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Factors Affecting the Establishment of Teleradiology Services: A Case Study of Iran

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Abstract

Background: Nowadays, the rapid advances in information technologies make fundamental changes in the life and workplaces around the world, which are also evident and considerable in the health care and health care systems. One of the branches of the field of information technology is telemedicine, and among various forms of telemedicine, teleradiology is the most developed and most used form.

Objectives: According to various applications of teleradiology in increasing the quality of patient care and accurate and rapid medical diagnoses, especially in cases of crisis and deprived areas, the application of this technology is increasing. Therefore, the current study aimed at identifying and prioritizing the factors affecting the establishment of teleradiology in a public hospital in Tehran, Iran, using the analytical hierarchy process (AHP) technique.

Methods: The current cross sectional and descriptive study was conducted in a public hospital in Tehran, Iran, in 2017. The study sample consisted of 30 experts in radiology and information technology (IT), health insurance, health services management, and health information technology (HIT) using purposive and snowball sampling methods. The required data were collected using a researcher-made questionnaire containing 47 items. The collected data were analyzed using AHP technique through Expert Choice 11.0.

Results: The obtained results showed that technologies and infrastructures (W = 0.249) and training the technical and medical staff (0.094) had the highest and lowest weights and priorities among the studied dimensions, respectively.

Conclusions: In Iran, the application of modern telecommunication technologies, especially in the field of medicine, such as teleradiology is accompanied by many challenges due to the lack of adequate infrastructures and their relatively high initial costs. Therefore, in order to establish and implement the teleradiology technology, adequate financial resources and incentives should be provided for hospitals by the government; i e, the ministry of health and social security organization. Also, the development of telecommunication infrastructures such as launching the national health network (SHAMS) can also help to implement teleradiology services.

Keywords: Factors, Infrastructure, Teleradiology, Iran

1. Background

Nowadays, the rapid advances in information technologies make fundamental changes in the life and workplaces around the world, which are also evident and considerable in the health care and healthcare systems (1). It is widely observed that information technologies transform the patient care, medical research, medical education, and health care management (2). The application of information technologies in the health care industry, especially in hospitals and medical centers, creates a huge potential to improve the quality of provided services, as well as the efficiency and effectiveness of the personnel (3). Telemedicine, as one of the methods of telecommunication, uses such technologies in the field of treatment in order to improve care. The world health organization (WHO) defined telemedicine as "the application of information and communication technologies to transmit information for proper diagnosis and treatment of diseases and prevention of injuries, continuous education of health professionals, and any other cases that affect the development of community health" (4). Among the various forms

of telemedicine, teleradiology is the most developed and the most commonly used form (5, 6). Teleradiology can be defined as transferring the medical images from a location such as a hospital to another medical center or hospital (7, 8).

The proper application of teleradiology has a direct impact on the quality of patient care through providing better care and diagnostic services and preventing unnecessary patient transfer and cost reduction. High-quality images and their quick transmission, as well as simplification of communications and cost calculation facilitate the development and implementation of teleradiology as a clinical function. Teleradiology is not limited to the transfer of images and information between two locations, but it involves technologies to share information and knowledge and doing group work. Also, the use of teleradiology can solve the problem of specialist shortages required for diagnosis, and improve the health and well-being (9, 10).

Various studies are conducted in Iran on the telemedicine and teleradiology. Most participants in the study by Kahouei et al., believed that due to the urgent need for access to patients' information for correct diagnoses, the use of health technologies such as teleradiology and communication infrastructure could be effective (11). The findings of the study by Zarei and Sharifat showed that there were problems such as the lack of picture archiving and communication system (PACS) and economic barriers to the implementation of teleradiology. They suggested that the provision of financial incentives by the government, the development of telecommunication infrastructure, and the increased experts and specialists' awareness of the teleradiology benefits could contribute to the development of this technology in hospitals (12). Sadoughi et al., also concluded in their study that some factors affecting the successful implementation of teleradiology were data security, controlling and limiting access to the patients' clinical information during the teleradiology process, the possibility of legal protection of the radiologists, the formation of executive teams in the organization and providing financial support to them, and the invitation of executive managers as the main supporters of teleradiology (13).

In Iran, due to the development of medical imaging sciences and the application of modern equipment, the imaging techniques are very diverse; however, despite the growth and development of imaging equipment, the number of radiologists, especially experienced ones, to interpret the images of new imaging modalities is inadequate. Therefore, in many remote and deprived areas and in many medical centers in cities, there is a problem with the accurate interpretation of radiology images, especially in the crises. Since medical imaging is considered as the eyes of medical knowledge, and providing appropriate medical images and giving their timely and accurate interpretations help to accurately diagnose the diseases, the use of teleradiology is very efficient and effective due to the lack of radiology specialists.

Tehran Province has equipped hospitals and imaging centers with many experienced physicians and radiologists, in which the specialized radiology and counseling services can be transmitted to remote rural areas. Thus, the best solution for the current problems can be the application of teleradiology to transmit digital images to a radiologist to receive advice and their interpretation. There are many factors affecting the establishment of teleradiology and it is not possible to achieve successful teleradiology services without considering such factors.

2. Objectives

According to the importance of teleradiology in the hospitals, the current study aimed at identifying and prioritizing factors affecting the establishment of teleradiology in a public hospital in Tehran, Iran, using the analytical hierarchy process (AHP) technique.

3. Methods

The current study investigated the experts' viewpoints to identify and prioritize factors affecting the establishment of teleradiology in a public hospital.

3.1. Study Design

The current cross sectional and descriptive study was conducted in a public hospital in Tehran, Iran, in 2017.

3.2. Sampling

The study sample consisted of 30 experts in radiology, information technology (IT), health insurance, health services management, and health information technology (HIT) selected by purposive and snowball sampling methods.

3.3. Data Collection Tool

Data were collected using a researcher-made questionnaire containing 47 items. After reviewing the related literature and using books and other databases, the needed materials were collected and in the 1st step, the 47-item researcher-made questionnaire was designed in six dimensions, including training the technical and medical staff, technologies and infrastructures, confidentiality and security of information, costs and economic factors, legal requirements, and creating a positive attitude. This questionnaire consisted of two parts. The 1st part included nine

items related to the studied experts' demographic characteristics and the 2nd part contained 38 items scored based on a five-option Likert scale.

3.4. Data Collection

The questionnaire was completed by 30 experts in radiology and IT, health insurance, health services management, and HIT working in the studied hospital.

3.5. Data Analysis

After collecting data, one-Sample t test was used to compare the mean of each studied dimension with the maximum score. In the next step, in order to prioritize the factors affecting the establishment of teleradiology in the studied hospital, a pair-wise comparison questionnaire was designed and given to the studied experts. The importance of each dimension was determined on the basis of numerical paired comparison values whereby 9 referred to extremely important, 7 to very strongly important, 5 to strongly important, 3 to moderately important and 1 to equally important. The required data were gathered by the researchers through referring to the hospitals and giving the pair-wise comparison questionnaire to the experts. Finally, the collected data were analyzed using AHP technique through Expert Choice 11.0 and the weight of each dimension was calculated.

The validity of the researcher-made questionnaire was approved through getting the related experts' opinions and calculating the content validity ratio (CVR) and content validity index (CVI) (CVR = 0.99, CVI = 0.79). Its reliability was also confirmed using Cronbach's alpha coefficient ($\alpha = 0.85$).

3.6. Ethical Considerations

Obtaining oral informed consent from the studied experts before conducting the study, retaining anonymity, ensuring confidentiality of responses, and observing the participants' rights of withdrawing from the study at any time were some of the ethical considerations in the current study.

4. Results

The obtained results showed that most of the studied experts participating in the current study were male (76.67%), in the age range of 40 - 59 years (64%), and had a bachelor of science (BSc) degree (53.33%), had studied in the BSc in radiology (46.67%), and had 15 - 20 years work experience (34.48%), one to four years of management experience (37.5%), and were official employees (57.14%) (Table 1).

Table 1. The Demographic Characteristics of the Studied Experts

Characteristics	Frequency (%)
Gender	
Male	23 (76.67)
Female	7 (23.33)
Total	30 (100)
Age (y)	
1 - 19	0 (0)
20 - 39	8 (32)
40 - 59	16 (46)
60 - 100	1 (4)
Total	25 (100)
Work experience (y)	
1 - 4	2 (6.9)
5 - 9	8 (27.59)
10 - 19	9 (31.03)
20 - 30	10 (34.48)
Total	29 (100)
Management experience (y)	
1 - 4	9 (37.5)
5 - 9	7 (29.16)
10 - 19	4 (16.67)
20 - 30	4 (16.67)
Total	24 (100)
Education	
BSc	16 (53.33)
MSc	5 (16.67)
PhD	2 (6.67)
GP practitioner	0 (0)
Specialist	7 (23.33)
Subspecialist	0 (0)
Total	30 (100)
Field of study	
BSc in radiology	14 (46.67)
Radiologist (specialist)	7 (23.33)
BSc in HIT	4 (13.33)
Others (health insurance and health services management)	5 (16.67)
Total	30 (100)
Employment status	
Official	16 (57.14)
Treaty	5 (17.86)
Contractual	6 (21.43)
Corporate	1 (3.57)
Total	28 (100)

Also, the study results showed that there were significant differences between the mean of each studied dimension and three (the mean of Likert index, indicating that the studied experts were neither agreed nor opposed), as well as the mean score of each dimension was more than 75% of the maximum score (Table 2).

Moreover, the results obtained from the pair-wise comparison questionnaires showed that "technologies and infrastructures" (W = 0.249) and "training the technical and medical staff" (0.094) had, respectively, the highest and lowest weights and priorities among the studied dimensions (Table 3).

In the dimension of training the technical and medical staff, "providing the necessary facilities and equipment to train the technical and medical staff" (W = 0.331), in the dimension of technologies and infrastructures, "using suitable telecommunication facilities and technologies such as appropriate bandwidth" (W = 0.241), in the dimension of confidentiality and security of information, "developing security policies" (W = 0.263), in the dimension of costs and economic factors, "sufficient funding to create sustainable financial resources" (W = 0.396), in the dimension of legal requirements, "establishing and implementing standards for teleradiology" (W = 0.246), and finally in the dimension of creating a positive attitude, "active participation and cooperation of managers and physicians in the implementation of teleradiology" (W = 0.181) received the 1st priorities among the sub-items of each dimension. Furthermore, "developing security policies" (W = 0.263) had the highest priority among all sub-items (Table 4).

5. Discussion

Today, technological advances such as information and communication technologies have a particular impact on the field of radiology and medical imaging. Radiology is one of the most distinguished medical specialties, which plays a major role in the diagnosis, treatment, and improvement of patients. Therefore, the access of all patients to this expertise and specialty is essential, and the use of teleradiology can be considered as a suitable way to distribute the specialized radiology services. The implementation of teleradiology in Iran, despite its successful experiences in the developed countries and East Asian countries, faces challenges. The current study aimed at identifying and prioritizing factors affecting the establishment of teleradiology in a public hospital in Tehran, Iran, using the AHP technique.

In the developing countries, the provision of technologies and infrastructures is one of the factors influencing the use of modern technologies. The results of the current study also showed that the dimension of "technologies and infrastructures" was the most important factor. The basic infrastructures required for teleradiology include medical imaging equipment, information technology (IT) infrastructures, and the establishment of a suitable telecommunication infrastructure. Orphanoudakis et al. (14), and Nazvia and Kodukula (15) in their studies concluded that the basic infrastructures needed for telemedicine and teleradiology services were hardware infrastructures and medical imaging equipment, workstations, telecommunication networks, and network management and data transmission tools. Since one of the common problems of the developing countries is low bandwidth, creating a suitable telecommunication platform such as the use of broad bandwidth and applying the appropriate telecommunication technologies make it possible to transmit more data at a faster rate and medical images with better resolution, and ultimately make optimal use of teleradiology capacities and facilities. The results of most related studies conducted in Iran showed a lack of appropriate bandwidth for the transmission of medical information and images at a good speed and quality as the most important problem in the implementation of teleradiology infrastructure (12, 16), similar to the results of the current study.

In the current study, "costs and economic factors" was the 2nd most important factor affecting the establishment of teleradiology, in which "sufficient funding to create sustainable financial resources" was the most important sub-item from the studied experts' viewpoint. Availability of sustainable budget, provided by the government, as well as sufficient funds is essential to implement and work with telecommunication technologies such as telemedicine and teleradiology. In this regard, it is necessary to provide appropriate information to patients and introduce the advantages of using such technologies in terms of saving time and costs, and provide the optimal quality of services to them; then the managers and users' perception of being luxury and costly use is changed into the positive view about the establishment of these technologies. The results of the studies by Alaboudi et al. (17), Mars (18), Lewis et al. (19), Masjedi et al. (20), Hayavi Haghighi et al. (21), and Debnath (22) were aligned with those of the current study.

Atac et al. (4), in their study concluded that passing the related national and international laws can ensure the security of individuals' health data. The results of the studies by Marti-Bonmati et al. (23), and Pattynama (24) showed that establishing legal requirements and setting the required standards, as well as providing an appropriate infrastructure to meet these standards increase the confidence of both service providers and recipients in using these technologies. In the current study, the dimension

Table 2. The Results of One-Sample T-Test for Different Studied Variables Affecting the Establishment of Teleradiology[a]

Variable	Mean	Standard Deviation	T	Df	P-Value	Mean Difference	95% CI[b]	
							Lower	Upper
Training the technical and medical staff	4.6286	0.31522	28.297	29	< 0.001	1.75862	1.9015	1.3647
Technologies and infrastructures	4.6404	0.38677	22.840	28	< 0.001	1.64039	1.3349	1.5787
Confidentiality and security of information	4.3667	0.53326	14.037	29	< 0.001	1.36667	1.1675	1.8565
Legal requirements	4.5476	0.50415	16.244	27	< 0.001	1.54762	1.3521	1.1347
Costs and economic factors	4.5402	0.50915	16.291	28	< 0.001	1.54023	1.3466	1.9337
Creating a positive attitude	4.4741	0.47760	16.622	28	< 0.001	1.47414	1.2925	1.8556

[a] Test value = 3.
[b] 95% confidence interval of the difference.

Table 3. Prioritizing the Factors Affecting the Establishment of Teleradiology[a]

Variable	Weights (W)	Priority
Training the technical and medical staff	0.094	5
Confidentiality and security of information	0.134	4
Technologies and infrastructure	0.249	1
Legal requirements	0.161	3
Costs and economic factors	0.228	2
Creating a positive attitude	0.134	4

[a] Inconsistency ratio = 0.06.

of "legal requirements" received the 3rd priority, indicating its important role in the teleradiology systems and increasing their efficiency. The development of teleradiology standards provides a framework that ensures that patients' electronic information and images are accessible and transmitted at anytime and anywhere in a safe and secure manner.

Two dimensions of "confidentiality and security of information" and "creating a positive attitude" were placed in the 4th priority. Since the radiological data are mainly transmitted through open networks, it can inherently jeopardize the confidentiality of data, the integrity of information, as well as the access to images transmitted among the teleradiology workstations. Therefore, appropriate policies should be developed and implemented to reduce such risks (25). The development of security policies is the most important step in maintaining the confidentiality and security of information. A proper security policy is a set of rules that should be applied by all individuals, including patients, physicians and specialists, network administrators, and operational managers. The results of the study by Ruotsalainen (25) showed that the methods of providing security and privacy in the teleradiology systems should be devised before the system is launched, and tools needed to increase the security and privacy, including authentication methods, data encryption, and users' accounts in order to write the reports, should be properly selected. The results of the studies by Al Ameen et al. (26), and Bashshur et al. (1), were in line with those of the current study.

Concerning the "creating a positive attitude", making changes in the habits of physicians and managers to take advantage of this technology, as well as changing their mentality about the applicability and accuracy of the services of this system are very important. Jennett et al. (27), believed that the medical staff's resistance was an important factor in the failure of telemedicine and teleradiology technologies. Taylor also in a study concluded that many physicians and patients cannot judge the correctness of the telemedicine process due to lack of awareness, and if they know that telemedicine can provide them with more advanced services, they may even prefer telemedicine to the ordinary care (28). Therefore, the involvement and cooperation of managers and physicians in the implementation of teleradiology is of particular importance. The executive managers' support of implementing the teleradiology system and their collaboration with physicians in hospitals is necessary since their support accelerates the improvement of infrastructures, making appropriate plans and policies, strengthening coordination, and allocating the necessary resources. The results of the studies by Zarefi and Sharifat (12), Jacobs et al. (29), Hayavi Haghighi et al. (21), and Hailey (30) were consistent with those of the current study.

The least important dimension from the studied experts' viewpoint in the current study was "training the technical and medical staff". Since education and training contributes to the cultural development and teleradiology application advancement, its importance should not be overlooked. Education and training should be provided at different levels of users, including technologists and radiologists, and materials required for each group should be

Table 4. Prioritizing Sub-Items Affecting the Establishment of Teleradiology

Variable/Sub-Items	Weights (wk)	Priority	Inconsistency Ratio
Training the technical and medical staff			0.05
Organizing theoretical and practical classes to teach the teleradiology software to the physicians and other medical staff according to the needs and access	0.292	2	
Providing the necessary facilities and equipment to train the technical and medical staff	0.331	1	
Creating and updating academic disciplines in relation to the modern communication and information technologies	0.137	3	
Inviting the foreign academic members and designers of teleradiology software and applications to conferences and seminars	0.124	4	
Providing continuous education and holding retraining courses	0.116	5	
Technologies and infrastructures			0.06
Hardware Equipment and Digital Imaging Systems	0.195	3	
Using suitable telecommunication facilities and technologies such as appropriate bandwidth	0.241	1	
Standard server and server room equipped with alert systems	0.177	4	
Information compression, storage and transfer software such as PACS	0.220	2	
Network stability and connectivity to other networks	0.167	5	
Confidentiality and security of information			0.04
Developing security policies	0.263	1	
Applying user authentication systems such as the username and password	0.227	2	
Data integrity	0.148	5	
Encrypting programs containing patients' information in order to prevent unauthorized access	0.187	3	
Enforcing the computer crime laws	0.174	4	
Costs and economic factors			0.05
The costs of purchasing equipment and software required	0.151	3	
The costs of training the medical and technical staff	0.109	5	
Sufficient funding to create sustainable financial resources	0.396	1	
The costs of equipment maintenance	0.124	4	
The costs of modernization of communication infrastructures	0.220	2	
Legal requirements			0.09
Passing laws on performing activities in cyberspace in the field of medical sciences	0.060	7	
Passing required laws on issuing licenses	0.062	6	
Passing laws on maintaining the safety of patients' information in order to prevent unauthorized access	0.124	4	
Passing laws on the liability and tracking errors and forensic medicine cases in teleradiology	0.179	2	
Passing laws on medical insurance and how to compensate	0.154	3	
Establishing and implementing standards for teleradiology	0.246	1	
Passing laws on patient rights and obtaining informed consent	0.121	5	
Passing laws on earning revenue from teleradiology	0.052	8	
Creating a positive attitude			0.08
Informing and attracting patients' trust in the benefits and quality of teleradiology services	0.084	5	
Make slow and gradual changes for adaptability	0.068	8	
Building trust in physicians about the quality and accuracy of teleradiology services	0.137	3	
Ensuring the employees to maintain their jobs	0.081	6	
Making changes initially by young employees	0.079	7	
The participation of insurance organizations and the increases in the insurance coverage of services	0.141	2	
Visiting the successful hospitals and medical centers which use teleradiology technologies	0.038	9	
Active participation and cooperation of managers and physicians in the implementation of teleradiology	0.181	1	
Holding briefing sessions to increase the physicians and medical staff awareness and prepare them for changes	0.128	4	

provided in different ways and with different methods. The results of the study by Whitten et al. (31), showed that the doubts and worries at the beginning of using telemedicine changed into the interest and desire after providing appropriate training by experienced people and successfully implementing this technology. The results of the studies by Chan and May and Veitch the importance of appropriate educational equipment in increasing the speed of transmission and understanding the medical concepts (32, 33) were in line with those of the current study.

Although the results of the current study indicated the willingness of physicians and managers to use the teleradiology technology, the use of this technology is accompanied by many challenges due to the lack of adequate

infrastructures and its relatively high initial costs. Therefore, in order to establish and implement the teleradiology technology, the issues of infrastructure development and adequate budget allocation should be the 1st priorities of managers and heads of hospitals and universities. Although at first glance such technology may be considered as a costly technology, it is affordable and economic in the long run through saving the costs, covering a wide range of patients, increasing access to services, and overcoming the problems caused by the lack of radiologists, especially in the large hospitals. Therefore, in order to implement this technology, adequate financial resources and incentives should be provided to hospitals by the government, i e, the ministry of health and social security organization. Also, the development of telecommunication infrastructures such as launching the national health network (SHAMS) can help to implement the teleradiology services.

The lack of related studies and accurate statistics to identify factors affecting the establishment of teleradiology and the use of AHP technique can be some limitations of the current study. Therefore, it is suggested that the fuzzy AHP be used to identify more important factors and prioritizing them, since in the traditional AHP although the studied experts used their skills and competencies to make comparisons, this technique cannot fully reflect the style of human thinking. The application of fuzzy numbers has more compatibility with verbal and sometimes vague human phrases. Therefore, it is better to use the fuzzy numbers in real-world decision making. Moreover, in order to optimize the use of teleradiology technology, it is also recommended that studies be conducted to resolve communication problems among different teleradiology software, including PACS, hospital information system (HIS), and radiology information system (RIS), as well as to determine the effects of teleradiography on the speed of disease detection and mortality reduction in the rural and remote areas, and also to identify the effects of teleradiology technology on reducing the costs of imaging departments. In general, it can be concluded that the most important factors in the establishment of teleradiology in terms of experts were technology and infrastructures, and costs and economic factors.

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Footnotes

Authors' Contribution: Ali Maher and Mohammadkarim Bahadori: study concepts and design; Mina Davarpanah: data collection; Mohammadkarim Bahadori and Mina Davarpanah: data analysis and interpretation of data; Mina Davapanah and Mohammadkarim Bahadori: writing the manuscript; Ramin Ravangard: revision and editing the manuscript. All authors read and approved the final copy of the manuscript.

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