Review article/Pregledni rad

HL7 Functionalities in RIS/PACS/ HIS System Integration

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Abstract

Availability of data is a leading factor for the development of society. Science and technology improvement contributed to modernization of information transmission and availability systems. All areas of life are covered, including health. As a basic field for social stability, it was necessary to determine precisely the organization of every individual step in communication into any healthcare institution. Considering diversity and the amount of data, the development of unique transmission standards faced all sorts of problems. However, with the emergence of HL7 and DICOM standards, data became properly structured, thus successfully avoiding obstacles to general availability. When enrolling a patient, demographic data stay permanently recorded in the information system for medical planning and testing with the identification of obtained results. Workflows within individual departments and financial management of healthcare institutions also belong to the options of HL7 standard participating in setting basic conditions for everyday work. Enrolling all clinical data in formulated form contributes to assistance in the diagnostic and therapeutic process, and it presents key data for medical research. Software platform of complete health data integration is a fundamental precondition for the use of artificial intelligence within individual workflow for every clinical department and institution. Furthermore, integration allowed the patient access to primary medical data to establish quality and efficient cooperation. The final aim of this work is to present primary information exchange process through the HL7 standard because of overall improvement in the quality of work within healthcare institutions.

Keywords: functionality, HL7, HIS, PACS, RIS

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Introduction

Progress of medicine and technology in the middle of the 20th century resulted in an increased number of information about patients, so it has become necessary to organize and systematize data to be effective in the accomplishment of correct diagnosis. With the development of informatics, previous system of archiving data with manual writing on paper is replaced with digitalization of data, enabling bigger capacity for collecting data with extra availability and efficiency. The foundation for the use of information and communication technology has been constructed inside medical imaging diagnostics because of easier archiving and availability of medical pictures, which had been a problem until then because of the huge dimensions and quantities of materials in complex tests. Administrative data in the form of demographic data and opinions of radiologists are exchanged and archived in RIS (*Radiology Information System*) [1]., A combination of systems has created HIS (*Hospital Information System*) to easier exchange of important medical documents between departments. It was very important to coordinate diversity of administrative data to avoid misunderstanding on patients damage. The solution is the software of communication with a standardized structure, HL7 (*Health Level 7),* for collecting important clinical, administrative and financial data while participating in the complete functioning of a healthcare institution [1]. Medical pictures are organized inside PACS (*Picture Archiving and Communication System*) to exchange and store digital images with corresponding communication protocol [2].

The connection between information systems in healthcare institutions, with standardized communication protocols, form the main condition for use of artificial intelligence (AI) in diagnostics and therapy. Initial idea was the project of comprehensive diagnostics to connect different medical data and helping healthcare staff in diagnosis, but because of inappropriate Information technology (IT) infrastructure, the project failed [23]. The AI found application in digital image analysis and based

on that, a software called RADIOMICS was formed, with quantitative analysis of every picture parameter. Special use of the RADIOMICS can be found in nuclear medicine for tumour heterogeneity [25].

Methods and procedures

Functionalities of HL7 standard in RIS system

Radiology information systems are an indispensable part of the complete information system of healthcare institutions and participate in work as individual items or in integration with the hospital information system. Elementary data about patients stay permanently preserved during medical exams and participate in further planning [1]. Thanks to HL7 standard communication between modalities or between HIS and RIS is arranged; therefore, it is possible to exchange important medical documents as specialist opinions, ordering and material consumption with reports about quality control of modalities and work [2]. Every functionality of HL7 standard in RIS is described in the following paragraphs. Visual representation of listed functionalities is shown in Figure 1, under the paragraphs.

Ordering, registration and schedule

The basic item of patient reception to a healthcare institution is registration, where identification data is entered for the further protocol of ordering patients and creating schedules with organized individual appointments [3]. Most common mistakes caused by a period of exam or wrong coding can be corrected with precise organization of schedule and a systematic categorization of radiology exams [3]. The system automatically sends notifications on changes inside schedule and ordering [4].

Demographic data and admitting of patient

Identification data enrolled during registration consist of demographic data important for regular access to the exam. Common mistakes such as change of last name or wrong input on demographic data are possible to avoid with careful input of data or using new software upgrades of the standard [3]. In addition, confirmation of appointment is important for checking the reliability and further forwarding on modality [3].

Monitoring the workflow of exam

A radiology exam is a complex procedure that starts with a schedule that consists of detailed, organized appointments of patients. Demographic and image data are forwarded in a system because of writing the specialist opinion [2]. After arrival and confirmation of the patient, data is sent on modality. Next is an activation of the beginning of the radiology exam, and after activation, radiologic technologists can properly do the requested exam. Radiologic technologist confirms completed radiology exam after the procedure [3]. Extra function inside the system is the option of cancelling the procedure to inform radiologic technologists about changes in schedule with different appointments and periods of radiology exams [3].

Specialist opinion

After the completed exam, image and demographic data are sent on the RIS/PACS system, where the radiologist can see images for further professional analysis [1]. The standard way of image analysis consisted of recording voice analysis of anatomy and pathology and manual writing in the system. This impractical way is replaced with software that directly transforms voice opinion in a textual form which is directly sent in the radiology information system. This way results in reduced time for radiologist analysis of images and increased efficiency of exams [3].

Finances and administrative checking of workflow

An healthcare institution consists of medical and administrative parts. The medical part consists of complete healthcare staff which performs medical procedures based on clinical protocols. An important role of the administrative parties is to check workflow in the number of completed exams and their periods to evaluate the efficiency of individual procedures along with material consumption [3]. The purpose of the administrative part is economic and juristic stability with the compatibility of all income and outcome in order to secure the persistence of institutions according to regulations and laws [4].

Quality control

Everyday use of modalities during radiologic exams creates a need for quality control of all workflow parameters. Quality control is performed by achieving optimal results important for the diagnostic value of medical digital images. Critical results obtained by regular tests must be reported to the department for quality management. With quality control, it is important to control the dose of radiation which has multiple functions in quality of images and radiation protection [3]. Negligence of results has serious consequences for patients and healthcare staff.

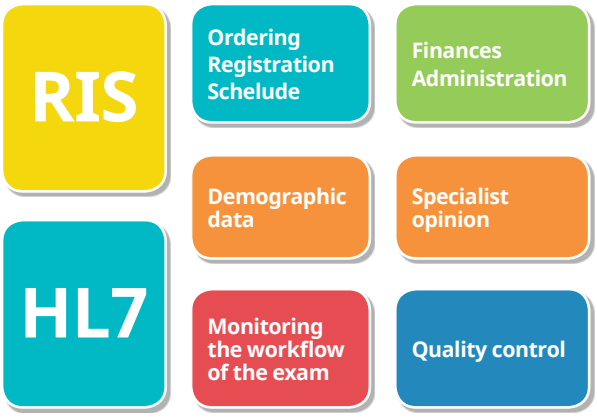

Figure 1. Schematic view of HL7 standard functionalities inside RIS. *Source: Author*

Using HL7 standard in RIS/PACS integration

Development of digital communication networks has a significant impact on increased collaboration between departments. Although, different departments had used

specific systems with characteristic content of messages, particular for individual departments. Systems without integration become useless parts of the protocol which constantly come to deficiency of key information about patients important for the procedure [1]. The problem is solved with the foundation of a workgroup between HL7 and DICOM (*Digital Imaging and Communications in Medicine)* to connect administrative and imaging standards. Further collaboration HL7 with IHE (*Integrating Healthcare Enterprise)* created the foundations for regulating all HL7 possibilities inside information systems in the form of protocol for every procedure. First HL7 version 2 created arranged segmented messages, then HL7 version 3 created shape for various information and finally whole integration in FHIR structure (*Fast Healthcare Interoperability Resources)* [3].

HL7 version 2 and HL7 version 3

The hierarchical form of segments in message structure is important because various types of data describe special content in messages. If there are one or more segments in a message it is necessary to use the term,, brackets" which amplify the meaning of the message. In order to achieve integration with DICOM format, there are some options like Date, Time, First Name, Last Name, Address, Name and Identification Number of the organization that should be written [5]. With upgrading of software platforms segment form of message is replaced with a form of modelling every profile depending on message content. Development of RIM ˙(*Reference Information Model)* brought characteristic models for individual departments based on user function and message content. Next is CDA (*Clinical Document Architecture)* with a similar structure but more advanced and faster version of HL7 version 3. CDA allows more availability of searched information depending on the function. Additional options inside CDA are common vocabularies as SNOMED CT (Systematized Nomenclature of Medicine-Clinical Terms) and LOINC (Logical Observation Identifier Names and Codes) which enhance and facilitate understanding of medical procedures and helps administrative staff in checking and charging completed procedures [5].

Workflow details inside integration Planned workflow

Work in the radiology department is an organized complex which consists of ordering, making a schedule, image data acquisition, archive and exam. Every part is explained in detail to reduce the possibility of mistakes during requested exams. Possibility of mistake falling on the minimum and mostly it is user mistake. Structured work will noticeably reduce patient inconvenience and make further planning easier. Control of every part of work can result in improvements for increasing the quality of the whole procedure. Duration of the procedure is decreasing, which improves the number of exams, efficiency of completed procedures and decreases expenses. The final product is the improvement of healthcare institutions' economic and clinical features [6].

Convergence of patient data

Identification data such as name, surname and ID number is present since registration to treatment and therapy planning. It presents necessary options for creating and following medical documentation of patients. They decrease mistakes, complete medical documentation, and avoid misunderstanding [7]. There are many options for enrollment of identification data, and they will be more detailed in future.

Workflow of image analysis and specialist analysis

Every step after image data acquisition is orderly controlled and organized thanks to the HL7 standard, which provides a worklist, status and final results of following every task in image analysis. Orders in image analysis are quality control, image reconstruction and CAD (*Computer-Aided Detection).* Process control increases efficiency in the schedule of image analysis tasks, which provides less effort for radiologic technologists and radiologists. Additional advantages are securing personal data and images while doing statistics about the number of completed procedures, their period and medical material consumption [8]. Parts for following orders in specialist opinion stay the same as parts for image analysis. Orders for specialist opinion are dictating, transcription and correction checking. Again there is noticeable less time and effort for healthcare staff. Every patient information with identification data and image material in DICOM is then archived in RIS/PACS where radiologists can provide professional opinions [9].

Workflow inside the alignment of input data

It is essential to align demographic and image information in a usable form for user usage. Whether digital or printed form, it is important to examine using the DICOM format of a digital image with structured demographic data to avoid possible misunderstandings. After information format checking and fulfilling the demand for the wanted procedure, it is necessary to archive the document. The software creates a copy of the document with corrections, reducing the possibility of mistakes and saving a copy for further use [10].

Workflow for image acquisition data of mammography

Mammography is a radiological diagnostic method for breasts examination with a special de vice that uses ionizing radiation. The importance of protocol for this exam is unquestionable because of the complexity of breast anatomy to achieve high-quality diagnostic images for further use and analysis [11]. Examination of technical properties such as identification data and matching marks participates in extra checking to avoid misunderstandings. Therefore, it is important to align the appointment schedule and archive to have a complete insight into full exam characteristics. Interpretation stations always receive original images and, if necessary, return them for corrections. That contributes to minimal mistakes, increased care for patients, improved workflow process, and finally reduced period and economic expenses [12].

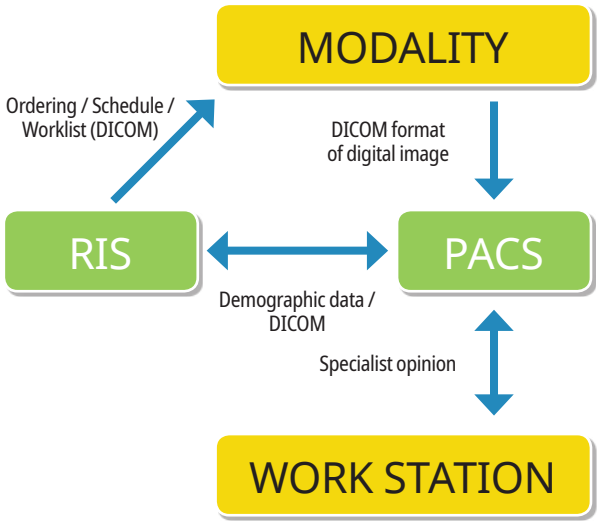

Figure 2. Schematic view of HL7 and DICOM characteristics respecting IHE rules inside RIS/PACS integration *Source: Author*

Functionalities of HL7 standard in HIS system

HIS connects all administrative, medical and financial departments inside one healthcare institution. This way of organization secures categorization in information systems on operational data, management data and clinical data with matching departments to avoid misunderstandings and data loss. Operational data cover care for patients, fulfilling everyday tasks given by schedule, following movements of patients by departments and procedures, control over material consumption and bed occupancy. Management data is statistical, and it comes down to the number of completed procedures, the average stay of the patient, economic incomes and outcomes and application of medical novelty inside the clinical practice. Clinical data is crucial for helping to clinical decisions, which represent guidelines for planning further medical procedures. That is the reason for precise entering clinical data to make the function more useful. Of course, function is only for direction, the final decision depends on professional opinion and experience of the physicians. The IT department is responsible for security and privacy of patient personal data, regular services of information systems, elimination of technical problems and connection between all individual systems in hospital [13].

Key HIS elements

One of the foundations of successful communication between departments is demographic data which stays permanently written in the system through registration. Every department has a specific user interface with matching actors, which must communicate with matching actors of the HIS. Harmony between actors is constructed by arranging IHE rules for the availability of demographic information [13]. First, the nurse enters patient data about height, weight, vital signs. The central system of orders allows ordering exams on different departments, making it easier to follow the workflow of procedure, material consumption, and payment [13]. HIS collects information from special devices for clinical data like laboratory tests or scanners for hardcopy documents. Electronic cards made demographic information and health insurance more available for administrative procedures [13]. It is vital to mention PDA (*Personal Digital Assistants)* as help in educative communication between physicians and patients [13]. The PDA is a software platform with specific health data where patients can consult with physicians about the disease. Also, a physician can refer to further medical procedures through this platform. All these functions are part of the software, so it is necessary to mention hardware that consists of modem, switches, cables and other tools for control over the network. To secure a network, it is important to create firewalls to prevent unwanted intrusions [13]. On the other hand, management has special tools for economic reports and procedures. The last key elements of HIS are information portals. Physician and nurse portal allows ordering, view of vital signs and results of completed medical procedures. Nurse portal participate in patient care, diagnostics and implementation of clinical data with their evaluation. Patient portal has options of e-visit, option to send e-mail and access to education material [13].

HIS architecture

The foundation of every HIS is core. Functions inside core share on specialty management and clinical departments. Specialties make important individual diagnoses or procedures while departments focus on the delivery of medical material or similar health administrative services. Special part is the system for archive and exchange of medical images PACS because of the special image format and tools. Mostly, it stays individual or shares a graphic interface with HIS through RIS because of data about orders, results and payment. Data archive is an important part of the system where much patient data is saved, and everything is available at the user's request. There are some components in HIS which must be mentioned. First is the function that helps the management department view critical results for the business. There are indicators for quality work in the form of death percentage or percentage of complications and infection to individual procedures. It is relevant to mention the function that helps physicians in clinical decisions. The function consists of passive and active forms. Passive informs physicians about contraindications in drugs or in some procedures while active has application in units of intensive care where shows abnormalities in heart work or breathing [13]. Registration of patient is done by function ADT (*Admission, Discharge, Transfer),* which is responsible for structured enter of demographic data. It allows a view of patient admission or discharge status with reflection on bed occupancy. Physician is responsible for entering procedure results in the system. After procedure and results, it is necessary to charge healthcare services. After submitting a request, health insurance organization must check all conditions of request with health insurance policy and then decide [13]. Finally, there is smart periphery that can measure blood sugare or vital signs and send results directly in HIS [13].

FHIR

Inconsistencies of health data created difficulties in deficiency of key information about the patient in medical documentation. Problem is solved thanks to API (*Application Program Interfaces),* thus enabling a connection between medical images, workflow and clinical data. The previous *message-based* system was replaced with a *service-oriented* system which allows user clearer data on request. Characteristic of this platform is the World Wide Web Consortium, which through searching, editing and deleting messages enables specification of request without searching entire medical documentation. The main base of this platform are *resources* that make up the specific type of information on user request. This system works on principle of putting patient in center of "*patient-centered approach"* where it is possible to connect clinical data with image material through ID number of the patient [15].

Administration

The administration module presents demographic and other administrative data about the patient, which the patient himself amounts to a competent person and enters data into the system. If some other person is authorized on a patient account, it is necessary to enter that person's data. There is some data about the location and name of the organization that provides healthcare services that must be entered in the system. The name and function of the physician are a relevant part of the data in the system. Every organization must have listed services it provides. After successful patient registration, it is necessary to create a schedule based on the period of exams, healthcare staff, and technical specifications about modality. The patient must be informed about the appointment and provide an answer about acceptance or rejection of the appointment because of work organization. An additional option is a technical description of the device and material consumption. Every part of the administrative module is important for upgrading the department's entire work quality and the healthcare institution [16].

Clinical module

Clinical data presents a base of complete medical documentation of patients. Precise entry is crucial to get a comprehensive insight into patient's health state to make diagnosis and therapy more accurate. It is necessary to enter allergic reactions to avoid complications. A special part of the module is family medical history with completed procedures. Plan of care presents multidisciplinary areas that include physician, nurse, pharmacist and other medical disciplines. The main task is a detailed organization of all procedures and professional consulting for the purpose of successful planning during illness. Condition for a successful organization is assembling a professional medical team that will regularly note clinical observations and contribute to the realization of the set goal. Impacts of drugs on patients must be noted to avoid new medical problems. Evaluation of risk is part of the module for predicting disease progression, the risk for individual chronic illness based on lifestyle or family factors [17].

Diagnostic module

Observations are one of the most critical resources in this module. Presents data given by measuring vital signs or other observations during starting evaluation of health state. Next is a resource where diagnostic tests or exams data is entered into the system. The following resource contains requests for a medical procedure, treatments and operations. Progress of software allows enter of audiovisual data as recording and images. That opened access to radiologic images in DICOM format by one or more radiologic modalities. Extra possibilities include the description of the biological sample on a molecular level and anatomic localization with particular anatomic regions exposed to medical testing and exams [18].

Drugs

Issuing pharmacologic therapy is a complicated process with several steps. First, the physician sends a request for a drug to the pharmacy to secure safe delivery. Next is issuing the drug to the patient according to the given instructions and documentation of the received drug. After a specific time, it is possible to check the consummation of the drug with a family member or patient. It is necessary to enter the name of the drug in generic form and their interactions, contraindications and other elements. Immunization is part of the module where the name of the received vaccine, recommended vaccine and later evaluations on the vaccine are entered [19].

Financial module

The financial module manages expenses, financial transactions and charging all possibilities of the healthcare services provider. Extra possibilities are acceptability, searches and charging between healthcare services provider and insurer. In the end, it is necessary to present reports about completed economic services between insurer, subscriber and patient. The main resource of the financial module is the bill as the main tool for tracking transactions in the form of charging medical procedures or having a view on the incomes of healthcare institutions. Structured charging is done by sending a request to check insurance policy characteristics. The insurer then sends an answer about the acceptability of requested terms and then details about charging requested services [20].

Workflow

Balance of medical procedures between different departments is achieved with the help of a module that forms workflow consisting of infrastructure, schedule and performed medical procedures. Infrastructure is responsible for creating workflow architecture with necessary steps for goal fulfilment and creating a schedule. Clinical procedure forms request for medical services and defines the activity of performance. The planning procedure consists of requests for using medical devices and requests for using medical material [21].

Clinical judgment

The purpose of clinical judgment module is appraisement of clinical knowledge in the form of rules for the function of clinical decision support, health control measures, public health indicators, groups of orders and clinical protocols. Coding of clinical protocols contributes to integration in different information systems that become active for sharing and evaluation. There are necessary procedures of the logic of expressions for successful functioning, defining resources and artefacts of knowledge with special software [22].

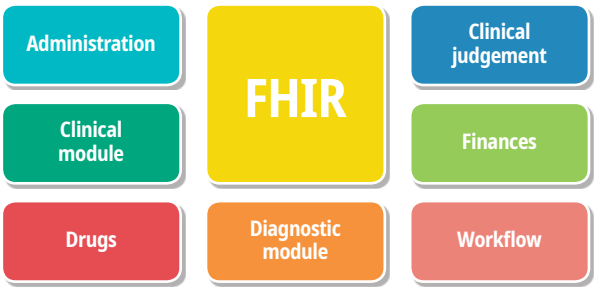

Figure 3. Schematic view of functionalities in FHIR platform. *Source: Author*

Discussion

Using artificial intelligence in HL7 standard and image analysis

Digitalization of medicine allows upgrading software for collecting image data which opens many possibilities in image analysis. With the organization of administrative data inside information systems, workflows are regulated, and communication between departments becomes faster. It is logical to expect a step in integrating all data forms in one system using artificial intelligence as an assistant in diagnosis. Based on that, it launched a project of comprehensive diagnostics. Deficiency of IT structure decelerate the progress, therefore it is in use in university hospitals. The basic precondition for starting the project of comprehensive diagnostics is the integration of all healthcare data. Development of HL7 and DICOM standards allows more simple use of data with potential for use in artificial intelligence with specific limitations [23]. The best example is the use of a function for clinical decision support. Platform FHIR solved problems like separated software and complex procedures and created the precondition for the use of artificial intelligence. It opened the possibility for RADIOMICS use in DICOM image analysis. It is about the extraction of quantitative data from images and artificial intelligence analysis. Research is being conducted in nuclear medicine for tumor heterogeneity which impacts on patient survival [25].

Using HL7 standard in personal electronic record achievement

A traditional health record is replaced with digitalization of health data in form of electronic healthcare record which is structured as longitudinal view of health information. Communication with the HIS is possible thanks to the HL7 and DICOM standards. Users can at any time get information about the identification of the patient, health problems, drugs, vital signs, history of disease, immunization reports and laboratory or radiology results. It is also possible to construct workflows and use clinical decision assistance. Patient information is accessed by ID number, which is special for every institution. Electronic medical record consists of direct care, supportive care and information infrastructure [26]. Direct care is responsible for providing healthcare services from healthcare staff in direct contact with patients. Supportive care describes clinical, demographic, administrative and financial data. The third part is the infrastructure of data responsible for the security and privacy of data, interoperability of data with the use of standard terminology. Availability limitation problem on health staff is solved with a project of Personal Health Record (PHR), with the purpose of health data availability to a patient about drugs, exams and other health procedures. Profiling data is taken from FHIR because of the more manageable data exchange. Many companies like Google or Microsoft tried to create a practical form of the personal health record, but they cancelled their project because of technical problems and lack of interest. Apple showed promising results in the development of personal health record, and they succeeded in the integration of laboratory results, allergies, vital signs and vaccines in application software. The final goal of PHR is the complete availability of health data inside the entire healthcare system [28].

Using FHIR inside medical research

There are two forms of using FHIR in medical research; FHIRPath and FHIR bulk data access. While FHIRPath uses hierarchical model of data to extract specific content from one medical record, FHIR bulk data access extracts requested data from a group of individuals which presents a significant quantity of data forwards approved from the data provider and applicant [29].

Conclusion

Development of information-communication technologies in the form of digitalization of data, infrastructure and education of healthcare staff contributed to faster and more practical transport of medical data inside healthcare institutions. Diversity of message content and communication is solved by the HL7 standard, which presents a norm in the structure and transport of messages. Standardization of data allows integration of all departments with improved data availability. Administrative functions allow permanent entry of demographic data without the need for new entry. Clinical data with the use of clinical assistance support helping physicians plan exams, drug prescriptions, and contraindications and allergies management. Healthcare staff has an opportunity to organize workflows and affect quality progress in work. With FHIR, it is possible to control finances and medical research. Integration of all health data sets foundation for the development of artificial intelligence as assistance in medical activity or development of basic health data availability for all smart gadgets. Education of healthcare staff is an important precondition for progress because only the connection between basic knowledge about the HL7 standard and clinical experience can improve work conditions and radiologic technologist function in the medical team for a positive outcome on the patient. ■

Sažetak

Dostupnost podataka vodeći je faktor razvoja društva. Napredak znanosti i tehnologije doprinio je modernizaciji sustava prijenosa i dostupnosti informacija. Obuhvaćena su sva područja života pa tako i zdravstvo. Kao temeljno područje za stabilnost društva bilo je potrebno precizno organizirati pojedini korak u komunikaciji unutar svake zdravstvene ustanove. S obzirom na raznovrsnost i količinu podataka, razvoj jedinstvenog standarda prijenosa nailazio je na niz problema. Međutim, nastankom HL7 i DICOM standarda podaci su postali pravilno strukturirani čime su prepreke u općoj dostupnosti uspješno izbjegnute. Demografski podaci prilikom upisa pacijenta ostaju trajno zabilježeni u informacijskom sustavu u svrhu planiranja medicinskih pregleda i testiranja uz identifikaciju dobivenih rezultata. Protokoli rada unutar pojedinih odjela te financijsko upravljanje poslovanjem zdravstvenih ustanova također pripadaju opcijama HL7 standarda koje sudjeluju u postavljanju osnovnih uvjeta za svakodnevno funkcioniranje. Upisivanje svih kliničkih podataka u formuliranom obliku doprinosi asistenciji u dijagnostičkom i terapijskom procesu te predstavlja ključne podatke za medicinska istraživanja. Softverska platforma integracije svih zdravstvenih podataka temeljni je preduvjet za upotrebu umjetne inteligencije unutar pojedinog protokola rada za svaki klinički odjel i ustanovu. Nadalje, integracija je omogućila pacijentu pristup osnovnim medicinskim podacima u svrhu uspostavljanja kvalitetne i efikasne suradnje. Konačna svrha rada je prikazati osnovne procese razmjene informacija putem HL7 standarda radi ukupnog poboljšanja kvalitete rada unutar zdravstvenih ustanova.

Ključne riječi: funkcionalnost, HL7, HIS, PACS, RIS

Literature

1. Janković S, Mihanović F. Radiološki uređaji i oprema u radiologiji, radioterapiji i nuklearnoj medicini. Split: Sveučilište u Splitu; 2015. str. 216-219
2. Janković S, EterovićD. Fizikalne osnove i klinički aspekti medicinske dijagnostike. Zagreb : Impresum; 2002. str. 154-159.
3. Kagadis G, Langer S. Informatics in Medical Imaging. Boca Raton FL: CRC Press; 2011. str. 257-259
4. HL7 Interface Specification for Connecting an Extrenal System to medavis RIS[Website] Dostupno na: https://www.medavis.com/wp-content/uploads//medavis_HL7_Interface_Specifications-4-1-2.pdf (pristupljeno 19.05.2021.)
5. Kagadis G, Langer S. Informatics in Medical Imaging. Boca Raton FL: CRC Press; 2011. str. 28-30
6. Scheduled Workflow[Website] Dostupno na: https://wiki.ihe.net/index.php/Scheduled_Workflow. (pristupljeno 23.05.2021.)
7. Patient Information Reconciliation[Website] Dostupno na: https://wiki.ihe.net/index.php/Patient_Information_Reconciliation.(pristupljeno 22.05.2021.)
8. Post-Processing Workflow[Website] Dostupno na:https://wiki.ihe.net/index.php/Post-Processing_Workflow. (pristupljeno 23.05.2021.)
9. Reporting Workflow[Website] Dostupno na: https://wiki.ihe.net/index.php/Reporting_Workflow.(pristupljeno 22.5.2021.)
10. Import Reconcilitation Workflow[Website] https://wiki.ihe.net/index.php/Import_Reconciliation_Workflow. (pristupljeno 23.5.2021.)
11. Janković S, EterovićD. Fizikalne osnove i klinički aspekti medicinske dijagnostike. Zagreb : Impresum; 2002. str.89-90.
12. Mammography Acquisition Workflow[Website] Dostupno na:. https://wiki.ihe.net/index.php/Mammography_Acquisition_Workflow. (pristupljeno 23.5.2021.)
13. Kagadis G, Langer S. Informatics in Medical Imaging. Boca Raton FL: CRC Press; 2011. str. 251-257
14. Matney SA, Dolin G, Buhl L, Sheide A. Communicating Nursing Care Using the Health Level Seven Consolidated Clinical Document Architecture Release 2 Care Plan. Comput Inform Nurs. 2016 Mar;34(3):128-36.
15. Kamel PI, Nagy PG. Patient-Centered Radiology with FHIR: an Introduction to the Use of FHIR to Offer Radiology a Clinically Integrated Platform. J Digit Imaging. 2018 Jun i 31(3):327-333.
16. Administration Module[Website] Dostupno na:. http://hl7.org/fhir/administration-module.html. (pristupljeno 26.5.2021.)
17. ClinicalSummary Module[Website] Dostupno na:http://hl7.org/fhir/clinicalsummary-module.html. (pristupljeno 26.5.2021.)
18. Diagnostics module[Website] Dostupno na: http://hl7.org/fhir/diagnostics-module.html. (pristupljeno 26.5.2021.)
19. Medications Module[Website] Dostupno na http://hl7.org/fhir/medications-module.html.(pristupljeno 27.5.2021.)
20. Financial module[Website] Dostupno na: http://hl7.org/fhir/financial-module.html. (pristupljeno 27.5.2021.)
21. Workflow Module[Website] Dostupno na: http://hl7.org/fhir/workflow-module.html (pristupljeno 27.5.2021.)
22. ClinicalReasoning Module[Website] Dostupno na: http://hl7.org/fhir/clinicalreasoning-module.html.(pristupljeno 27.5.2021.)
23. Bukowski, M., Farkas, R., Beyan, O. et al. Implementation of eHealth and AI integrated diagnostics with multidisciplinary digitized data: are we ready from an international perspective?. Eur Radiol 30, 5510–5524 (2020).
24. Mar-Apr, Braunstein ML. Health Care in the Age of Interoperability: Part 4. IEEE Pulse. 2019 i 10(2):31-33.
25. Mayerhoefer ME, Materka A, Langs G, Häggström I, Szczypiński P, Gibbs P, Cook G. Introduction to Radiomics. J Nucl Med. 2020 Apr i 61(4):488-495.
26. Kagadis G, Langer S. Informatics in Medical Imaging. Boca Raton FL: CRC Press; 2011. str. 259-261
27. Saripalle R, Runyan C, Russell M. Using HL7 FHIR to achieve interoperability in patient health record. J Biomed Inform. 2019 Jun i 94:103188.
28. May-Jun, Braunstein ML. Health Care in the Age of Interoperability Part 5: The Personal Health Record. IEEE Pulse. 2019 i 10(3):19-23.
29. Jul-Aug, Braunstein ML. Health Care in the Age of Interoperability Part 6: The Future of FHIR. IEEE Pulse. 2019 i 10(4):25-27.