Review article

UDC: 621.39:617.7
doi:10.5633/amm.2018.0117

THE OPHTHALMIC INFORMATION SYSTEM

Gordana Stanković-Babić[1,2], Rade R. Babić[4], Zoran Milošević[1,5]

The introduction of information systems to the healthcare industry has led to the automation and modernization of the system of work, increased the quality of diagnostic and therapeutic procedures, reduced consumables and increased the level of system utilization, simultaneously saving time and enabling the integration of heterogeneous systems into a single computer unit.

The ophthalmic information system (OIS) is a part of the hospital information system (HIS). The network, computer hardware and software, WEB technology, Digital Imaging and Communications in Medicine, Picture Archiving and Communication System, Health Level Seven protocol are essential to the functioning of the information system.

Teleophthalmology is a form of the medical information system that requires the use of telecommunication systems in order to provide ophthalmic services among remote locations.

The application of smart mobile phones for mobile ophthalmology has shown great efficacy in the diagnosis of macular degeneration, glaucoma, cataracts etc.

Web technologies in the ophthalmic information system have made health services available to everyone, enabled a fast and effective treatment, provided timely information and also enabled good communication between ophthalmologists.

Acta Medica Medianae 2018;57(1):116-121.

Key words: *information systems, ophthalmic information system, telemedicine, teleophthalmology, mobile ophthalmology*

[1]University of Nis, Faculty of Medicine, Niš, Serbia
[2]Clinic for Eye Diseases, Clinical Center Niš, Niš, Serbia
[3]Centre of Radiology, Clinical Center Niš, Niš, Serbia
[4]High Health School of Professional Studies "Hippocrates", Bujanovac, Serbia
[5]Institute of Public Health Niš, Niš, Serbia

Contact: Gordana Stanković-Babić
Vase Smajevića 22, 18000 Niš, Serbia
E-mail: gordanasb@mts.rs

Introduction

The introduction of information systems to the healthcare industry has led to the automation and modernization of the system of work, increased quality of diagnostic and therapeutic procedures, reduced consumables and increased the level of system utilization, simultaneously saving time and enabling the integration of heterogeneous systems into a single computer unit (1–5).

The ophthalmic information system (OIS) is a part of the hospital information system (HIS). The network, computer hardware and software, WEB technology (telecommunication systems and technologies), Digital Imaging and Communications in Medicine (DICOM), Picture Archiving and Communication System (PACS), Health Level Seven protocol (HL7) are essential to the functioning of the information system (1–11). Modalities that make OIS (and present small OISs themselves) include: biomicroscope, fundus camera (FA, laser), OCT, ultrasound, computerized perimetry, ophthalmic surgical microscope, etc. The data collected in the form of electronic recording (e-recording) from the above-mentioned modalities are stored and kept for a certain period of time in different formats. The ophthalmic information system must provide a quick and easy access to e-recordings, while the speed of access to the data may vary. The OIS should provide a greater and faster information flow of patient data from each part of the Eye clinic–examination rooms, depatments, operating rooms etc.

Integration of OIS into HIS

In order to be integrated into a single information system, the hospital information system and ophthalmic information system exchange the following information: patient registry (data on the new patients, updating the data on existing patients); patient examination results (who referred the patient and what type of examination is required, referral diagnosis, level of emergency, etc.); examination status and various reports (radiological findings, specialist reports, laboratory findings, histopathological findings, etc.); delivery of findings; distribution of findings to the patient; data synchronization between HIS and OIS (examination methods, physicians, departments etc.) and other information (4).

It is possible to exchange information between OIC and other information systems integrated into a HIS, such as the radiology information system (RIS), surgical information system (HRIS) and others.

A radiology information system is one of the most advanced and most developed health information systems. It comprises a large number of different modalities such as: digital radiology, computed neurology, computed tomography (CT), magnetic resonance imaging (MRI), echocardiography, angiography, mammography, mobile radiology, teleradiology, dental radiology, orthopantomography, radiotherapy apparatus, radiosurgery appliances (gamma knife, cyber knife) and others (1, 2). OIS, HRIS and other medical information systems originated from the RIS.

The HL7 standard protocol is necessary for the integration of an ophthalmic information system into the health information system. The HL7 standard enables the exchange of medical information among different information systems of hospital organizational units, regardless of the programming language they are written in and regardless of the platform they are executed on. The HL7 is not a software application, but a standard encompassing thousands of pages with detailed explanations, which supply analysts and developers with a starting point on the standard, in order to implement it technically (1, 2, 6, 8).

PACS is based on the web technology (1, 2, 6–8). It is integrated into OSI, RIS, HRIS and other medical information systems. It represents a modern system for archiving images and communication. It is frequently used with the RIS. Designed as the computer systems for paper and filmed archives, PACSs handle medical images and information (1, 2). They store recordings from various medical devices-modalities (fundus cameras, biomicroscopes, computerized perimeters, fundus cameras, OCTs, ocular ultrasounds, standard ultrasounds, color Doppler ultrasounds and other appliances, then MRIs, CTs, angiography apparatuses, digital x-ray machines, mammography machines, PET scanners, nuclear medicine appliances, dental x-ray machines, and others). A PACS unites the functions of teleophthalmic, teleradiological and other services, and systems for archiving, searching, viewing medical images, patient data etc. The ophthalmic PACS configuration is given in Figure 1.

A PACS contains a device for medical diagnosis, servers, workstations to access the data, computer network that connects the system components, databases and interfaces to other systems. Computers of operating units are networked in a PACS and they represent the modalities that send the processed information (images) to the central computer

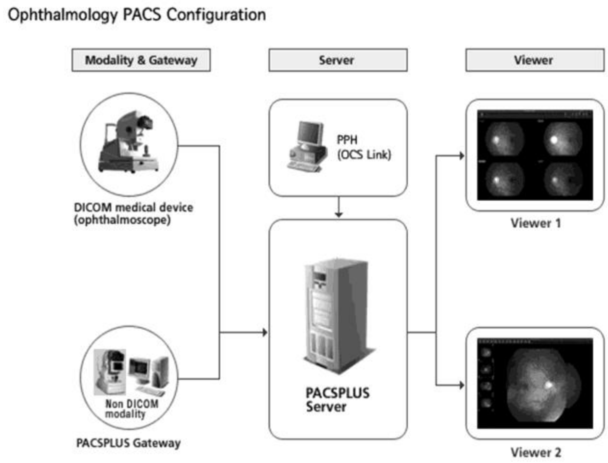

Figure 1. Ophthalmic PACS configuration

http://www.pacsplus.com/02_solution/sulotion_05.html

(server) and depositing it in PACS. Each computer in a PACS network is identified by its network address (1, 2, 4, 6, 8).

Benefits from the application of PACS are: saving space and time for filing the material (ophthalmic and/or radiological records), an easier search for the material with the purpose of staff training, cash savings (instead of buying ray films and photographic paper, only a CD is required), a higher quality of the deposited material, increased speed of establishing an ophthalmic diagnoses, possibility of visualizing records from remote locations. This leads to a better use of human resources as well as to an opportunity to connect within a network one or more health care providers, which results in the modernization of ophthalmic institutions in question, reducing the cost of servicing equipment etc.

DICOM is a standard for handling, storing, printing and transmitting information in medical practice. It is a set of rules that enable the exchange of medical images and information between computers of one or more health centers, by means of establishing a common information language, regardless of the manufacturer of the equipment and a digital system used (9–11).

DICOM and PACS are directly linked. DICOM consists of a file format definition and network communication protocol. Primary DICOM functions are the communication and exchange of digital medical images (fluorescent angiograms, echosonograms, CT orbits, etc.) (Figure 2) regardless of the manufacturer; the facilitation of the integration of PACS into the HIS, OIS, RIS and other information systems; the availability of a database of medical images regardless of the browser distance, enabling thus the functions of teleophthalmology, teleradiology, etc. (1, 2, 11–15).

The disadvantages of DICOM arise while searching databases and processing of images; with a simultaneous display of several images on the monitor, which results in the reduced quality of individual images or even a cut-off of individual segments. Moreover, a false coloration at the adjacent gray level may occur, followed by a false coloring in contrasting colors, etc.

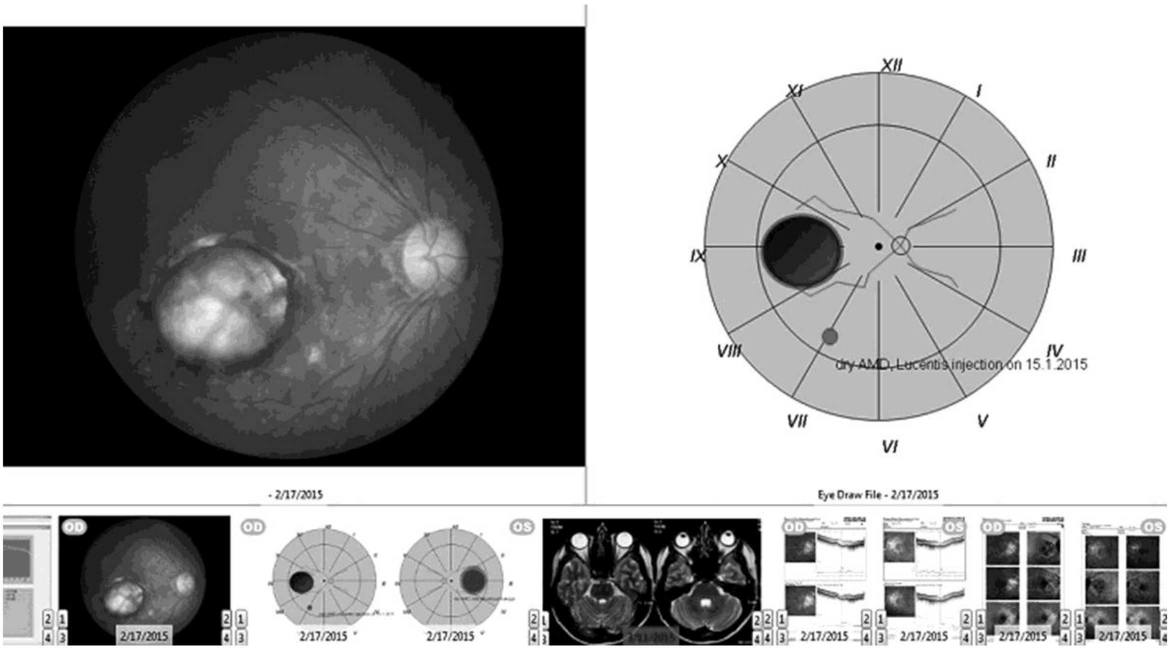

Figure 2. DICOM in an OIS

http://www.ifa4emr.com/index.php/News/Health-IT/VNA-for-ophthalmologists

Teleophthalmology

Teleophthalmology is a form of medical information system that requires the use of telecommunication systems in the form of satellites, the Inernet, mobile phones, computers and other devices for the exchange of data (images, video, audio or other ophthalmic and/or radiological, and similar information) with the aim of providing ophthalmic services between remote locations (11–15).

Teleophthalmology commonly utilises the Global System for Mobile Telecomunications (GSM), General Packet Radio Service (GPRS) and 3G systems for the transmission of information, because they allow the transfer of multimedia contents at high speed.

One of the requirements of telemedicine in general, and hence of teleophthalmology, is that information and communication technologies facilitate long-distance transfer of relevant medical data, by adhering to medical, technical and technological standards related to the collection, storage, transmission and retrieval of medical images, video, audio, and other similar ophthalmic and medical information, to a standardized and high-quality equipment and systems for telemedicine, quality devices, telecommunication equipment and connections.

Web technologies in teleophthalmology allow for the review and writing of ophthalmic findings on any computer, at any location, observing the relevant regulations and rights related to security and confidentiality of patient data, by means of the Internet Explorer (1, 2, 15).

The application of teleophthalmology is possible in ophthalmic institutions that have a digital ophthalmic camera, DICOM and PACS. The problem arises in areas where analogue ophthalmic devices are used. The question is how to digitize and archive ophthalmic findings, how to relate them to images, how to make information available to information systems of an ophthalmic clinic, hospital, clinic, other medical institutions in the country and abroad (1, 2, 4, 6, 9, 11).

Teleophthalmology is supposed to promote the development of telemedicine in Serbia, to modernize ophthalmic centers in the country, enable the timely availability of ophthalmic images (eye echosonograms, fluorescein angiography findings, radiographs, CT, MR, etc.) and their interpretation from rural and remote areas (mountains, forests, islands and other places); to provide a sub-specialist support to an ophthalmic diagnosis at a given time (e.g. the consulting body), to contribute to an easier establishement of the diagnosis by a quality analysis of identical examples or some rare diseases; to facilitate the distribution of ophthalmic images to other ophthalmic centers with the purpose of consulting;

to provide education and/or update of knowledge in ophthalmology, etc (1–4, 11–14).

The size of static images is the main technological challenge for telemedicine and teleophthalmology. Typically, uncompressed digital medical images vary from about 25 kB (nuclear medicine) to 50 MB (digitized mammography). Often, due to the need for repeated recordings (from different angles or in order to compare images from the same perspective), the total size of uncompressed examination data increases by 1 or 2 MB, up to almost 200 MB. The DICOM standard recommends the use of JPEG and JPEG 2000 compression formats, and the number of required shots depends on the device type. For most types of images only one shot is required, but FA, ocular echosonography, CT, MRI or Positron Emission Tomography (PET) scanning require a greater number of shots (e.g. 20 shots for a CT study of the orbit) (1, 2).

The flow of information necessary for the transmission of such images depends upon several factors. The time required for the transfer and the allowed compression level are particularly significant (image quality degradation is not allowed, since it would compromise data interpretation and diagnosis). Lossless compression techniques reduce the image size by 3 to 4 times, and while lossy compression reduces the image size by 10 to 20 times, yet still retaining a diagnostic image quality in some applications. An acceptable level of compression depends on the application domain (teleconferencing of ophthalmologist) and the image user (an ophthalmologist or a specialist in general practice). The security of data is also essential when using teleophthalmology, since the doctor-patient confidentiality and data integrity must be preserved during the transmission and storage of images. The confidentiality of personal data can be achieved by means of the techniques of user authentication, image access control and data encryption. Data integrity can be preserved (an important feature of a digital image is that it can easily be maliciously altered) by a digital signature technology. It is necessary to reconcile these requirements to the cost and ease of use.

Mobile ophthalmology

The development of mobile medicine is associated with Maria Sklodowska Curie, who worked on the creation of a mobile X-ray room during the World War II (Figure3). The alliance of French women provided the funds for the first mobile „radiological car", later called "little Curie" in 1914 (15–17).

Nowadays her brilliant idea is used by well-known manufacturers of X-ray machines who install x-ray devices, CTs, MRIs, mammographs and other radiological devices in trucks with trailers, therefore making these devices mobile and accessible to all communities, under all weather conditions, in peacetime or wartime. Further, manufacturers of ophthalmic equipment install these devices on planes and helicopters, making them mobile as well (13, 15, 18).

Together with the development of telecommunications technology, the mobility of ophthalmic devices using mobile telephony has increased (15, 18).

Figure 3. The first mobile "radiological car", later called "little Curie" from 1914.

This ingenious idea is just one of the links between telemedicine and teleophthalmology that made ophthalmic and other relevant medical information available everywhere, on any terrain in real time.

In radiology, the relevant characteristics of mobile phones are the screen diagonal of 3 inches, 250 CDL lighting, 256 MB of RAM memory, an 800 MHz processor and the mobile internet standard that supports HTML5 and Java script (2, 15). The use of the smart mobile phone is important in Mobile Ophthalmology (Figure4), since it would help teleophthalmology to become more relevant and far more realistic than the current reality (14, 18).

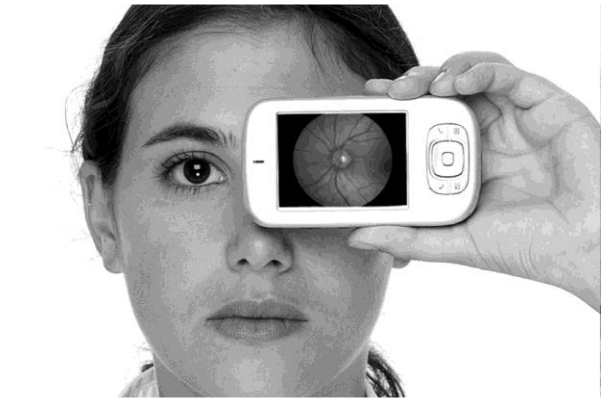

Figure 4. Mobile ophthalmology

http://www.kmendis.org/index.php/78-medical-informatics/124-teleophthalmology-an-annovation-that-could-change-medicine

The application of smart mobile phones in mobile ophthalmology has shown great efficacy in the diagnosis of macular degeneration, glaucoma, cataracts, anterior eye segment etc. It is believed that smart mobile phones in mobile ophthalmology will be initially applied in the treatment of diabetic retinopathy.

According to the World Health Organization (WHO), it is estimated that 135 million people suffer from diabetes, and that by 2025 this number will have increased to 300 million people. In order to prevent eye changes in patients with diabetic retinopathy, the use of smart mobile phones will be of great importance both for the needs of mobile teleophthalmology and static ophthalmology (18).

Contemporary teleophthalmology designs the future ophthalmology.

Conclusion

The ophthalmic information system has enabled the introduction of ophthalmology into the world of digital medicine. Web technologies within the ophthalmic information system have made health services available to everyone, enabled a fast and effective treatment, provided timely information, and facilitated the communication between ophthalmologists.

References

1. Babić RR, Babić RR, Milošević Z, Stanković-Babić G. Web technology in health information system. Acta Facultatis Medicae Naissensis. 2012; 29(2): 81–87. [CrossRef]
2. Babić RR, Milošević Z, Djindjić B, Stanković-Babić G. Radiološki informacioni sistem. Acta Medica Medianae. 2012; 51(4): 39–46. [CrossRef]
3. Milošević Z, Bogdanović D, Stanković A. Medicinska informatika. 2011. www.medfak.ni.ac.rs/PREDAVANJA/3.%20FARMACIJA/STATISTIKA/15.%20predavanje.pdf (Last: maj 2016)
4. Babić S. Zdravstveni informacioni sistem. Seminarski rad. Medicinski fakultet Niš. 2012.
5. Babić RR. Image diagnostic services in Southeast Serbian population 1960-2010. In: Strahinjić S, editor. Prilozi istoriji zdravstvene kulture Srbije. Niš: Galaksija-Niš; 2011: 221-8.
6. PACS sistemi. http://www.telemed.rs/pacs-sistemi (Last: maj 2016)
7. Michelson S. PACS brings retinal imaging the 21sr centre. Picture archiving and communications systems have helped streamline and improve patient care. *Retinal Physician.* 2013; 10: 42-44.
8. Ophthalmology PACS. http://www.pacsplus.com/02_solution/sulotion_05.html
9. DICOM standard. http://www.telemed.rs/dicom-standard
10. Data communication assay and efficient as never before – Oculus pent cam® goes DICOM. http://www.pentacam.com/sites/schnittstellen.php
11. Singh PR: Integrating image management into EHR systems. Factors to consider when moving into the digital age. Retinal Physician 2013; 10: 45-47.
12. Dinevski D, Poli A. Technology solutions and standards for teleradiology informacion sistem. Informatica Medica Slovenica 2010; 15 (2): 37-46.
13. Paunksnis A, Barzdžiukas V, Kurapkienė S. Teleoftalmologija Lietuvoje. Lietuvos oftalmologija 2006; 2: 31-36.
14. Teleopthalmology – an annnovation that could change medicine. http://www.kmendis.org/index.php/78-medical-informatics/124teleophthalmology-an-annovation-that-could-change-medicine (Last: November 2015)
15. Babić RR, Milošević Z, Stanković Babić G. Teleradiology – radiology at distance. Acta Facultatis Medicae Naissensiss. 2012; 29(3): 145–151. [CrossRef]
16. Babić RR, Stanković-Babić G. Marie Sklodowska Kiri (1867-1934) contribution to war radiology development. Acta Medica Medianae. 2010; 49(1):70–72.
17. Babić RR, Stanković-Babić G. Maria Sklodowska Kiri (1867-1934) – Contribution to the development of radiology. Med Pregl 2011; LXIV (3-4): 229-233.
18. Mobile adaptor promises faster, cheaper eye health diagnostics. http://www.eye-contact.co.uk/mobileadaptor/ (Last: maj 2016)

Revijalni rad

UDC: 621.39:617.7
doi:10.5633/amm.2018.0117

OFTALMOLOŠKI INFORMACIONI SISTEM

Gordana Stanković-Babić[1,2], Rade R. Babić[4], Zoran Milošević[1,5]

[1]Univerzitet u Nišu, Medicinski fakultet, Niš, Srbija
[2]Klinika za očne bolesti, Klinički centar Niš, Niš, Srbija
[3]Cenar za radiologiju, Klinički centar Niš, Niš, Srbija
[4]Visoka zdravstvena škola strukovnih studija "Hipokrat", Bujanovac, Srbija
[5]Institut za javno zdravlje Niš, Niš, Srbija

Kontakt: Gordana Stanković-Babić
Vase Smajevića 22, Niš, Srbija
E-mail: gordanasb@mts.rs

Uvođenjem informacionih sistema u zdravstvenu delatnost omogućena je automatizacija i modernizacija sistema rada, povećan kvalitet dijagnostičkih i terapijskih procedura, smanjen potrošni materijal, povećan stepen iskorišćenosti sistema, postignuta ušteda vremena i omogućena integracija raznorodnih sistema u jedinstvenu informatičku celinu.

Oftalmološki information sistem (OIS) je deo hospitalnog informacionog sistema (HIS). Mreža, hardver i softver kompjutera, WEB tehnologija, digitalne slike i komunikacija u medicini, sistem za arhiviranje slika i komunikaciju, kao i protokol "Health Level Seven", neophodni su za funkcionisanje informacionog sistema.

Teleoftalmologija je forma medicinskog informacionog sistema koja zahteva korišćenje telekomunikacionih sistema u cilju obezbeđivanja oftalmološke službe između udaljenih odredišta.

Primena smart mobilnih telefona za potrebe mobilne oftalmologije pokazala je veliku efikasnost u dijagostici makularne degeneracije, glaukoma, katarakte i dr.

Primena web tehnologije u oftalmološkom informacionom sistemu omogućila je da zdravstvene usluge postanu dostupne svima, brzo i efikasno lečenje, pravovremene informacije, kao i međusobne komunikacije oftalmologa.

Acta Medica Medianae 2018;57(1):116-121.

Ključne reči: *informacioni sistemi, oftalmološki informacioni sistem, telemedicina, teleoftalmologija, mobilna oftalmologija*