Telemedicine Software Application

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Abstract

Currently, hospitals and medical practices have a large amount of unstructured information, gathered in time at each ward or practice by physicians in a wide range of medical branches.

The data requires processing in order to be able to extract relevant information, which can be used to improve the medical system. It is useful for a physician to have access to a patient's entire medical history when he or she is in an emergency situation, as relevant information can be found about the patient's problems such as: allergies to various medications, personal history, or hereditary collateral conditions etc. If the information exists in a structured form, the detection of diseases based on specific symptoms is much easier, faster and with a higher degree of accuracy. Thus, physicians may investigate certain pathological profiles and conduct cohort clinical trials, including comparing the profile of a particular patient with other similar profiles that already have a confirmed diagnosis. Involving information technology in this field will change so the time which the physicians should spend in front of the computer into a much more beneficial one, providing them with the possibility for more interaction with the patient while listening to the patient's needs. The expert system, described in the paper, is an application for medical diagnostic of the most frequently met conditions, based on logical programming and on the theory of probabilities. The system rationale is a search item in the field basic knowledge on the condition. The web application described in the paper is implemented for the ward of pathological anatomy of a hospital in Romania. It aims to ease the healthcare staff's work, to create a connection of communication at one click between the necessary wards and to reduce the time lost with bureaucratic proceedings. The software (made in PHP programming language, by writing directly in the source code) is developed in order to ease the healthcare staff's activity, being created in a simpler and as elegant way as possible.

Keywords: - expert system; database; algorithms; statistics; efficiency; flexibility.

1. Introduction

Telemedicine consists of the remote communication of healthcare services, based on the use of information and communication technology, in cases where the healthcare professional and the patient (two or more healthcare professionals) are in different locations. Using the digital transformation of the gathered medical information, as described in the paper, the specified technology allows decoding in necessary formats (image, text, sound) on the patient's condition, diagnosis and treatment, and tracking its evolution. These services of consultation, monitoring, digital transmission of information for the purpose of specialized interpretation of symptoms are basically telemedicine. In the context of the strategic approach to pandemics (social distancing) this technology is crucial due to the safety and efficiency of data communication, recommended by the World Health Organization and taken over in Romanian legislation on strengthening the health system in the pandemic context triggered by COVID-19.

It is recommended to use a dedicated application for medical practice (so that data can be recorded simultaneously in both the file and the registry) or a dedicated platform for telemedicine that can ensure the registration, for a period of time, both for the patient and for the physician of the content of the consultation and data security.

Expert systems based on production rules use a knowledge called expertise from human experts in a field, healthcare experts in this case, and the process of obtaining this information is called the acquisition of knowledge. In other words, expert systems multiply and make explicit the professional experience of human experts [1, 2]. The reasoning of the system is based on the search for disease in the space of basic knowledge. In order to build the knowledge database, more interviews with the medical expert are needed [3,4]. Over time, a multitude of expert systems in the medical field have been implemented (the best known being MYCIN (*backward chaining expert system that used artificial intelligence to identify bacteria causing severe infections, such as bacteraemia and meningitis* – diagnostic of the bacterial infections [5]), however each having its set of rules. The processing power of these systems consists in the inferential engine and the explanation system they have. The basic activity of the expert system is the diagnosis and refers to the establishment of a correlation between characteristics or symptoms and typical situations.

One benefit of medical databases in electronic format is that data can be kept secure without deteriorating over time [6,7]. Also, extracting the information is much easier, the user having access to all the information without wasting time searching through the patients' files. Medical databases show various problems that arise and can affect the accuracy of reports. These need to be solved quickly, so that physicians

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can use the application correctly to help them keep track of patients, so that the reports they have to issue are accurate and error-free. Because the database is used by multiple people, the used terms differ from person to person, so this issue needs to be addressed [8].

The software developed in the paper is based on the management of medical records for at least two wards and comprises the following characteristics [9]: adding in the database the patients who were sent to the related wards, entering the personal and medical data of the patients in the database, viewing the patients registered in the database, modifying the personal and medical data of the patients, creating the forms for printing (medical bulletins) along with all personal and medical information, searching the patients' database by name, date or a certain period of time, managing the access accounts of healthcare professionals, backing up the database with a single direct click from the web application, manipulating the access level of healthcare professionals in the web application.

All the above features are managed extremely easily, in a simple and compact way, with the help of the web application. The web application uses a MySQL database and is run on an Apache server. Programming is done with the programming language PHP [10], the code which the Apache server generates, being HTML (H*yper*T*ext* M*arkup* L*anguage*) alongside with the following programming languages CSS (C*ascading* S*tyle* S*heets*) and JavaScript [11]. The commands line writing was carried out with Adobe Dreamweaver CS4, and the code viewing can be achieved with any text editor (Notepad, Wordpad). The application was developed with the help of CodeIgniter [12] framework, being an open source that required considerably to the creation of the application for fast development. The application was run on most browsers: Google Chrome, Mozilla Firefox, Internet Explorer, Safari and Opera. It behaved exemplary on all of them and did not suffer changes in appearance, deficiencies on the part of CSS being non-existent. The application was made and also tested on a computer with the Microsoft Windows operating system.

Telemedicine can help improve the quality of life of people, both patients and healthcare professionals, by providing the opportunity to respond to the challenges facing the health system. This facilitates access to specialized treatment in areas where there are not enough specialists or where access to healthcare services is difficult. Telemedicine cannot replace a classic medical examination, but it can play the role of a preliminary medical consultation, having multiple benefits for both the patient and the health professionals.

2. Expert diagnosis systems in telemedicine

2.1 Structure of the expert system

The expert systems aim to help physicians working in the integrated outpatient clinic or hospital system, as well as family physicians, while being an assistant in establishing the diagnosis. The expert general medical diagnosis system is made in an object-oriented visual programming environment, in the Windows operating system, with the possibility of extension on Android / iOS [13]. It comprises three main modules that form the so-called essential system but also the relationships between them. For the collection of knowledge about the field of the problem to be solved a *knowledge database* is developed, and for the knowledge of the way of solving the problem an *inference engine* is required (it constitutes the effective element of data input processing). The auxiliary memory, which contains all the user data and the intermediate results produced by the course of reasoning, forms the facts database. The explanatory module provides explanations regarding the reasoning used in obtaining the solution in a natural language, and the acquisition module takes over the specialized knowledge provided by the human expert through the cognitivist in a form specific to the internal representation. For expert systems based on probabilities it is required to represent knowledge with the help of the *Bayes* theorem [14,15,16,17,18].

The primary knowledge-symptoms database is granulized in order to use most accurately the knowledge. The user interface is intuitive and contains a menu system with expressive names (*"patient record", "add disease"*,…) and a toolbar with buttons for quick actions. When opening/ creating a patient record, there are two pages: "*Personal data*" and "*Diagnosis*", which switches from the bottom of the application window (Fig.1). The "*Diagnosis*" page represents the interface with the *facts database* (patient's symptoms) and the results of the diagnosis. Here the diagnosis is required after the facts database has been introduced. It comprises a *ComboBox* from which the symptoms claimed by the patient are selected, and on the right the "down arrow" button is pressed to be loaded in the list (facts database). To indicate that the symptom is not present in the patient, the character (√) is taken, with the meaning "seen" in front of the symptom. Obtaining *the diagnosis* is done by pressing the "*Diagnosis*" button.

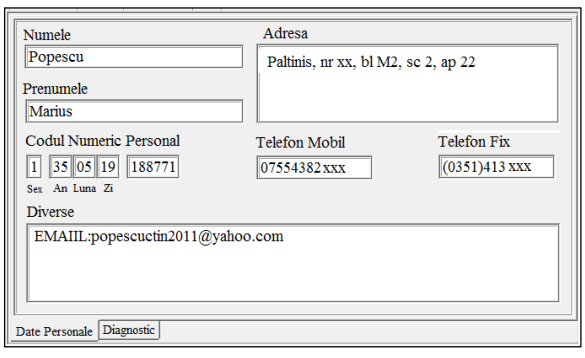

Figure 1. "Patient Record", of S*ingle* D*ocument* I*nterface* type, comprising personal data. Legend Numele – Surname, Prenumele – First Name, Codul Numeric Personal – Personal number, Adresa – Address, Telefon mobil – Mobile, Telefon fix – Telephone, Diverse- Others, Date personale – Personal Data, Diagnostic – Diagnosis.

The list of "*most likely diseases*" will show the probable conditions. If the result is not satisfactory, we continue to complete the facts database (adding symptoms) using the "*Ask the patient*" option (as before) or "*Automatic*" (the possibility to use this option is offered only after requesting a diagnosis using "*Ask the patient*"). If the "*Consult*" option is selected, we continue by pressing the "*Continue*" button. The issued form will automatically select possible symptoms. The questions asked will be answered. The answer "*Not known*" will continue to generate possible symptoms. The "*End*" button causes the recalculation of the initial probabilities of the diseases and cancels the diagnosis. The acquisition module takes the specialized knowledge provided by the human expert through the cognitivist. This *module* is activated via the "*Add Diseases&Symptoms*" menu and comprises three forms of data entry: "*Enter_diseases*", "*Enter_symptoms*", "*Enter_rel*". The form "*Enter_diseases*" allows for the introduction and deletion of diseases together with the initial probabilities (Fig.2).

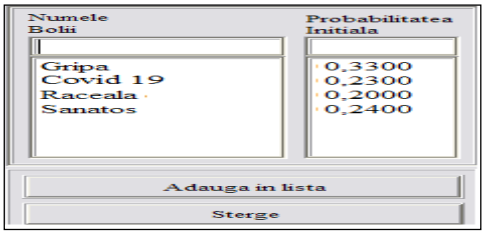

Figure 2. "Enter_diseases" Form. Legend: Numele bolii – Disease name, Probabilitatea initiala – Initial Probability, Gripa – Flu, Raceala – Cold/ Influenza, Sanatos – Healthy, Adauga in lista – Add in the list, Sterge – Delete.

The initial probabilities are calculated with the relation:

$$P(E_i) = \frac{|E_i|}{n}, \tag{1}$$

where $P(E_i)$ represents the initial probability of the disease, n represents the total number of patients who have come to the consultation so far, and E_i ($|E_i|$) is the number of patients having the E_i, disease.

The form "*Enter_symptoms*" allows you to enter and delete symptoms relevant to diseases introduced by the form "*Enter_diseases*" (Fig.3).

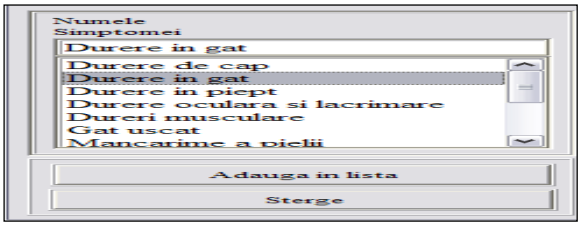

Figure 3. "Enter_symptoms" Form. Legend: Numele simptomei – Symptoms Name, Durere in gat – sore throat, Durere de cap – Headache, Durere in piept – Chest pain, Durere oculara si lacrimare - Eye pain and tearing, Dureri musculare – Muscle pains, Gat uscat – Dry throat, Mancarime a pielii – Skin itching, Adauga in lista – Add in the list, Sterge – Delete.

The form "*Association of diseases&symptoms*" allows the association of symptoms with diseases, introducing at the same time the probabilities of occurrence of each symptom to the respective disease. (Fig.4).

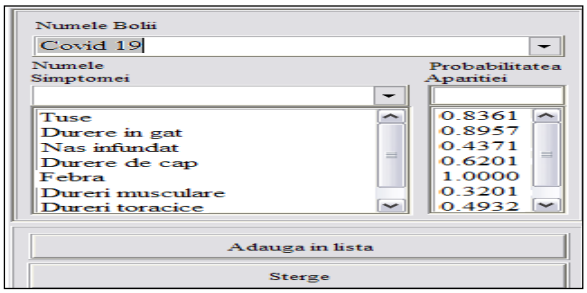

Figure 4. "Association of diseases&symptoms" Form. Legend: Numele bolii – Disease name, Numele simptomei – Symptom name, Probabilitatea aparitiei – Probability of occurrence, Tuse – Cough, Durere in gat – Sore throat, Nas infundat – Stuffy nose, Durere de cap – Headache, Febra – Fever, Dureri musculare – Muscle pain, Dureri toracice – Thoracic pains, Adauga in lista – Add in the list, Sterge – Delete.

These probabilities of occurrence are achieved by using the relation:

$$P(S_j / E_i) = \frac{|E_i \cap S_j|}{|E_i|}, \tag{2}$$

where $P(S_j/E_i)$ represents the probability of the symptom S_j occurring related to the disease E_i, event, and $|E_i \cap S_j|$ is the number of patients who, have the disease E_i event, showed the S_j symptom.

Gathering knowledge in the knowledge database is performed in two ways: manually - through the menu "*Add diseases&symptoms*" and automatically - by recalculating the initial probability after the end of the diagnostic operation (learning process or "experience"). The fact base represents the auxiliary memory that contains all the user data (the symptoms that the patient has when he presents to the consultation) and the intermediate results (probable diseases after the first interrogation) produced by the course of reasoning. The inferential engine uses both the knowledge database and the facts database and using Bayes theory calculates the posterior (conditioned) probabilities when new symptoms are known. The relation implemented in the program relies on the statistic independent of the S_j symptoms for an E_i given disease:

$$P(E_i/S_1\cap S_2\cap\ldots\cap S_k)=\frac{P(E_i)}{\prod_1^k \frac{|S_j|}{n}}\bullet\frac{|E_i\cap S_1|}{|E_i|}\bullet\frac{|E_i\cap S_2|}{|E_i|}\bullet\ldots\bullet\frac{|E_i\cap S_k|}{|E_i|} \quad (3)$$

2.2 Data description

The expert system *knowledge database* is encoded and stored in a compressed database. Data security is ensured by password-protecting the database. This database contains three tables for the knowledge database ("BC_diseases", "BC_symptoms" and "Symptoms – diseases") and the table "Patients" with personal data about patients (Fig.5).

It is possible to use a remote (networked) knowledge database by pressing the *"Administrator settings" button*.

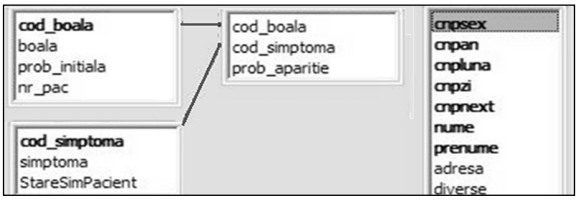

Figure 5. Tables fields and relations between tables. Legend: cod boala- disease code, boala – disease, cod_simptoma – code_symptom

The database work was carried out using activeX (ADO) data objects, which is an extension of active server page programming, supported by Microsoft's Internet Information Server (IIS) for database connectivity. *ADOConnection* is the object through which the connection to the database was made using "Jet OLEDB4" drivers. *TADOTable* is used to access a database table using ADO. *TADOTable* allows direct access to each record and field in the attached table. *TDataSource* achieves the interface between the dataset component and the data controls on the form. TDataSet introduces the basic properties, events, and methods for working with data. The expert system allows the creation of a report that will include the date of the examination, the patient's name, the diagnosis, a report that can be printed. The *TRvProject* class allows access to the visual report created with Rave. *Rave Reports* is an application built into the Delphi software development environment (visual programming in Pascal) that allows you to create reports. Delphi is a RAD (Rapid Application Development) and at the same time a database-oriented application development environment for Microsoft Windows operating systems. It contains simple design visual tools for creating from the simplest to the most complex highly customized reports.

2.3 Results and discussions

In the context of the COVID-19 pandemic, infection with the new coronavirus may be confused with seasonal flu. The symptoms are similar, the difference being that the seasonal flu is caused by the influenza A virus or the influenza B virus, and COVID-19 is caused by the infection with SARS CoV-2 (*Severe* A*cute* R*espiratory* S*yndrome* C*oronavirus* 2).

The first symptoms of a respiratory virus are those of fatigue, sore throat and nasal congestion. Sneezing and coughing are also present, as is fever, which is not mandatory. Lack of fever is a first symptom that can make a difference. It is also very important that the nasal mucus changes its appearance: from mucous, to mucous-purulent and then purulent.

Therefore, when specific symptoms occur, the only solution to find out if the condition is seasonal flu or COVID-19, there are specific RT PCR (*reverse transcription real time)* testing or specific blood tests that detect the presence of anti-virus antibodies. SARS-COV-2.

For the experiments, the knowledge database was loaded with four diseases and twelve associated symptoms. The initial probabilities, in a diagnostic case, are obtained by the cognician by processing the information from the expert (physician). *100* patients were consulted, of which: *33* were diagnosed with influenza, *31* were diagnosed with Covid19, and *16* were found healthy, and, according to relation (1), for N = 100 the following initial probabilities were obtained:

$$P(flu)=\frac{number\ \ favorable\ cases}{number\ \ possible\ cases}=0.33$$

$$P(covid\_19)=0{,}31,\ P(cold)=0{,}20\quad P(healthy)=0{,}16$$

In other words, although it provides extremely important information, the expert system, depending on the good delimitation of the accused symptoms (presented by the patient), may have an ascending efficiency in the case of diagnosis of influenza (cold) vs. Covid19 or other type of respiratory virus.

Both the physician and the patient must ensure data protection and patients must be informed about the limits of remote consultation and the need to call the practice or 112, a unique emergency number, in case of change or worsening of symptoms.

The probabilities of symptoms in the above diseases were obtained using the information from the physician (expert)

$|E_i\cap S_j|$, $|E_i|$ and the relation (2). For instance:

$$|E_1\cap S_1|=|(covid\_19)\cap(cough)|=31\ patients\ \Rightarrow$$

$$P(cough/\mathrm{cov}\,id\_19)=\frac{31}{33}=0.(93)\ .$$

The knowledge base was loaded with the four relevant diseases and thirteen symptoms [19]: cough, headache, sore throat, chest pain (thoracic pain or pressure), itchy skin (skin irritation), eye pain and tearing (conjunctivitis), muscle aches, dry throat, loss of taste or smell, stuffy nose, fever, strong cough and well felt, associated with disease. The probabilities of these symptoms occurrence in the disease were also introduced. Thus, the diagnosis process could be

started. The symptoms claimed by the patient (based on the facts) were introduced with the option "Ask the patient": "headache", "chest pain", "eye pain and tearing" and the request for diagnosis was launched (Fig.6).

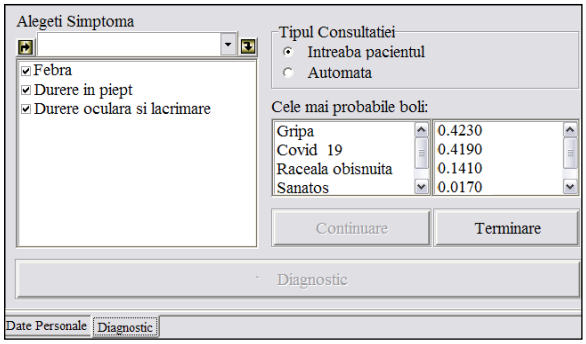

Figure 6. Diagnosis with the option "Ask the patient". Legend: Alegeti simptoma – Choose the symptom, Febra – fever, Durere in piept – Chest pain, Durere ocular si lacrimare – Eye pain and tearing, Tipul consultatiei – Type of consultation, Intreaba pacientul – Ask the patient, Automata – Automatic, Cele mai probabile boli – Most probable diseases, Gripa – Flu, Raceala obisnuita – Common influenza (cold), Sanatos - Healthy

For a more accurate diagnosis, continue the process using the automatic option. It offers two symptoms: "strong cough" and "itchy skin". After a consultation, it was found that the patient has symptoms of "strong cough", but no symptoms of "skin irritation" (the result of the diagnosis - see Fig.7). It is observed that, after the addition of symptoms, the difference in probability between the flu and the other diseases has increased, so the error in making the diagnosis is smaller..

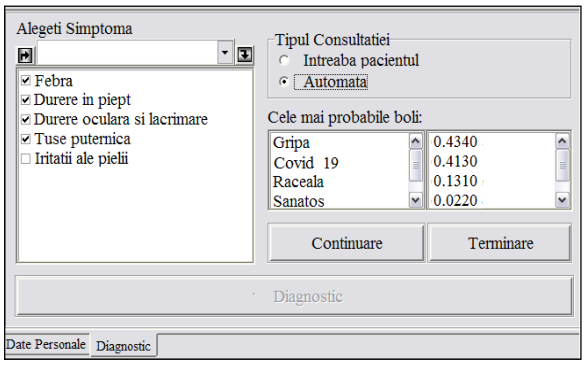

Figure 7. Diagnosis after automatic selection of the symptoms. Legend: same as figure 6 plus iritatii ale pielii – skin irritation.

Health professionals, the elderly and people with comorbidities have a high risk of COVID-19 infection. Telemedicine can help reduce this risk by minimizing face-to-face interactions, where remote medical consultations are possible.

3. Management of medical bulletins through telemedicine

3.1 Database description

The web application uses a MySQL database called "histopap_histo" (Fig.8). The database is based on efficient management and administration. The database is created with the name "histopap_bio", based on the histopathology and biochemistry practices of a hospital. The unit table contains the medical practices for which all the information of the patients within the hospital registered in the pages of the web application "add_bio.php" and "add_pacient.php" is managed.

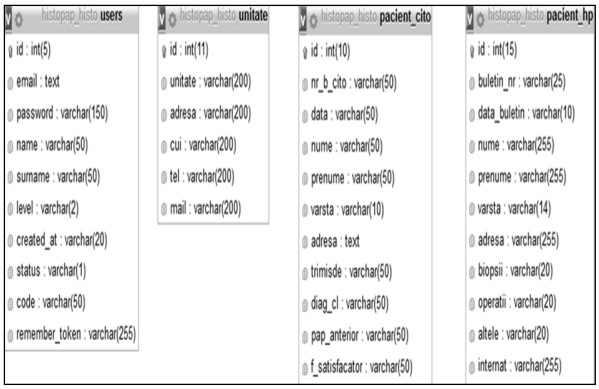

Figure 8. Concept Scheme.

The *patient_hp* table represents the patient data transferred to the histopathology ward and is managed by the "histol.php" page by the staff related to the access level in question. In addition to the fields with personal information, there are some fields essential to the medical practice that are required to make the histopathological result such as: biopsies, operations, hospitalizations, sent by (which physician sent the person to the ward), *data_send, diag_clin, lesion code* and so on). The "result" field represents the balance of all the patient's exams, representing the diagnosis on the *histopathology* ward. The *patient_bio* table is similar to the *patient_hp* table and represents the data of the patient transferred to the biochemistry ward which is managed by the "bioch.php" page by the staff related to the access level in question. In addition to the fields with personal information there are some fields essential to the medical practice that are needed to make the biochemical result such as: *hpv, hsv, am_various, mss*, specific, unit, etc. The "status_result" field represents the balance of all patient's exams, representing the diagnosis on the *biochemistry* ward.

3.2 Structure of the web application

The functions of the application are: registration of patients in the database, creation and management of medical records along with personal and medical data of the patient on the histopathology or biochemistry ward, printing the medical report after diagnosis, regular backup of the database for the private archive of the medical practices, the management of

the medical staff's access to the application according to the level of access they have. The application is divided into three branches, each with a unique folder: *Models* – manages the database, *View* – displays the data supplied by the models and *Controllers* – is the link between *models* and *view*, it receives the request, studies it, initializes it, invokes the models and send it to views. Before entering the web application, the medical staff is welcomed by a login window with the user and the password encrypted by the MD5 hash function, having the length of 128 bit [20]. In the Header section, there is the Histopathology or Biochemistry logo, which changes, being dynamic depending on the access which the user has or depending where it is in the menu, on the side of "Patient bio" or "Patient histo" (Fig.9).

Figure 9. Web application – screen management.

We find in the *Conten*t section the content of each entry on the accessed menu, but also information on patients, accounts and medical reports. Being an online application that is made in php, it uses session variables ($ _Session) to manage information between pages. At the same time, the connection to the database in MySQL must be performed. All files that are connected to the MySQL database are used by the "database.php" file.

The "slidebar" section defines the actual menu of the application, which is dynamic and divided according to the access rights that the user has. The software manages the database of two medical practices in a hospital, respectively, the histopathology ward and the biochemistry ward. The menu is divided into two categories: physician (chief physician), physician and nurse, and in terms of source code in levels 3, 2 and 1. Each login of one of these users gives the right to access only certain tabs from the menu. The physician, level 3, has access to both medical practices and has the right to manage the entire application resulting from: general information, viewing, adding, deleting and editing patients in the ward of histopathology and biochemistry, printing medical records of patients in the ward of histopathology and biochemistry, viewing, adding, deleting and editing the medical staff that has access to the web application, backing up databases. The physician level 2 is catalogued on a single medical unit, having access to only one of the wards, either histopathology or biochemistry and has the following rights: general information, viewing, adding, deleting and editing patients in the ward, printing medical records of patients in the related department. The nurse, level 1, just like the physician, is catalogued on a single medical unit, but has access only in one of the wards (histopathology or biochemistry) and has the following rights: general information, viewing patients in the related department, printing medical records of patients in the related department. Total access to this menu has only level 2 (physician), some of the tabs being restricted to level 3 chief physician and level 1 nurse. The physician has access to the entire menu developed in the web application and manages the smooth running of the activity of his subordinate staff. (Fig.10).

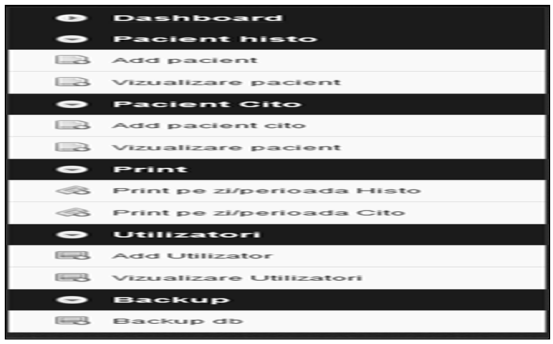

Figure 10. Web application menu.

The *Dashboard* tab represents the input content in the web application (Fig.11). Here, there are inserted the administrative data that must be taken into account when altering the information in the web application.

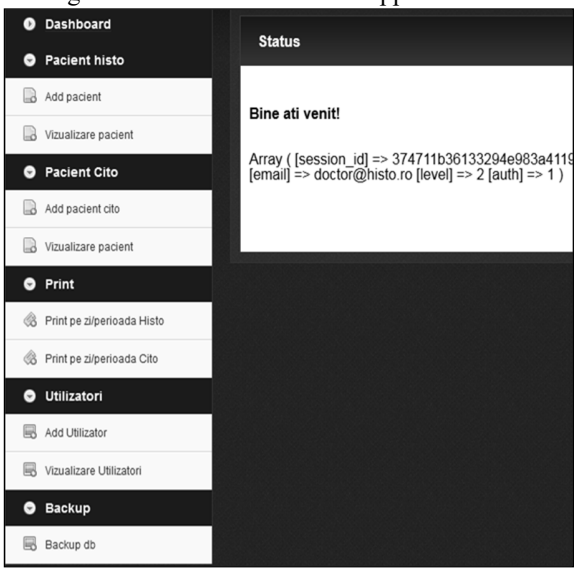

Figure 11. *Dashboard* section.

The *add_patient* subtab is based on a form like a table where the personal and medical data of the patient in question must be entered (Fig.12). Once the function validation rules have been created and the fields with the variable "required" are inserted, the "date_time" libraries must be loaded for the date, time when the form is performed and *patient_model* (patient's medical data).

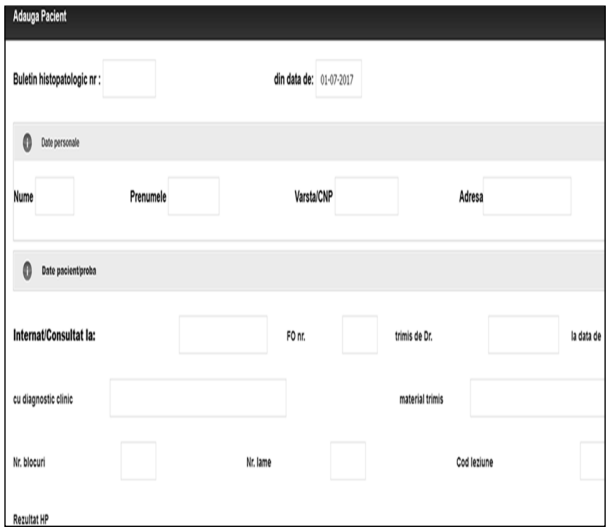

Figure 12. Subtab *add patient*, for the histopathology practice. Legend: Adauga pacient – Add patient, Buletin histopatologic nr. – Histopathology report no, din data de – of, date personale – personal data, nume – surname, prenume – first name, varsta/ CNP – age/ Personal number, Adresa – Address, date pacient/ proba – Patient data / sample, Internat/ Consultat la – Hospitalised/ Consultation at, trimis de – sent by, la data de – on, cu diagnostic clinic – with clinical diagnosis, material trimis – sent sample, nr. blocuri – no of blocks, nr. lame – no of blades, cod leziune – lesion code, Rezultat HP – HP result

The *view patient* subtab is based on a form with all the entries filled in by the physician in the MySQL database (Fig.13).

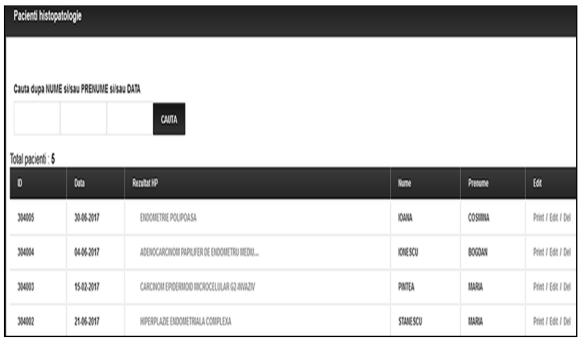

Figure 13. Subtab *view patient*, for the histopathology practice. Legend: Pacient histopatologie – Histopathology patient, Cauta dupa NUME si/ sau PRENUME sau DATA – Search by SURNAME and/ or FIRST NAME or DATE, CAUTA – SEARCH, Total pacienti – Total patients.

All this data is viewed in the web application using the files: "print_all.php", "histol.php" and "mod_pacient.php", located in the "views" folder. A form is created in the form of a table with all the fields and patient information, ready to be modified and saved by the application user (Fig.14).

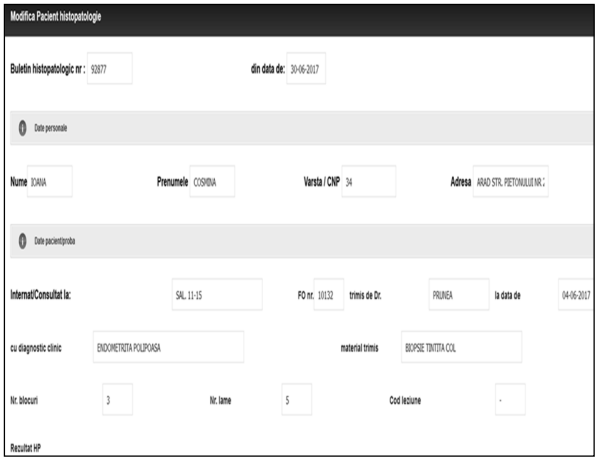

Figure 14. Change patient. Legend: Modifica pacient histopatologie – Change patient histopathology, Buletin histopatologic nr. – Histopathology report no, din data de – of, date personale – personal data, nume – surname, prenume – first name, varsta/ CNP – age/ Personal number, Adresa – Address, date pacient/ proba – Patient data / sample, Internat/ Consultat la – Hospitalised/ Consultation at, trimis de – sent by, la data de – on, cu diagnostic clinic – with clinical diagnosis, material trimis – sent sample, nr. blocuri – no of blocks, nr. lame – no of blades, cod leziune – lesion code, Rezultat HP – HP result

The *patient_bio* tab makes it easy to add, view, delete, edit and print personal and medical data of patients in the biochemistry office. The *add patient* subtab is based on a form likely to a table where the personal and medical data of the patient in question must be entered (Fig.15). The only changes are the visual ones (other medical notions, fields with other elements that can exemplify the patient's problems, medical problems) and of course the file names in the "controllers", "models" and "view" folders and the names of the functions, generally in instead of the prefix or affix *"histo"* was used *"bio"*.

Figure 15. Subtab *add pacient,* for the biochemistry practice. Legend: Adauga pacient Cito – Add patient cytology, Buletin citologic cervico-vaginal nr. – Cytology report cervical-vaginal no, din data de – of, date personale – personal data, nume – surname, prenume – first name, varsta/ CNP – age/ Personal number, Adresa – Address, Trimis de – Sent by, Diagnostic clinic – Clinical diagnosis, Teste PAP anterioare - Previous PAP tests, Calitate frotiu – Smear quality, Frotiu satisfacator – Satisfactory smear, Frotiu nesatisfacator – Unsatisfactory smear, acelular – no cell, hipocelular – hypo-cellular, fixat necorespunzator – inadequate fixation, intins necorespunzator – inadequate stretch

The subtab *view patient* relies on a form with all the entries filled in by the physician in the Mysql database, being from the point of view of the source code almost identical to the one in the subtab *view patient* of the tab patient *histo* (Fig.16).

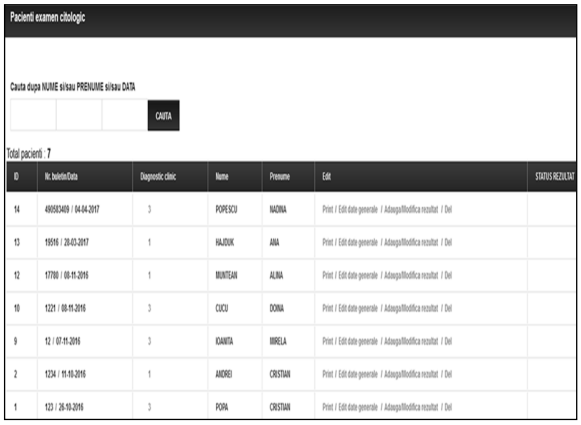

Figure 16. Subtab *view patient*, for the histopathology practice. Legend: Pacient examen citologic – Cytology exam patient, Cauta dupa NUME si/ sau PRENUME sau DATA – Search by SURNAME and/ or FIRST NAME or DATE, CAUTA – SEARCH, Total pacienti – Total patients.

The *print* tab is an easier way for medical staff to manage patients' medical reports (Fig.17). Medical records can be extracted from the database as a form, ready to be printed in two ways: after the current date or another date and for a period of days, months or years.

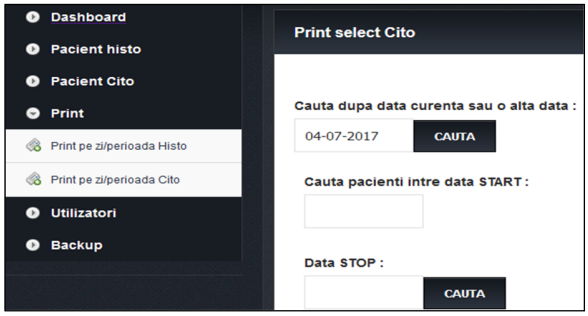

Figure 17. Subtab *Print* per day/period bio. Legend: Pacient histo – Histopathology patient, Pacient cito – Cytology patient, Print – Print, Print pe zi/ perioada Histo – Histo print by day/ period, Print pe zi/ perioada Cito – Cytology print per day/ period, utilizatori – users, Cauta dupa data curenta sau o alta data: Search by current date or another one, Cauta pacienti intre data START – Search patients between START date, Data STOP – STOP date

In both medical practices the algorithms and functions are identical, the differences being in shape, the names of folders, files and functions.

The *users* tab represents the users (medical staff) that are inserted in the MySql database of the web application. This tab is only accessible for access level 2, which is the physician. For the rest of the medical staff, respectively the rest of the users, the access is restricted. The *users* tab consists of two subtabs: *add user* (adding medical staff) and *view user* (a form as a table that consists of medical staff inserted in the MySql database of the web application). The *user add* subtab shows the same procedures for creating, communicating with the database and viewing information in the application (Fig.18).

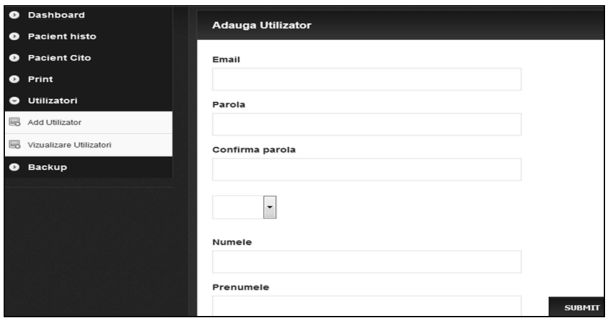

Figure 18. Subtab *add*, for the biochemistry practice. Legend: Pacient histo – Histopathology patient, Pacient cito – Cytology patient, Print – Print, utilizatori – users, add utilizator – add user, vizualizare utilizatori – view users, Adauga utilizator – add user, e-mail – e-mail, parola – password, confirma parola – confirm password, Numele – Surname, Prenumele – First name.

The *view user* subtab was also developed under the same style (Fig.19). Like any MySQL database, it needs to be archived and backed up regularly. The *backup* tab is the possibility to copy the entire MySQL database of the web application. The purpose of the copy is to prevent a disaster in the event of a server failure or mismanagement of information or even loss of information. The functionality of the *backup* is given by a simple gesture, respectively the operation of the left mouse on the backup.db subtab (Fig.20). When this is done, a window will appear to perform the save operation in a file named "histo.gz".

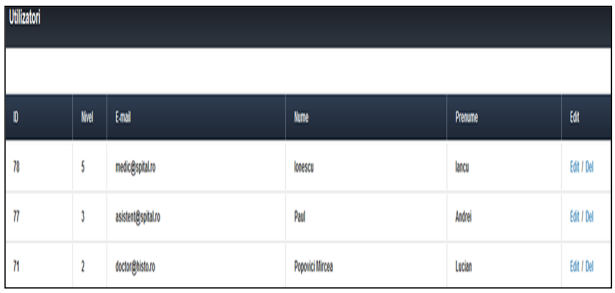

Figure 19. Subtab *view users*, for the biochemistry practice. Legend: Utilizatori – users, Nivel – Level, Nume – Surname, Prenume – First name.

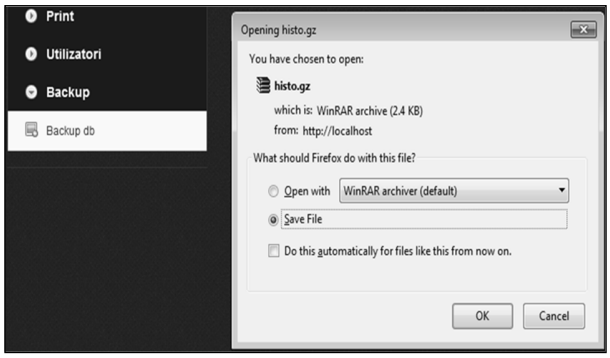

Figure 20. Subtab *backup.db.* Legend: utilizatori – users.

3.3 Discussions

The advantages of using software in manipulating histological and biochemical data of patients are cost-effective, safe, simple and quick.

Biochemistry deals with the study of the chemistry of organisms at the molecular level, and with the help of histology we study cellular morphological aspects (Fig. 21: structure of nuclear chromatin, changes in cytoplasm homogeneity, appearance of cell organelles, etc.), which occur in various inflammatory or neoplastic pathological processes.

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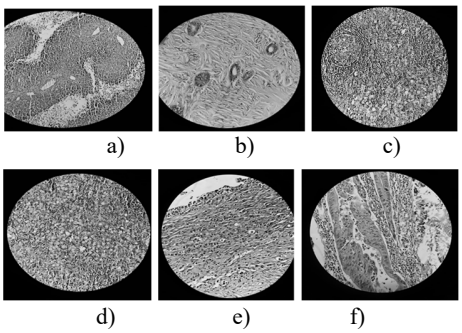

Figure 21. Cellular morphological aspects – tests that will be comprised in the application database: a) Granular tumour - ovary, b) Infiltrative ductal carcinoma - breast, c) Gastric Signet ring carcinoma d) Gastric tumour - gastric carcinoma in "Singnet ring", e) Diffuse gastric carcinoma, f) Tubular adenocarcinoma, moderately differentiated, G_2- colon.

There can be identified on smears commensal or pathogenic microorganisms, but also the local effect, resulting from the induction of an acute or chronic immune response. Biochemical examination is performed on cells harvested by specific techniques. Biochemical methods can be used as a test:

- *diagnosis* – in case of suspicion of an inflammatory or neoplastic pathology,
- *screening* – to identify the occurrence of precursor changes in people at high risk of developing certain pathologies.

In the future, the development of the application is also considered for the inclusion of cell pictures in jpeg format, so that the chief physician (level 2) and the physician have access to this information. (level 3).

4. Conclusions

Currently, in the context of the covid pandemic 19, increasing the knowledge of telemedicine experts is an objective necessity. However, telemedicine is not entirely a solution to the current crisis, but it has every chance of becoming one of the lasting "consequences" of this pandemic. Expert systems are able to respond in a reasonable time, at a level of competence with that of a physician, to problems related to symptomatology, drawing conclusions related to diagnosis. Thus, the consultation of a patient can be initiated, providing the diagnosis with the highest probability (as close as possible to 1). The application is in line with modern methods of making intelligent software tools for achieving medical diagnostic problems. Expert systems can be used by family and outpatient physicians as an assistant in diagnosing general medicine. In addition to the diagnosis, the application creates a "*patient record*" for each consulted patient. With consulted each patient, the knowledge database will be enriched, so the expert system will gain experience. The expert system can access the knowledge database stored on a server connected to the network, but with only one user at a time. It can be developed in a multi-user system for

networking, by storing the main software on a server and accessing it from different client terminals.
The second application can bring a real benefit to the medical staff and also to the patient, because it considerably reduces the time lost on a bureaucratic level and focuses on the most important thing, the patient's health. Such a system should be implemented in every medical institution, in order to increase the development of healthcare. The web application can be managed by a person without programming knowledge. All the features mentioned in paragraph 3 are entered in the MySQL database and do not require further modification. The development possibilities on the web application can be the following: the addition of more medical practices in the hospital institution (for a better communication between the related wards), the implementation of a management system on a larger scale, allowing the transfer of patients from one institution hospital to another, notifying the patient by e-mail about the results of more complex performed tests.

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