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# Development of Teleradiology in Private Practise in Serbia and its Influence on Increased Efficiency and Effectiveness of Medical Professionals

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As a system of transmission of radiologic images over a distance teleradiology has been explored for nearly 50 years and has become a widely used concept of telemedicine – providing health care services over a distance. The aim of this article is to show the methodology of development of teleradiologic network and its role in promoting improved efficiency, effectivity and quality. The choice of adequate however not expensive teleradiologic system and digital radiologic equipment as well as a confident provider are two main conditions for a stable teleradiological network in the developing countries. Besides, the involvement of expert radiologists who can provide reliable and fast interpretation of teleradiologic findings is very important as well. We present our teleradiological system exploited in five private radiology centers in Serbia.

**Keywords:** teleradiology, Internet, private practice, WAN, Serbia.

Teleradiology is a system of electronically transmitting a radiological image from one location to another for interpreting or consulting purposes. Teleradiography allows for a prompt interpretation of radiological examinations over a distance and offers a range of opportunities for a secondary, consultative examination. In addition, teleradiology enables a continual education. The users geographically distant from one another are in a position to simultaneously observe radiological image while holding a teleconference using the Voice over Internet Protocol (VoIP). Teleradiography is a most widely used form of telemedicine. Such a method of describing radiological examinations and making diagnosis over a distance started in the 1960s. In that period, as well as in the 1970s, an interactive television transmission was used Bird, 1972. In Serbia, the television transmission was implemented at the Institute for Radiology, the Military Medical Academy (VMA) in Belgrade as early as 1970s. It was in this decade that the National Aeronautics and Space Administration (NASA) improved and developed modern telemedical procedures as we know them today Charles et al 2009; et al. 2005. During 1980s a computer-based principle of telemedicine was introduced with a digital image format transmission which enabled a commercial development of telemedicine Thrall, 2002. In the beginning, several principles for image digitalization were used and then the image was sent in that respective format. The 1990s witnessed a tremendous improvement in both the computer technology and the networking systems, so the data transmission became less expensive and easier while the image resolution was improved. This is the time when a number of teleradiological systems were established in Serbia, mainly incorporated into telemedical systems and hospital information systems (HIS) of large hospital centres, where telepathology and teleconference systems were increasingly used. Such local hospital networks were designed at the Military Medical Academy, the Institute for Oncology at Sremska Kamenica, the Military Hospital in Niš and at the Clinical Centre of Serbia, Belgrade Putnik et al 2001,5. A real teleradiological boom came in the 2000s with a start of a large number of companies that offer telemedical services and millions of radiologic images are inspected and described from locations far away from the examination site Hagler, 2005. The first functional, commercial, global information network of this kind (Wide Area Network – WAN) in Serbia is our teleradiological network established in 2005.

The aim of this paper is to present a methodology of the teleradiological network development and the importance of this network for the improvement of efficiency and effectiveness of radiological centres networked into the teleradiology system.

## Methods

A case study was used to analyse the exploitation of the teleradiological networking system to transmit images and record medical findings over a distance, all as an attempt to increase the efficiency and the effectiveness of work in geographically dispersed radiology centres, with a top-flight medical team available to all the centres in the teleradiology network on equal basis.

The core business of private radiological practice linked together via an open teleradiological system is radiological diagnostics, primarily CT and MRI diagnostics. The first centre in the teleradiological network is the Hram Diagnostic Centre in Belgrade, founded in 2001. The Institute for Radiology and Ultrasonic Imaging, Eurodijagnostika was established in 2005 and is linked with the Radiological diagnostic centres Hram in Belgrade, Eurodijagnostika in Novi Pazar and Niš and with Ćuprija, in Ćuprija, into an integrated teleradiological system. The problem all radiology and hospital centres, ours being no exempt, encounter worldwide is how to recruit quality radiological staff that will keep up with the technological development of radiological services, especially in smaller centres.

The first private radiology practice in Serbia equipped with CT and MRI is the Hram Diagnostic Centre, established in 2001. Over time, other radiology institutes were set up with a tendency of spreading to regional centres with hospitals in which there is a need for the CT and MRI diagnostics, however, they lack either an adequate radiology equipment or experts in radiology in these specific diagnostic areas. The primary strengths of this network of health care centres are their excellent radiologists in the parent centres in Belgrade, that is, Hram and Eurodijagnostika, who have for years been highly respected by their colleagues. The satellite centres also employ the most competent and reputed radiologists in their respective regions. Examinations are performed using modern equipment and in an environment that is comfortable, pleasant and highly clean, which is not always the case with health centres in Serbia. Contrary to the public health care system where patients have to wait for medical examination for several months, here the appointments are made for the next day; in case of emergency, services are available any time, day and night. Such facilities of almost 24/7 work and an expert radiology examination equally for any patients from any satellite centres are made possible through the telecardiology network. The doctors that provide teleradiology services are stimulated for their work. Another advantage of the private practice network is that they have a prompt and reliable technical support in medical and IT equipment maintenance. It is for this reason that private practices do not make long breaks in their work due to the routine, planned, check-ups or failures of the equipment, which again are characteristic of the competition, the state-owned institutions. One weakness, however, of these private practices is that they cannot keep up with the latest technical achievements in the field of radiology equipment on a regular basis as such a trend would not be payable given the financial situation of the population in Serbia and the price of the equipment in millions of euros. For example, according to a comparative analysis of health care systems presented in the work of Squires, 2011, an MRI examination in 2009 amounted to \$824 in Canada, \$436 in France, \$ 839 in Germany, \$567 in the Netherlands, \$1200 in the USA 2011. Our centres charge an MRI examination from €100 to €150. As far as competition, there is a public health care system where patients have to wait for a CT or MRI examination for several months and there is a private health care sector with a similar technological level of equipment. An insufficient number of radiologists employed on a full-time basis and the need to consult a large number of consultants result in the relations in the private sector institutions being constantly unstable and hence the quality of findings is not always as high as desired. Another weakness is the Law on prohibition of advertising health care institutions that limits their marketing activities to a considerable extent. Among significant external threats are uncertainty and obscure prospects of the Serbian health care system with the private sector that has been outside that system for decades. Besides, the financial situation in Serbia is far from favourable. The strategy of spreading the business to satellite centres through teleradiology network was the following know-how: from a specific preparation and construction of the radiology centre premises, to procurement of equipment, to recruiting radiology experts, to teleradiology networking, to creating a well-based marketing service to a large number of reliable, long-term collaborators throughout Serbia. One conclusion that can be drawn on the basis of the SWAT analysis, in spite of external threats that cannot be controlled, and with internal weaknesses that are gradually being overcome and turned into strengths, e.g., a selective procurement of new equipment, is that the development of diagnostic radiology centres in the regional centres throughout Serbia, with teleradiology support, is a good business strategy.

## Discussion

Modern teleradiology practice differs from one continent to another and from country to country, both in structure and in purpose. In the USA, teleradiology has for years been used as a method to compensate for an insufficient number of qualified radiologists and to distribute radiology examinations among hospital centres and writing radiological reports from home. In 2003, 73% of radiology examinations were performed using teleradiology, a rise by one fourth in comparison with 58% in 1999 ( $p \leq 0.05$ ). It is interesting to note that the use of teleradiology in polyspecialistic practice increased from 53% in 1999 to 81% in 2003 ( $p < 0.05$ ), while in private radiology practices the increase was from 74% to 88% ( $p < 0.05$ ) Ebbert et al 2007.

Also remarkable is a steady increase in the number of teleconsultation examinations on call at after hour times. In the public health care sector such examinations are common in radiologic imaging in traumatized patients late at night, when one radiology centre covers several hospital centres Thrall, 2005. For economic reasons mostly, such a practice has spread in this decade, so thousands of radiologic imagings performed in the USA, especially at night, are teleradiologically reviewed and interpreted in the centres in India or Singapore McLean, 2009.

The European Union countries with developed social and health care systems view the health care system from a health care and social aspects, rather than from economic ones. Hence teleradiology systems in Europe are generally developed on the state level, especially in the Scandinavian countries which maintain high social standards. A recommendation of the European Society of Radiology is that the primary goal of teleradiology is not the creation of new business opportunities but rather a provision of a quality service, of solutions to the shortage of radiologists and, most importantly, enabling patients to obtain a reference specialist opinion as well as a second opinion by a reference specialist et al 2013..

Teleradiology practice in this region is developed in Croatia and Greece. In these countries these are also public health care projects developed to overcome the shortage of qualified medical personnel in the islands. In 1990s, LAN networks were devised in several hospital centres in Serbia. A real WAN teleradiologic, telecommunication connection was established in 1999 between the Institute for Radiology of the Military Medical Academy (VMA) in Belgrade and the Conference hall in Subotica. It was the Seventh annual meeting of radiologists of Yugoslavia in Subotica with a teleradiology and a teleconference broadcast of interventional radiology procedure from VMA. The Health care centre in Valjevo established a WAN network with a Centre for Magnetic Resonance of the clinical Centre of Serbia (KCS) to be used for consultant examinations by magnetic resonance imaging. Thus a waiting period at the Clinical Centre of Serbia was shortened while a high quality of radiological findings and a continuous education were provided in the Health Care Centre in Valjevo. The waiting lists for MRI and CT medical tests in the public health care system in this country are still rather long. In Croatia, this problem was partially solved by redirecting patients from the waiting list to private radiology centres and regional hospitals Štimac, 2009; Trošelj et al 2005.

Our teleradiology system is the first functional WAN system in Serbia. It was established in 2005, and in the following year it was presented as a pilot project "Teleradiology in Serbia" at the 9th Annual Management in Radiology (MIR) Congress, Budapest, October 6, 2006, followed by the "One file form as a solution for teleradiology during unstable conditions of Internet" at the 10th Annual Management in Radiology Congress, Oxford, October 12, 2007. It connected radiology centres in Belgrade, Čuprija and Banja Luka. The system has constantly been adapted to new radiology equipment and five private radiology centres are included in it at the moment: two in Belgrade, one in Čuprija, one at Novi Pazar and one in Niš.

The primary goals of establishing such a teleradiology network in private practice were the following:

- A larger number of medical tests in a larger number of radiology centres.
- Improving work technology.
- Radiology diagnostic centre resource management.
- Reducing the film use by using CDs.

These goals were set as basis for the process efficiency improvement at the diagnostic centres networked into the teleradiology system. This helped cover a large number of smaller centres that do not dispose of enough radiology experts or whose radiology specialists are limited in certain subspecialist expertise cases. The secondary goals of teleradiology networking in private practice were the following:

- Maintenance and improvement of specialist activities.
- Coordination and consulting of employees.
- A higher quality education.
- An economic stimulation of employees.

This group of goals had a direct impact upon the improvement of effectiveness in the networked diagnostic centres. It is important to note the importance of teleradiology in providing the opportunity for everyday consultings in cases of diagnosis reporting and decision making on the level of consultation body. This improves the expertise of any radiologist and gives an opportunity for a permanent education of the employed in smaller diagnostic centres and those with less clinical experience. The most common transfer of medical images for the purpose of consulting or obtaining a second opinion was in the area of neuroradiology or the musculoskeletal system diagnostics, especially of sports injuries. Characteristic of these areas of radiology is a shortage of experts, and this is a situation worldwide Crocker et al 2010 .

The technological outcomes of such a teleradiology system are the following:

- The software is a domestic product, user-friendly, open for improvements.
- Wide Area Network with PC workstations.
- Unlimited archiving of images and text records into the database.
- Simple handling and access to database.
- Opportunity for individual database creation at PC workstations.

Such technological solutions enabled a prompt and simplified manipulation within the system as well as archiving images, text records, findings that can be used both in control medical tests and in evaluation of a physician's work Struber et al 2004; Bergmo, 1996; et al 2007; Passadore et al 2001.

## Results

The following developmental problems were defined during the initiation of the teleradiology network:

- The need for a larger number of computerised tomography (CT) and magnetic resonance imaging (MRI) in small health care centres.
- Shortage of highly qualified radiologists and radiology technicians to work on CTs and MRIs.
- High price of medical tests with travel and sojourn expenses for radiologists and radiology technicians in the satellite centres and their simultaneous absence in the parent centres.
- The quality of tests and findings in case a radiology technician and a radiologist with less expertise are hired.

The right solution to such problems is teleradiology which enables a continually high quality of radiology findings with the already existing radiology staff. The cost of image transfer in the teleradiology system is not high; also low is the cost of additional training of radiology technicians to work on CT and MRI equipment.

The technical problems in the execution of this project were as follows:

- The problem of image acquisition from CT and MRI equipment without a DICOM (Digital Imaging and Communication in Medicine) support.
- High price of software for image processing and PACS (picture archiving and communication systems).

These problems were overcome by technical solutions concerning the application of the frame grabber card for image acquisition and by using a domestic software for data and image archiving and transfer. Such technical solutions were also implemented on the occasion of establishing the radiology information system at the Institute for Radiology of the Military Medical Academy, Belgrade and before the procurement of the equipment with the DICOM standard Putnik et al 2001, 20. With the equipment supported by the DICOM standard there was no need for an acquisition using a frame grabber card. DICOM is an international standard for defining and transmitting medical information and images that ensures interoperability between different devices. In case the DICOM standard is not supported on the medical devices, a medical imaging conversion device has to be used et al. 2005, 21.

Given that our teleradiology system includes two radiology centres in Belgrade and one each in Ćuprija, Novi Pazar and Niš, a system of wide area networking, WAN, was implemented. WAN is a communication system that covers vast distances, larger than the large metropolitan areas, often using varied technologies of communication networks. Within the centres themselves the local area networks, LANs, were established

For the use of wireless, land and permanent connections among the centres the following was provided:

- On-line data and image transfer.
- Transfer speed up to 2Mbit/sec.
- The transfer time of average imaging (30 images 512x512 ~ ½ MB) up to 2min.

If needed, a system of wireless, mobile and intermittent connections is used, with a laptop computer as a workstation, which allows for non-standard and emergency medical tests in the centres, as well as makes it possible for a radiologist to work from home.

All the centres are also networked through the Voice over Internet Protocol (VoIP). This is a system of voice transmission over the computer networks rather than over the analogue, telephone or GSM system of communication. It is in this way that a teleconference network is enabled among the radiology centres.

The teleradiology transfer of image system involves 5 magnetic resonance imaging systems (MRIs) and 4 computerized tomography devices (CTs). In the beginning, all these devices worked without the DICOM; today, 3 CT and 2 MRI devices are supplied with the DICOM. Three centres in our system employ one radiologist each, while two centres, those in Belgrade, have two radiologists each, all of them with a long experience in work on the CT and MRI diagnostics. Thus a continuous support and education is provided for diagnosing in the satellite centres, as well as for a two shift work schedule in all the centres.

More equipment and a larger number of new methods and models of radiology equipment are not followed by a larger number of radiologists, especially of adequately trained radiologists. The number is constantly rising, hence, according to the estimates of the journal Health Imaging & IT, the teleradiology and PACS market will amount to \$4.4 billion in 2010. According to the ECR data, the distribution of radiologists in the European Union is 104 radiologists per million inhabitants, 84 of which are specialists. The count in Serbia is 700 radiologists for around 7,000,000 people which is similar to the average number in the EU. However, we have to be aware of the fact that the obligation of permanent medical education in Serbia is not adequately regulated by law yet, which hinders the adoption of new technical and diagnostic methods. Attention should also be paid to the motive, desire and opportunities for adopting new methods among the older population of radiologists. The largest number of teleradiology users in the USA come from the population younger than 35 (88%); follows the population aged 35 to 44 (82%), and those aged 55 to 64 (81%), while the percentage fall abruptly as we near the older population of radiologists.

Teleradiology has proven to be very important in the area of human resource management. The area of radiology in this country, as well as worldwide, is deficient in expert human resources, especially in the fields of high technology, CT and MRI diagnostics. The use of teleradiology ensures a high level of expertise in the work in all the centres. The employees in the base centres in Belgrade are the radiologists with extensive clinical experience and rich practice in work on CT and MRI diagnostics. This ensures high quality medical consultings for patients in satellite centres too, without them having to travel to larger health care centres. This in turn guarantees high quality diagnoses at minimum expenses for both the patient and the health care system Plathow et al 2005; et al, 2010, et al. 2013 .

In addition to saving both time and money to patients who would otherwise have to travel to large medical centres, as well as savings for the daily allowances and accomodation of radiologists who would travel to satellite centres, teleradiology allows for savings in work days and work hours. Thus, in the example of these 5 radiology centres, the savings in work hours in 2009 amount to 1004 work days or 6264 work hours. More than 3000 MRI and CT imaging tests are transmitted annually for the consulting or diagnostic purposes.

## Conclusion

Networking 5 radiology centres in different regions of Serbia into a WAN teleradiology system and thus enabling expert and timely medical imaging brought benefits to both the patients and the health care system in that the efficiency, effectiveness and quality of work of the centres were improved. A similar attitude was published in the paper of Israeli authors Benjamin et al iz 2010. Also enabled is the two-shift work in all the centres, reporting the findings from home, as well as after hour medical tests in emergency cases. A high quality findings and an opportunity of consultant interpretations in all the centres in the teleradiology network is ensured through engaging expert radiologists with long and extensive experience in MRI and CT diagnostics. Expert support also enhances the education of radiologists in smaller centres. Physicians are stimulated to write teleradiological reports and participate in teleradiological consulting. Thus a high quality findings are enabled for CT and MRI diagnostics at the satellite centres, as well as a full engagement of full-time radiologists and consultants.

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