

*Medicina i tehnologija/  
Medicine and technology*

E-HOSPITAL, CHILDREN'S UNIVERSITY  
HOSPITAL IN BELGRADE AND HELIANT  
HOSPITAL INFORMATION SYSTEM

ELEKTRONSKA BOLNICA:  
UNIVERZITETSKA DEČJA KLINIKA U  
TIRŠOVOJ I INFORMACIONI SISTEM  
HELIANT

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**Ključne reči**

Bolnički informacioni sistem, elektronski  
zdravstveni karton, primarna zdravstvena  
zaštita, softver

**Key words**

Hospital information system, electronic  
medical record, electronic health record,  
primary care software

**Apstrakt**

Softver za rad ambulanti u Univerzitetnoj dečjoj klinici u Tiršovoj, najvećoj dečjoj bolnici u Srbiji, je postao osnov za razvoj bolničkog informacionog sistema i softvera za primarnu zaštitu Heliant koji u potpunosti pokriva medicinske poslovne procese u zdravstvenim ustanovama i podržava sa njima povezane poslovne funkcije. Primena ovog softvera, uz korišćenje naprednih tehnologija računarske komunikacije pruža mogućnost zdravstvenim ustanovama da uz efikasnije poslovanje i podršku radu zdravstvenih radnika pruže kvalitetniju uslugu pacijentima. Na ovaj način se u rad zdravstvenih ustanova mogu integrisati moderne tehnologije u dijagnostici i lečenju. One takođe olakšavaju internu komunikaciju unutar zdravstvenih ustanova, kao i saradnju između delova zdravstvenog sistema.

A quality HIS (hospital information system) relieves medical staff from overdoing administration so doctors can pay more attention to scientific researches and enlargement of their knowledge and skills. It improves patient treatment, enables better accommodation to particular patient needs and increases productivity of doctors and other medical staff.

Belgrade University Computer Centre (RCUB) has been involved in medical informatics since 1996. Recent projects include telemedicine, 3D visualization and complete solutions for hospital information systems. Heliant was first introduced in University Children's Hospital in Belgrade. Now, Heliant has been built in many hospitals and health care facilities, including the regional health centres in Kraljevo, Valjevo and Vranje. It has been customized for primary care centres and institutions throughout Serbia. It is based on an open source software.

Children's University Hospital in Belgrade, the largest children's hospital in Serbia, has a gigabit internal network with a large number of IP telephones and several clinical and diagnostic devices attached to it. It is connected to the NREN (National Research and Education Network) and has 1 Gigabit per second connection to the national backbone. This network is used to host the internal communication, HIS, feed of high-resolution videos of surgical interventions, remote consultation during surgery by using the newest medical

imaging modalities. The network is interactive and it allows video streaming, visualization of 3D images and remote storage of multimedia and DICOM files generated by diagnostic medical devices on a Grid cluster and Storage Area Network server located in Belgrade University Computing Centre. In this way, the NREN is being used as a testbed for access to distributed medical data, visualization, storage, and computing.

Heliant has been built around the concept of integration of patient centres using electronic medical records. The Web was the medium of choice in a heterogeneous hospital environment with many client workstations. This HIS has a sophisticated scheduling system accommodated to special requirements of the hospital and clinic treatments, which allows web interaction for incoming patients. It also supports the use of SMS messages and e-mail for the notification of the patients. It features computer supported mustering that uses pre-recorded voice sequences for inviting patients, electronic medical records with Web based access, powerful search engine and attaching mechanism for any type of multimedia file (including DICOM files) to the patient records. It also includes a mechanism for automatic opening and viewing all types of results and attachments created by diagnostic and imaging devices and provided by the local PACS (Picture Archiving and Communication Systems).

The web-based Grid-enabled Volumetric Image Visualization Environment (VIVE) is being integrated into hospital's HIS. It is an interactive analysis tool for 3D medical images, facilitating diagnosis, surgical planning, therapy evaluation and remote 3D examination. It improves understanding of complex anatomy by providing a portable and interactive three dimensional environment with simple user interface. Various virtual tools, like surfaces, cutting planes, callipers, dicers, and annotations allow analysis of various imaging modalities. The lightweight VIVE client based on Java provides user interaction and 3D rendering. It can use a special, dedicated server or it can be integrated with a Grid infrastructure, providing access to its resources. The Grid technology provides VIVE with access to storage and computation resources, data transfer, security and replication mechanisms. VIVE is also the regional Grid application of SEE-GRID initiative that joins the countries of South-Eastern Europe, with the goal of seamless integration of user communities and the Grid infrastructure being developed within participating countries.

### *DESCRIPTION OF THE FUNCTIONALITY OF THE HELIANT SOFTWARE*

The software supports many interactions between patients and health care facilities, within the health facilities and between health facilities and the Republic Health Insurance Fund (RZZO). These are some of the main applications and functions of the software.

#### *General features and outpatient management*

##### *User Authentication*

For each user in the system, a special account can be created, which is determined with a username and password. When user logs on, the software also archives information about computer from which the user logged on the system and tracks his further activities.

##### *Handling of medical records*

This software enables better communication between patients and health care providers. It improves the quality of scheduling, examining, documenting and monitoring both outpatients and inpatients.

Patient record contains all data about the patient, his examinations, hospitalizations, diagnoses, findings, case history, internal and external referrals, results of laboratory and histopathological analyses, medical procedures, operations, prescribed and administered medications, applied therapies and provided services, both during outpatient and hospital care. Among these data, the user will see only those which he is entitled to see.

Access to the patient records is provided only to the authorized users.

##### *Admission of patients*

The process of receiving booklets is realized through a series of intuitive screens through which the user passes, on spots where orientation of the patients and reception of the patients' booklets is performed.

When processing insurance booklets, search is done through home registries for the area of the local branch of the Republic Health Insurance Fund (RZZO) on the basis of the medical document, patient's name or surname, per-

sonal identification number or the insuree ID number (LBO). As a result of the search, the software displays the personal and contact data of the patient (evidenced by the user) for the first 20 patients whose personal data correspond to one of the given search parameters.

If the user notices the difference between data in the patient's booklet and the data in the system, the software user can update the personal data (name, surname, sex of the patient, LBO, personal identification number, time and place of birth, contact number), as well as blood type and medical warnings. Data updated in this step is used when generating electronic invoices, medical reports and statistical reports. The software remembers the change in patients' data history along with the user who made the change.

The software can keep records of patients who are received for medical examination even without health documents. In this case there is no control over identification number and LBO. Mandatory data are surname and date of birth.

When creating new record for a patient, the software checks if a patient with the same identification number exists and the user is warned if trying to create a patient with an identification number that already exists in the database. The software sees different records of patient with the same identification number as various individuals.

If the selected (or default) ambulance is defined during system configuration, several types of examination can be done in that ambulance and the user can choose the type of the examination that out-patients are referred to. The software user who performs admission of the patients does not have to choose the type of examination. In that case, the user starting the examination defines its type. The user who performs the referral may, among available doctors within the ambulance, choose at which doctor the examination is required. For general practice, the patient's previously chosen GP is initially selected.

After the end of the admission process, the patient appears in the list of patients who are scheduled for the day when the process of receiving booklets is done.

After patient referral, the users are offered, on the list of scheduled terms, an option to start a new examination based on appointment or insight into the patient's medical record.

##### *Appointments*

The user can specify the exact date and time for which he wants to schedule the examination, while the software, based on previously selected ambulance, type of the scheduled examination and doctor, will set the first available term. The software selects the first available term so there would not be any overlap.

After finishing the process of booking the terms, the patient appears in the list of patients scheduled for the day which the user has selected or the software has offered and user confirmed.

After scheduling, the user can also start a new examination or inspect the patient's medical record.

##### *Recording of the outpatient examination*

It is possible to configure multiple types of examination in a single organizational unit as well as define multiple forms of findings during each type of examination, independently, within each organizational unit.

For each ambulance and cabinet which uses the system, daily tabulation of patients is provided. Users who use the software for keeping records of performed services and expenditure during the medical examinations may use it independently from the users who use the software for keeping records of findings, therapies, diagnosis, etc.

The user is enabled to keep records of services and expenditure of drugs and materials, recording of findings, diagnosis and practiced therapy and other actions during the examination.

When the examination starts, the doctor can select the end time for the examination to be automatically filled with the configurable estimated duration for the given examination type. Otherwise, the examination is considered to be incomplete until the moment when the user explicitly ends the examination. Unfinished examinations are displayed on the examination list for all days from the moment when they begin until the moment when the end time is set.

#### *Recording of the findings during outpatient examinations*

When a doctor starts an examination by selecting a patient from the list of scheduled examinations, a page for entering typical data during the usual examination is provided. If the default finding type is not set, then the doctor is offered a choice of all types of findings which can be recorded during the examination. After a simple selection the list of items of selected finding is opened. Examination types and ambulance examinations can be configured in each ambulance independently, according to the needs of the health care institution.

As for the items of current entry, they can appear as text fields of various sizes, fields for entering numerical values, selection lists with arbitrarily defined elements, yes / no selections and optional checkboxes. The names and order of input items are configurable.

While recording the findings, the user could also be shown a configurable number of previous findings of the same type on the same page, for easy insight into the previously recorded medical data about the patient.

Apart from arbitrary number of types of the findings during the examination, which are filled and electronically stored in a well structured form, a number of templates for document which can be printed from the system can also be defined for each examination type. During the customization of a document template, one could determine in advance which of the data entered within forms is to be shown in the generated document along with patient and doctor data. A single document can even automatically include the data from several input forms. The produced documents can be refined by doctors and printed whenever it is necessary to produce the paper documents based on the data accumulated within the system.

#### *Recording of the services provided and the expenditure of drugs and materials during outpatient examination*

An arbitrary number of sets of the services, drugs and materials can be defined for each ambulance, which enables faster and easier tracking of a larger number of services and expenditure of drugs and materials. The order of these sets, as well as the order of items within each individual set can be configured for each individual ambulance according to customer requirements.

The user can also keep record of services, expenditure of drugs and materials during the examination by searching

through the lists of services and products by a code or a part of the name. Time and quantity of the expenditure is recorded along with optional notes.

#### *Recording of the diagnosis and prescribed therapy during outpatient examination*

Diagnoses entry is enabled only for the users with certain authorization.

When making a diagnosis, a search can be made through ICD-10 (International Classification of Diseases) code list by diagnosis code or a part of the name in Latin or Serbian.

Diagnoses can be characterized as chronic, and in that case they are shown during each of the following examination.

When making a diagnose, the user is shown a configurable number of previous diagnoses which can be reused from last examination very quickly. It is also possible to search for old diagnoses of the patients by date.

Medication administration is facilitated by search of medications entered into the software by generic or branded names. If the desired medication was not found in the code list, the user can enter the name of the medicament and enter a therapy outside the code list. Application of such medication will be recorded in the software and shown in patient file, but the data about such specific medications will not appear in statistical reports.

During the therapy prescription, the user can, among current diagnoses and ones set during the same examination, select a diagnose for which the therapy is applied. The user can prescribe therapy application in the most appropriate way, for example in equal doses by terms, different doses by terms, application when needed, or every few days. Also, the user can record the specific treatment-related notes and the therapy duration. Therapies, for which the end time is set, are shown during every examination in the time between the beginning and the ending of the therapy. Therapies which end time is not set will be visible during every of the following examination until they are ended.

#### *Recording of therapy applications*

Time of the provision, provided quantity and, if necessary, note can be recorded. The recording of application for the recorded therapy is possible only when this therapy is still active.

For the purpose of electronic invoicing, in a case when the doctor did not administer the therapy, nurses may be enabled to record the diagnosis, services and expenditure resulting from the therapy administration. However, administration can be recorded only for a therapy that is currently active. This record contains the time of the administration, quantity and, if necessary, a note.

In every recorded therapy administration in the software, the username of the user who recorded this provision is kept as well as the time of provision. The user can set current time or time in the past as the time of the administration.

#### *Recording of the provided services and the spent material*

One of the most important features is that the software can record of all the services and expenditure of medicines and materials. This enables the health care provider to keep track of all the expenses, which in turn simplifies the

communication with the insurance fund. Lists of committed services and spent medicines and materials can also be printed at any time.

#### *Management of medical supplies*

Maintenance of the data about stocks of the products tracked in the records of applied therapies and expenditures of materials and medicines is realized. Products are divided into several categories according to prescription and administration modes.

For each product, a record must be kept on the factory name, country of origin and size of the package. Also, it is able to put data about the official RZZO code, JKL (medicine classification of the Republic of Serbia) code, ATC (Anatomical Therapeutic Chemical Classification System) code, the type of packaging, two possible measurement units, bar code of group and individual packaging, the internal product code, external product code, generic product name, regime of issuance and permitted daily dosage. Two different measurement units for application and expenditure can be defined for each product.

#### *Hospitalization*

Admission to inpatient treatment and opening of the patients' case history

The process of receiving patients to inpatient treatment is performed through a series of screens provided to the user with necessary permissions.

On admission, all patients referenced to inpatient treatment by the doctors in ambulances are shown and it is possible to search through the registry of insureds for the local branch of the RZZO if the patient was not previously scheduled.

It is necessary to indicate the regime of care when admitting the patient (if it was not entered by a doctor who hospitalized the patient) and enter the data required for printing the law regulated forms which are partially filled on admission (history of disease, report of hospitalization, registration form, bill for treatment). The unfilled parts of these documents are to be filled during the discharge.

The software automatically keeps the admission protocol and allows its printing for an arbitrary period of time.

#### *Collocation of the admitted patients*

The collocation of the admitted patient usually has to be noted when the patient physically arrives at the inpatient department. Depending on the inpatient ward workflow, the system can be configured to skip the step of patient collocation.

The process of completion of the patient admission includes defining the regime of care and specification of the room and bed number at the department to which the patient is admitted.

#### *Flow of hospitalization*

The software allows tracking of the flow of hospitalization through recording of the consultations, produced documents, examinations, diagnoses, therapies, and provided services.

#### *Recording of the examinations at the department of hospitalization*

During the inpatient treatment, the user can record performed examinations. Examinations types which can be created depend on the role of the user and the department

where the patient is hospitalized. The list of possible examinations and procedures during hospitalization can differ from department to department.

Files of different format can be uploaded and added as attachments to the hospitalization records.

#### *Updating the regime of care during the hospitalization*

During the hospitalization, the patient is assigned one of three care regimes (standard regime, semi-intensive care and intensive care). It is possible to change the regime by a simple selection of a new regime, as well as to move the patient to another room or bed.

#### *Vital signs and temperature/therapeutic/dietary list (TTDL)*

Entry of the vital signs, prescribed diet, printing of the temperature chart with therapeutic and dietary lists for any given period of time are all supported. During the vital signs recording, the user also enters the time of measurement.

#### *Recording of required and performed consultations*

For the patient who lies on the department, the user may seek consultation with a doctor from other departments. When requesting the consultation, it may be indicated that it is urgently needed. The doctor assigned to the department where the consultation was requested can see the required consultations and schedule and start such a consultative examination.

Recording of the examinations, findings, diagnosis, applied therapy, provided treatment, services and spent materials during such consultations is done in the same way as during inpatient examination.

#### *Keeping records of surgical procedures*

Authorized user can request a surgery for a hospitalized patient by selecting the necessary procedures. Based on the list of requested operations the user with adequate authorization can create and print surgery programs for operating rooms.

Keeping records of performed surgeries is simple and intuitive. The selection of the operating room where the surgery was performed, the type of the surgical procedure, along with the start and end time of the operation are mandatory.

Upon finished operation, the user can record operational findings, operational lists and other relevant data sets. All participants of the operation can be noted as well.

The software allows recording of data of a sample taken for histopathological analysis. In order to record a sample, it is necessary to choose a laboratory in which the sample is sent, enter the time when the sample was taken, select the type of the sample and requested type of analysis. After recording the sample collection it is possible to print referral for histopathological analysis.

#### *Discharge from inpatient treatment*

The user can discharge the patient from inpatient treatment. When discharging, it is necessary to enter the data which are needed for printing of the law regulated forms on discharge (history of disease, report of hospitalization, registration form, bill for treatment).

Upon the discharge, calculation of the price of performed medical services and spent medical items is done. Services implied by duration of the hospitalization are recorded automatically based on the length of stay of the patient for the inpatient treatment, branch of medicine and care regimes.

### *Supporting features*

#### *Internal pharmacy*

The software supports managing of the distributed internal pharmacy where individual workers have strictly defined permissions (entering the initial stocks, admissions, returns, log of internal production of medications, requisition, issuance to departmental pharmacies, entering delivery notes, write-off, inventory, correction of stocks). With multiple internal pharmacies in different locations, materials can be transferred between them. Within the central pharmacy, the software can also generate requisitions of the materials from external suppliers.

#### *Laboratory*

During the examinations and hospitalization, doctors can schedule patient appointments (for inpatients) and laboratory analyses by selecting tests from predefined set of tests which are done in the hospital laboratory. A referral for laboratory analyses is generated automatically at the end of scheduling.

Tests, i.e. analysis that can be done in the laboratory, are grouped in the so-called batteries and usually only one sample per battery is required. For each analysis, the patients for which the analysis was required, but the samples were not taken, can be listed separately.

The software automatically records data about the user who recorded the sampling. A sample number and a sample receipt number can be assigned to the sample.

Automatic sending of requested tests to the laboratory devices, as well as receiving the final results is possible and it is supported for many common devices. If the laboratory device is not integrated with Heliant, results of the analyses can be manually entered into the provided forms.

The software allows automatic recording of provided services and spent material for invoicing to RZZO when the results of the analysis are saved.

#### *Scheduling between institutions*

It is possible to schedule an examination from other institutions (usually primary care) if there is a network connectivity and if it uses a system that communicates in accordance with the HL7 standard.

#### *Statistical reports*

The software can produce reports on any data entered during the work process as PDF and XLS documents. All mandatory and many other optional, but useful, reports are already provided.

#### *System configuration*

The system administrator can maintain the organizational structure, add, delete and adjust the organizational units and employees. The administrator can configure the system – set the types of examinations, hospitaliza-

tions, operations, diagnoses, associate types of examinations and hospitalizations with organizational units, define data input sets available during the examination and hospitalization, define items of current entries, define documents available during the examination and hospitalization and define sets of services for organizational units. Also, the software administrator can assign roles which determine permissions for user actions.

#### *Checking the rights and safety*

Control of the assigned roles and permissions is done for each user and during each action in the system. Alongside the roles, additional direct rights can be assigned to individual users.

When changing the data, old values will remain recorded (in accordance with the EuroRec 2008 criteria). For all entered and changed data, a record is being made about the user who entered or modified data, and the time when this action was performed (in accordance with the EuroRec 2008 criteria).

The software is implemented so that data is deleted only on the logical level - after deletion, the medical data will not be visible to users, but it will permanently remain in the database.

## *CONCLUSION*

Heliant helps health care institutions in providing a better service, which leads to having satisfied patients.

Detailed record of the provided treatments helps in performance and expenses control, thus enabling higher health care standard, which will cost less.

Its ability to provide an electronic medical records and scheduling between health care centres simplifies and unburdens the communication between the health care organizations and other institutions. Accessibility of information collected through this (and other similar information systems) brings the opportunity of better insight and fast track for health care insurance funds, regulatory institutions and epidemiological institutes.



*Video streaming during operation at Children's University Hospital in Belgrade*