor in prescribing pharmacotherapy and helps to reduce the occurrence of medical errors and complications. ECP is integrated into the medical information system of the medical institution, monitors drug prescriptions in the background, and also issues recommendations in the automated workplace of the doctor.

According to the results of research and testing in a scientific article [2-4, 27, 28], the scientific team of Stavropol scientists showed that drug interactions with other drugs occur most often. But when using the Medical Decision Support System, ECP was integrated into the MIS "Jupiter" of the Stavropol Diagnostic Center. The system checked the doctor's prescriptions in the background and issued advisory opinions on the correction of pharmacotherapy, taking into account the individual characteristics of the patient. The use of ECP has made it possible to increase the effectiveness of detecting errors in prescribing medications for the following pathologies: IHD (up to 90%), pyelonephritis (up to 87%) and psoriatic arthritis (up to 90%) [29-31].

Another scientific article tells about patients with influenza and SARS infections combined with COVID-19, but having different clinical courses and outcomes. The researchers developed and tested a special machine learning algorithm to distinguish between two viral infections using the available vital signs and demographic data set found in the hospital (emergency department) - 3883 patients who had confirmed diagnoses of influenza A/B, COVID-19 or negative laboratory test results. Prognostic models were externally tested in 15,697 meetings with 3,125 patients available in the TrinetX database, which contains patient-level data from various medical organizations. The study confirms the potential of using machine learning (Artificial Intelligence) models to accurately distinguish between two viral infections [32].

And scientists from Stavropol State Medical University have developed new algorithms based on artificial intelligence to find combinations of genes responsible for certain diseases, in addition, the article talks about the developed system for predicting risks, including coronavirus, and determining the best way to treat various diseases. A new approach is proposed for predicting nosological diagnoses by intelligent analysis of the totality of results used in laboratory diagnostics of specific patients. The scientific article says that the study showed the fundamental possibility of using machine learning methods for data analysis using a common sample, subsequently divided into training and test, where diseases were included in 4 nosologies: D50 (iron deficiency anemia),

E11 (insulin-dependent diabetes mellitus), E74 (other disorders of carbohydrate metabolism), E78 (disorders lipoprotein metabolism and other lipidemia) [33,34].

Application of the Medical Decision support system ECP

According to the results of the survey, we found that the test users of the MS ECP application mainly made the following suggestions for correcting treatment using MDSS ECP:

1. Correction of antibiotic therapy
2. Individual approach
3. Rational treatment

Only 27.9% of users used ECP recommendations.

It is worth mentioning in more detail about the wishes of users (subjects) concerning individual antibiotic therapy (which spectrum of antibiotics should be used in the treatment of both COVID-19 and individual diseases), an individual approach to the selection of treatment, the production of more affordable and more pronounced therapeutic effect of medicines [35]. During the survey, we analyzed that the majority of respondents were treated with arbidol, but other drugs were also prescribed: Dostinex, bergolac, amoxiclav, etc.

Respondents used rimantadine (3%), brustan, vitamin C, ingavirin and other pharmacological drugs for self-treatment.

Comparative performance indicators of the ECP system in two groups (when prescribing a doctor and self-medication) are shown in Table 1.

Table 1: General characteristics of the purpose and efficiency of the ESP system in two groups.

Performance indicator	1st group (with ECP support)	2nd group (without ECP support)	Total
total number of identified drug interactions	30	14	44
- of them with chronic diseases	14	14	28
the total number of identified limitations to use related to diagnosis and age	18	24	42
total number of identified duplicate combinations	28	30	58
the total number of warnings that allowed the user to correct the therapy in a timely manner	68	0	68
the total number of errors in the appointment/development of side effects or complications of therapy	37	50	87
- of these assignment errors identified by the ESP system	1	33	34

As we can see from the first rows of the table, the two groups were comparable in the number of irrational assignments. However, the total number of therapy errors and complications of the condition was much more common in the second group.

In the second group, without the use of ECP (self-medication or doctor's appointment), side effects, complications of therapy, irrational combinations, polypragmasia, drug interactions were noted in 67% of cases. The respondents in this study had dizziness and shortness of breath.

The study revealed that women used the ECP application the most (70%). Men were less active, as they spend less time using applications, possibly due to the complexity of use. In the future, it is planned to improve the interface and functionality of the ECP application, taking into account the wishes of users (test subjects).

Due to the fact that clinical and methodological recommendations are updated quite often, doctors do not keep up with the release of updates of clinical recommendations of the Ministry of Health of the Russian Federation. But in our ECP medical decision support system (including in the mobile application), all updates of clinical and methodological recommendations from the Ministry of Health of the Russian Federation are taken into account [36]. In our study, it can be seen that the subjects - students of medical universities used the clinical recommendations in the ECP application.

The COVID-19 pandemic has led to changes and frequent chronic diseases of the respiratory system [37,38]. In the study, we showed that respondents in 1st place had chronic diseases of the bronchopulmonary system (7.5%), the endocrine system (7.5%) and in 3rd place was diseases of the cardiovascular system (5%).

Out of 44 respondents, 27 people were self-medicating using the Electronic Clinical Pharmacologist application, and 13 respondents – were treated under the supervision of a doctor.

6 Conclusion

As it was written above, the ESP system helps the user (in our case, medical students) in prescribing pharmacotherapy, and helps to reduce the occurrence of medical errors and complications in clinical practice. MDSS ECP allows you to provide a "bridge" between the Internet search system and the doctor, as it allows you to immediately get objective information in one place. The system also takes into account the user's personalization based on medical history, gender, age, BMI, etc. indicators.

7 Availability of Data and Material

Data can be made available by contacting the corresponding author.

8 Acknowledgement

The work was carried out using the Center for Collective Use of the North Caucasus Federal University.

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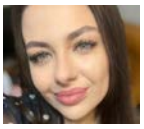

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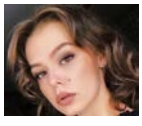

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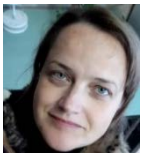

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