Vol 4, Issue 2, Apr 2017
Journal of Health Management & Informatics
jhmi.sums.ac.ir
Original Article

An Assessment of Infrastructures of Telemedicine at Shiraz University of Medical Sciences

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Received 18 Sep 2016 ; Accepted 11 Jan 2017

ABSTRACT

Introduction: Telemedicine is defined as the ability to provide interactive health care by modern technologies and telecommunications which require related infrastructure and technologies. The aim of this study was to assess infrastructures of telemedicine at health centers, hospitals and clinics affiliated to Shiraz University of Medical Sciences.

Method: This is a cross-sectional study conducted in 2015 on health care facilities equipped with telemedicine. These facilities consisted of 15 health centers, three hospitals and two clinics which were studied through census sampling method. Data were collected using a standard checklist and analyzed using descriptive statistics through SPSS version 21.

Results: All the studied centers used laptop platform, of which 95% (19 Centers) had camera platform and 80% had monitors with full HD resolution. Of all the centers, 14.44% used clinical facilities and equipment and 85% (17 centers) had required facilities to hold video conferences. Totally, there was 21.31% of the required communicational protocol to establish telemedicine. The average internet network bandwidth of health centers was 644.68 MB/S.

Conclusion: According to the current condition of technical infrastructure of telemedicine, it is suggested that authorities make decisions and policies to develop and improve technical infrastructure for providing more advanced services in the field of telemedicine.

Keywords: Telemedicine, Assessment, Technical infrastructure

►*Please cite this paper as:*
Garavand A, Asadi H, Samadbeik M, Hasumi M, Mohammadi R, Abhari SH. An Assessment of Infrastructures of Telemedicine at Shiraz University of Medical Sciences. J Health Man & Info. 2017;4(2):51-56.

Introduction

In all health care systems in which spatial distance is the main factor, utilizing information and communication technology to exchange valid information for diagnosing and treating diseases, preventing injuries, performing researches and assessments, and continuous education of health care providers is inevitable (1). The emergence of health information technologies such as telemedicine has played a key role in the timely diagnosis and treatment of diseases, especially in remote areas and villages (2). Telemedicine is a new field in which modern telecommunication technologies are used for exchanging medical information. The main idea of telemedicine is based on the use of information and communication technologies to provide health care services in circumstances where spatial or time distance or both exist between health care consumers and health care providers (3).

Telemedicine has been defined by the American institute of telemedicine as an exchange of information from one site to another through electronic communications for the improvement of patients and providers' level of education (4). Furthermore, as telemedicine is cost-effective, it is considered as an appropriate alternative for clinical interventions which prevent morbidity and mortality and improve health level of a society (5). Although there is a consensus among most of the researchers and experts about the effectiveness of this technology in providing specialized services and increasing access to these

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services, this technology is not considered as the ultimate solution to overcome all the problems related to lack of financial and human resources in the healthcare system. It is recommended that telemedicine should be considered as a complementary solution to resolve some of the problems in the way of providing high quality care services (6).

The most important advantages of telemedicine include improvement of health care quality and productivity, improvement of accessibility to medical care for rural and underpreviledged areas, increase of justice in health, promotion of professional interaction among physicians and specialists (especially in rural and urban areas), reduction of costs, reduction of unnecessary traffic and travels, reduction of patients' traveling time, possibility of working in several hospitals and health centers by specialists, increase of interactions and opinion exchanges among physicians and specialists, and more importantly reduction of mortality, morbidity and disabilities (7).

Establishment of health information systems, especially telemedicine, requires related and necessary infrastructure (8); therefore, in developing countries providing theses infrastructures is the first thing that should be accomplished. However, considering the increasing development of telemedicine systems, there is a need to formulate and develop new rules and guidelines in such fields as information confidentiality, legal responsibility and commitment and the validity of documentation of medical records. In Iran, few studies have examined the telemedicine technical infrastructure (9). Hayavi et al. in their study entitled "the feasibility of implementing telemedicine in Hormozgan University of Medical Sciences" concluded that all centers affiliated to Hormozgan University of Medical Sciences had access to internet, and the network bandwidth for each center was 128 KB/S. This University also lacked the required video conference equipment for telemedicine process which showed that in terms of infrastructures, the University is faced with the lack of network bandwidth, and it is only able to provide telemedicine technology in a store and forward (asynchronous) mode (10).

Ghaed-Amini et al. in their study entitled "assessment of telemedicine infrastructure in Shahr-e-Kord's Ayatollah Kashani educational hospital" found that this hospital was in a decent state in terms of information technology and medical equipment. They also found that hospital's information system infrastructure and database had the minimum level of regional standards and could be used as a base for establishment of telemedicine system (11).

Rahimzade et al. conducted a study with the aim of assessing the feasibility of implementing and establishing telemedicine in Ardabil's Emem Khomeini hospital, in which 108 specialists participated; they found that despite favorable administrative culture, there are no favorable communicational infrastructure and enough related knowledge among specialists; hence, the studied hospital is not currently able to provide telemedicine services and it is recommended that hospital chief managers formulate strategies for preparing telemedicine infrastructure in close future (8).

In other countries, studies have also been conducted in the field of telemedicine. Kodukula et al. (2011) in their study on "evaluation of critical success factors for telemedicine implementation" concluded that communication and information technology infrastructures such as access to hardware and software infrastructure, adequate network bandwidth, clear definition of telemedicine referral mechanisms, and adequate well-trained human resources are the most important factors in successful implementation of telemedicine. He mentioned other critical success factors for telemedicine implementation as follows: Supporting regulations and policies of the government, political support, and availability of financial resources (12).

In a study that reviewed the critical factors in successful implementation of telemedicine, the authors found that in addition to human resources, telecommunication lines and communications equipment are vital for successful implementation of telemedicine technology. They also concluded that in all of hospitals in Malaysia only a few are prepared and equipped for tele- medical consulting and most of the hospitals lack these equipment (13). Therefore, the present study specifically assessed the infrastructures of telemedicine at health centers, hospitals and clinics affiliated to Shiraz University of Medical Sciences.

Method

This is a cross-sectional study conducted in 2015 on all health care facilities of Shiraz University of Medical Sciences equipped with telemedicine. It is worth mentioning that information and communication technology management of Shiraz University of Medical Sciences equipped 20 affiliated health centers in Shiraz and other cities (15 centers in cities as advice-receivers and five centers in Shiraz as advice-givers) for setting up telemedicine system. Considering the importance of studying all health care centers, they were enrolled in the study using census method. The studied health care centers were as follows: located in cities including Lar, Eghlid, Safashahr, Kharame, Arsanjan, Firouz-Abad, Mamasani, Abadeh, Neyriz, Kovar, Sarvestan, Khenj, Lamard, Estahban, and Darab; two clinics in Shiraz including Shahid-Motahari and Emem-Reza; and three hospitals in Shiraz including Hafez, Shahid-Rajaei, and Madar & Kodak (Mother & Baby). The data collection instrument was a valid and reliable researcher-made checklist designed based on assessment standards of leading countries in Telemedicine including America, Australia and India (14-16). Using back translation method, English standards were translated into Persian and then translated back into English by an interpreter. The checklist was designed after resolving the conflicts.

To confirm the content validity of the checklist, we used opinions of three professors of health information management department of Shiraz University. The checklist consists of 57 questions in three main dimensions including technical infrastructures (hardware and medical equipment), communicational and network infrastructures, and software assessment. The first part of the checklist (technical infrastructures) includes a variety

of required platforms for implementing telemedicine such as Cell phone, PDA, Tablet PC, Laptop PC, and Desktop PC. Platform accessories included camera, microphone, headset, monitor connectors, clinical devices connectors and related facilities for holding video conference. The second part (communicational and network infrastructures) includes the type and resolution of platforms' monitor images in full HD and other resolutions, bandwidth (mb/s), and clinical equipment and devices such as PACS, Tele-pathology microscope + camera, Fetal Heart Rate monitor, Pulmonary Function Test machine, Portable X-ray machine, Glucometer, Sonography machine, X-Ray Digitizer, and Digital ECG. Required communicational protocols for implementing telemedicine included CDMA, Wireless LAN, ISDN, GPRS/GSM/3G, Optical fiber, Leased Line, POTS PSTN, and VSAT.

All checklist questions, except for the amount of bandwidth which needed to be mentioned in terms of mb/s, had two options to select: have and do/does not have. The third part of the checklist, which was designed by telemedicine council of Shiraz University of Medical Sciences, to assess the capabilities of telemedicine software, consisted of 24 questions about capabilities such as ability to access, save, display patient information, and other abilities. Assessments were done by two health information technology experts, face to face and separately. In case of different opinions of two experts, assessments were referred to the third expert. After completing the checklist, and entering data into SPSS version 18 21, data were analyzed using descriptive statistics based on research objectives.

Results

As shown in Table 1, 70% of health centers had desktop PC useable as platform in university telemedicine system, 100% of centers had laptop useable as platform in university telemedicine system, and no center used PDA and tablet pc platforms. Cellphone platforms were used in Hafez hospital for medical tele-consultations. Except Shahid-Rajaei hospital, which had no platform accessories for medical tele-consultations, all the studied health centers had cameras connected to platforms and their platform accessories were connectable to clinical devices. Results of the present study showed that 70% of the studied health centers had monitors with full HD resolution images and the rest had monitors with other resolutions.

As Table 1 shows, of all 15 advice-receiver health centers only Kharame health center had Gluco-meter and the rest had no clinical equipment or devices. Our results also showed that 85% of the studied centers had video conference equipment. It was shocking to find that none of advice-giver health centers (health centers in Shiraz) had required videoconference equipment for telemedicine. Table 1 indicates that none of the studied health centers, in their communicational infrastructures, used VSET protocols, old simple telephone services, network public telephone, and integrated digital network services; they mostly used leased line protocols. The findings of present study showed that bandwidth average of health centers was 644.67 mb/s. Of all the studied centers, 12 (63%) had optical fiber infrastructure with bandwidth of 1000 mb/s, four centers (21%) had wireless infrastructure with bandwidth of 54 mb/s, and three (16%) had wireless infrastructure with bandwidth of 11 mb/s. Based on Table 2, telemedicine software used by Shiraz University of Medical Sciences had 19 abilities of all 24 studied abilities (79.16 percent).

Discussion

Results of the present study showed that in tele-consulting system of all the studied centers there was laptop while in no center portable devices and platforms (Cell phone, PDA, Tablet pc) were available. Since the designed telemedicine software was web-based, portable platforms can be useful in providing broader services in different places and greater use of telemedicine benefits. In a report by a technical working group on telemedicine standards published in India (2003), it was stated that in most of telemedicine systems, hardware platform includes a personal computer (PC) among which desktop PCs are the typical ones. However, regarding the planned program and space limitations, the platform can also be of various types of portable ones such as mobile phones, laptops or personal digital assistants (PDA) (17).

Results of this study also showed that due to the existing poor condition of clinical equipment and devices in advice-receiver centers, it is not practically possible to provide a wide range of telemedicine services. However, it is possible to hold visual conferences and provide services which do not need clinical examinations, sending patients' medical images, and taking the patient's vital signs such as telepsychiatry, genetic counseling, psychological counseling, etc. Shiraz University of Medical Sciences (SUMS) for holding other specialties' services like teleradiology, telepathology, telecardiology, teleneurology, telemonitoring, etc requires clinical equipment and devices, especially in advice-receiver centers. In a study conducted by Ghaed-Amini, it was found that, unlike SUMS health centers, Ayatollah Kashani hospital was in a good condition in terms of required information technology infrastructures to implement telemedicine system. This result doesn't match with our results found in this study (8).

Other results of this study indicated that 70% of the studied centers had monitors with high quality and resolution (full HD) and other 30% of the centers had monitors with other image resolutions. Considering the importance of the resolution of the monitors in disease recognition by consulting physicians in specialties such as teleradiology, telepathology and other image-related diagnoses and according to our results which showed none of the studied centers in Shiraz had high quality monitors, we can conclude that these centers are in a poor condition. However, American Radiology College in a report on teleradiology technical standards (2012) states that monitors used for teleradiology should be of the type of liquid crystal display with high definition (HD) resolution (4).

Table 1. Frequency distribution of equipment for tele-medical consulting

	The Equipment Lateral*	Clinical equipment**	Communicational protocols ***
Lar	C, S, Mph, MCC, CECC	-	Leased Line, GPRS/GSM/3G
Eqlid	C, S, Mph, MCC, CECC	-	Leased Line
Safashahr	C, S, H, MCC, CECC	-	Leased Line, Wireless LAN
Kharameh	C, S, Mph, H, MCC, CECC	GM	Leased Line
Arsanjan	C, S, Mph, MCC, CECC	-	Leased Line
Firuzabad	C, S, Mph, H, MCC, CECC	-	Leased Line, Optical fiber
Mnmasani	C, S, Mph, H, MCC, CECC	-	Leased Line, GPRS/GSM/3G, Wireless LAN
Abadeh	C, S, Mph, H, MCC, CECC	-	Leased Line, GPRS/GSM/3G
Neyriz	C, S, Mph, H, MCC, CECC	-	Leased Line, GPRS/GSM/3G
Kavar	C, S, MCC, CECC	-	Leased Line, GPRS/GSM/3G
Sarvestan	C, H, MCC, CECC	-	Leased Line, GPRS/GSM/3G
Khonj	C, S, MCC, CECC	-	Leased Line
Lamerd	C, S, Mph, H, MCC, CECC	-	Leased Line
Estahban	C, S, Mph, H, MCC, CECC	-	Leased Line, GPRS/GSM/3G
Darab	C, S, H, MCC, CECC	-	Leased Line
Motahari clinic	C, Mph, H, MCC, CECC	DECG, X, SM, PFTM	Optical fiber, Wireless LAN,
Hafez hospital	C, S, H, MCC	DECG,X, SM, PXM, FHRM, TPM+C, PACS	Optical fiber, Wireless LAN,
Shahid Rajaei hospital	-	SM, PXM, FHRM, PACS	Optical fiber, Wireless LAN,
Ghadir Mother and child hospital	C, S, Mph	DECG,X, SM,TPM+C, PACS	Optical fiber, Wireless LAN, CDMA
Emam Reza clinic	C, S, Mph, H, MCC, CECC	DECG,X, PFTM	Optical fiber, Wireless LAN,
Frequency	C(19), S(17), Mph(13), H(13), MCC(18), CECC(17)	DECG (4), X (4), SM (4), GM (1), PXM (2), PFTM (2), FHRM (2), TPM+C (2), PACS (3)	VSAT (0), POTS PSTN (0), Leased Line (15), Optical fiber (5), GPRS/GSM/3G (7), ISDN (0), Wireless LAN (7), CDMA (1)
Frequency present	C (95%), S (85%), Mph (65%), H (65%), MCC (90%), CECC (85%)	DECG (20%), X (20%), SM (20%), GM (5%), PXM (10%), PFTM (10%), FHRM (10%), TPM+C (10%), PACS (15%)	VSAT (0), POTS PSTN (0), Leased Line (75%), Optical fiber (25%), GPRS/GSM/3G (35%), ISDN (0), Wireless LAN (35%), CDMA (5%)

* C (Camera), S (Speaker), Mph (Microphones), H (headset), MCC (Monitor connection Capability), CECC (Clinical Equipment connection capability)

** DECG (Digital ECG), X (X-Ray Digitizer), SM (Sonography machine), GM (Glucometer), PXM (Portable X-ray machine), PFTM (Pulmonary Function Test machine), FHRM (Fetal Heart Rate monitor), TPM+C (Tele Pathology Microscope + Camera), PACS

*** VSAT, POTS PSTN, Leased Line, Optical fiber, GPRS/GSM/3G, ISDN, Wireless LAN, CDMA

From 1998 to 2011 about 132546 episodes of telemedicine services including telepathology, teleultrasound, and real-time teleconsultations were used in Alentejo, Portugal. Alentejo centers were equipped with video conference facilities with high resolution and convenient access to patients' clinical information (18). According to our result, most of the consult-giver centers lack video conference equipment; therefore, for wider use of telemedicine benefits, it is necessary to equip these centers with aforementioned equipment. In a study done by Hayavi Haghighi et al. (2011), it was concluded that health centers affiliated to Hormozgan University of Medical Sciences lack video conference facilities. In comparison to this result, our findings showed that in terms of video conference equipment SUMS is in a more favorable condition than Hormozgan University of Medical Sciences (10).

Findings of the present study revealed that none of the 20 studied centers, in their communicational infrastructures, used VSET protocols, old and simple telephone services, public telephone network, and integrated digital network services, and other protocols have not been fully used and integrated. According to our findings in 12 centers, which have benefited from optical fiber infrastructures, the amount of bandwidth was sufficient for implementing telemedicine consultation. As only five out of all centers in Shiraz use optical fiber, more centers can be selected (equipped) for implementation of telemedicine consultations. Tourani et al. (2011) in their study found that only 60% of the surveyed hospitals had required communicational equipment for implementing telemedicine consultation network (19).

In a study done by Hayavi et al., it was found that all centers affiliated to Hormozgan University of Medical Sciences

(HUMS) have access to the Internet. This accessibility had been defined privately (not accessible to users outside the university) and its input bandwidth was 4 mb/s. The problem was that the internet was shared between users and because of high number of users, average bandwidth for each center declined to 128 kb/s. Current bandwidth of HUMS is only adequate for the lowest level of telemedicine and thus increasing bandwidth and providing the required technology infrastructures to optimize the use of telemedicine technology seems necessary (10). Jonse et al. (2012) in their study concluded that low network bandwidth is a common problem in developing countries. In this case, the best use of telemedicine is in tele-continuing education and tele-consultation (20).

Use of telemedicine with low bandwidth (112-128 kb/s) in family medical consultation has resulted in high effectiveness of tele-consultation and satisfaction of patients, local providers, and medical specialists. It also showed that consultation through telemedicine, instead of telephone, has improved the quality of care. Other results of the present study showed that the mentioned software, out of 24 factors assessed by researchers, included 19 (79.16 %) factors. In a study by Yellowlees (2005), it was found that data transmission media and equipment used in telemedicine services should be appropriate to support common practices (21). It should be insured that the existing hardware and software are able to do considered practices with a reasonable cost, and also appropriate technical support is available. Selecting software and telemedicine sites should be based on scientific researches and studies, and the considered system should also be user-friendly (21).

Conclusion

Results of the present study indicated that telemedicine technical infrastructures of Shiraz University of Medical Sciences are in relatively suitable condition. Required medical equipment exists in Shiraz University of Medical Sciences telemedicine system. Shiraz University of Medical Sciences covers 1511 heath care centers in urban and rural areas of Fars province which are connected to the University network through the existing communication infrastructures and can be used in telemedicine project of the University.

Of all urban and rural centers affiliated to Shiraz University of Medical Sciences, 100 centers through asymmetric digital subscriber line and 28 urban health centers through wireless, and others through general packet radio service have been connected to the University network.

Table 2. Assessment of capabilities of Telemedicine Software used in SUMS

Telemedicine Software Capabilities	status
Access patients' information	√
Save patients' information	√
Display patients' information	√
Transmitting patient information through different communication links (more than one link)	√
Planning and timing visits with GP (Physician)	√
Receive images and documents through scanner	√
Receive video and other types of data through medical equipment output and convert it into DICOM format	-
convert DICOM formats into non-DICOM formats	√
Create patient record supported by the software	√
Receive patient demographic information such as full name, national identification number, patient number, address, telephone, insurance status and etc.	√
Receive patients history such as previous diseases, currents diseases, details of treatments and previous interventions	√
Receive details of medical examinations such as checkups, clinical and systemic examinations	√
Attach audio files in formats like WAW, MP3, and etc. to patients' medical record	√
Attach audio visual files captured by devices. Images and videos can be received directly from imaging equipment or images can be scans of pictures.	-
Attach any kind of file formats such as Doc, pdf, Excel, etc.	√
Attach DICOM and non-DICOM video files	-
Determine the level of authorized access for different users of the system, including the main physician, consulting physician, nurse, physiotherapist, secretary, operator, …	√
make various reports based on performed medical examinations (e.g. report about the number of consultations carried out within a specified interval of time or by a determined physician)	-
Receive and record comments of main and consultant physicians and attach them to the patient's medical records	√
Record details of meeting of the Telemedicine such as duration, date and time of the meeting.	√
Record summary of the discussions and issues raised at the meeting of the Telemedicine	√
Record physicians diagnosis and experts opinion and additional explanations of medical staff	√
Record physician treatment plan including orders for diagnosis and treatment measures, medicines, prescriptions, record patients	√
following for treatment and other actions performed	-
Hold meeting and sessions using video conference	√

All Shiraz University of Medical Sciences hospitals in Fars cities have a network bandwidth of 2 mb/s.

Based on the results obtained, it is recommended that authorities should equip the centers determined for providing telemedicine services to portable platforms such as tablets and smart mobile phones. Considering the network being busy in all the existing centers, they should also pursue the improvement of network bandwidth. As the software used for telemedicine has suitable capabilities, for successful implementing of telemedicine it would be more effective to determine some of the specialists and scientific board members as leaders and managers. It is also recommended that implementation of PACS system and image-related specialties telemedicine such as tele-radiology, as its benefits are tangible for physicians, patients and managers, should start.

Acknowledgment

This study is the result of an independent research project that was conducted without any financial support, researchers appreciate all those who helped in doing and completing this research project.

Conflict of Interest

None declared.

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