Research Paper: Presenting a Model for Telemedicine in Earthquake for Iran

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Citation: Kheyrati L, Keshvari H, Fatehi F, Hemmati M, Khankeh H, Habibisaravi R, et al. Presenting a Model for Telemedicine in Earthquake for Iran. Health in Emergencies and Disasters Quarterly. 2019; 4(3):157-164. http://dx.doi.org/10.32598/hdq.4.3.157

doi: http://dx.doi.org/10.32598/hdq.4.3.157

Article info:
Received: 22 Oct 2018
Accepted: 13 Feb 2019
Available Online: 01 Apr 2019

Keywords:
Telemedicine, Disasters, Emergency, Earthquake, Iran

ABSTRACT

Background: Iran is a country with a high rate of natural disasters like earthquake. The environmental conditions slow down the delivery of health services, especially in the event of disasters. The modern technologies such as telemedicine are appropriate for facilitating disaster relief operations after an earthquake. This study aimed to develop a model for the implementation of telemedicine in an earthquake.

Materials and Methods: The study was carried out using a mixed-methods research in three phases: 1. Review of the literature; 2. Qualitative study (modeling); and 3. Delphi method (validation of the model). Databases of Google Scholar, Web of Science, Scopus, and PubMed were searched from 1990 to 2019 with the keywords of "telemedicine" AND "disaster" OR "emergency" AND "earthquake". After screening of the retrieved records, 13 articles met the eligibility criteria and were included in the review study. Ten experts extracted all key elements of telemedicine in the disaster from the articles and categorized them in 6 themes with 38 subthemes. The model of telemedicine in the earthquake was finalized with 2 rounds of Delphi with groups of selected volunteer experts.

Results: In the first phase of the study, 6 key themes (telecommunication infrastructure, technical infrastructure, financial infrastructure, health infrastructure, organizational infrastructure, social infrastructure, and cultural infrastructure) with 38 subthemes of telemedicine for implementing in the disaster were obtained. At the conclusion of the third phase of the study, 6 key themes with 33 subthemes contributed to the model of telemedicine in the earthquake. Telecommunication infrastructure with a maximum score of 9.24 earned the priority, and social and cultural infrastructure themes with the minimum score of 7.53 came in the end.

Conclusion: The model derived from this study can be used as an applied telemedicine model in an earthquake. We suggest that the results of this study be implemented as a theoretical model, or in a pilot study in a region of the country, and to be evaluated by regarding mortality reduction. We also recommend that a comparative study for using telemedicine in other types of disasters be undertaken.

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1. Introduction

In recent decades, longer life expectancy resulted in an increasing demand for health care. The use of Information and Communication Technology (ICT) is a way to expand health services to these growing needs [1]. ICT has various applications in health services in many fields. The health information network, remote medical networks, and patient's electronic records are examples of health information technology applications [2].

Telemedicine, as a new technology in the 21st century, is one of the latest ICT technologies that can be used for delivering health services remotely [3] . High-speed telecommunications systems and the invention of devices capable of capturing and transmitting images in digital form had main roles in development [4] . Not only using proper hardware and software is essential, but we also need expert users [5]. There are four factors for prospering telemedicine: therapists' motivation, proper infrastructure, ongoing investment, and technical support [6].

Providing health services in disasters is one of the essential applications of telemedicine. In the event of disasters, local health facilities can be severely damaged– local hospitals and clinics may be physically damaged or inaccessible. In this situation, various telemedicine services could be applicable. Distance counseling, distance education, remote monitoring, and remote operation, as well as various types of data transmission (text, audio, image, etc.), are among these services [7]. The implementation of the telemedicine system can be effective in solving health problems in affected areas, especially during the early hours of the disaster.

The National Aeronautics and Space Administration (NASA) was the first organization that used telecommunication technology in the Mexico City earthquake in 1985. The disaster managers and rescue and relief personnel communicate with each other by satellite voice communication [8].

So many disasters occurred in Iran previously and placed it among the top 10 countries with disaster occurrence in the world. Seismic activity is the most frequent hazard in Iran, and several major faults cross most area of the country [9].

Iran has special environmental and geographical conditions as well. There are many mountainous and desert areas in Iran [10]. In these conditions, we need new technologies to meet the health requirements of the disaster-affected population. Given the special circumstances of Iran, telemedicine can be considered as one of the ways to provide health services in disasters. The present study was designed to provide a practical model for telemedicine implementation in disasters in Iran, especially in earthquakes.

2. Materials and methods:

According to the research objectives, the present study was carried out using a mixed-methods research in three phases: a review of articles, qualitative study (modeling), and Delphi method (validation of model).

In the first phase, available articles were reviewed to determine the factors affecting the successful deployment of telemedicine in disaster. All databases such as Google Scholar, Web of Science, Scopus were searched from 1990 to the end of 2017 with the keywords of "telemedicine" And "disaster" Or "emergency" And "earthquake". The inclusion criteria were articles in English or Farsi published up to 2019, about telemedicine, disaster, or emergency and earthquake. According to title and abstract, of 3024 articles, all irrelevant documents ruled out. After reading the content of 76 remaining articles, 13 articles with full text remained for further analysis (Table 1). All key themes of telemedicine in the disaster were extracted from articles. With the discussion in the expert panel of 10 selected professionals, all elements were categorized as 6 key themes with 38 subthemes. The participants gave a score to all items from 1 to 5. Mean, median, mode, and standard deviation values of each item were calculated. Finally, themes and subthemes were ranked by mean scores.

In the second phase, a group of 35 selected volunteer experts (Table 2) enrolled in Delphi to finalize the initial framework. A researcher-made questionnaire was used for data collection, which was validated by face validity, and its reliability was positively evaluated by the Cochran's formula with the Cronbach alpha coefficient of 0.911. The participants scored each item from 1 to 10 for the final scoring and ranking. At the end of this phase, the applicable model of telemedicine in the disaster was determined.

Subsequently, in the third phase, the second round of Delphi with 29 remaining experts performed to finalize modeling of telemedicine in disasters with the focus on the earthquake. SPSS V. 18 was used for doing statistical analyses and preparing descriptive results.

Table 1. Articles used in the review

No.	Author(s)	Title	Year
1	Bashshur et al. [1]	Telemedicine: Theory and Practice	1997
2	Crane, Wiegand, Kamali, Reif, Wratni, Montante R, et al. [2]	Telemedicine Delivery and Successful Reimbursement in Toxicology	2018
3	Nicogossian & Doarn. [3]	1988 Armenia Earthquake and Telemedicine: Lessons Learned and Forgotten, Telemedicine and e-Health	2011
4	Dullet et al. [4]	Impact of a University-based Outpatient Telemedicine Program on Time Savings, Travel Costs, and Environmental Pollutants	2017
5	Helsel BC et al. [5]	Telemedicine and Mobile Health Technology are Effective in the Management of Digestive Diseases: A Systematic Review	2018
6	Strode, Gustke, Allen. [6]	Technical and Clinical Progress in Telemedicine	1999
7	Østbye & Hurlen. [7]	The Electronic House Call: Consequences of Telemedicine Consultations for Physicians, Patients, and Society	1997
8	Garshnek, Frederick, Burkle. [8]	Applications of Telemedicine and Telecommunications to Disaster Medicine: Historical and Future Perspectives	1999
9	Latifi & Tilley. [11]	Telemedicine for Disaster Management: Can It Transform Chaos Into an Organized, Structured Care From the Distance	2014
10	Ahmed, Sandhya, Shankar. [15]	ICT's Role in Building and Understanding Indian Telemedicine Environment: A Study	2019
11	Handschu et al. [17]	Telemedicine in Emergency Evaluation of Acute Stroke: Inter-rater Agreement in Remote Video Examination With a Novel Multimedia System	2003
12	Lambrecht. [18]	Emergency Physicians' Roles in a Clinical Telemedicine Network	1997
13	Czaplik [19]	Employment of Telemedicine in Emergency Medicine: Methods of Information in Medicine	2017

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3. Results

According to the first phase of the study, 6 key themes with 38 subthemes of applicable telemedicine for implementing in the disaster were obtained. Technical infrastructure with 11 subthemes and financial infrastructure with 4 subthemes had maximum and minimum subthemes, respectively (Table 3). In the second phase, all key themes and subthemes are scored by the participants individually. In this phase, social and cultural infrastructure themes obtained the minimum Mean±SD score of Mean±SD=7.29±2.07 and telecommunication infrastructure the maximum Mean±SD score of Mean±SD=8.93±1.68 (Table 4).

Table 2. Demographic characteristics of the participated experts

Demographics		No.(%)	Total/ No.(%)
SEX	Male	31(89%)	35(100%)
	Female	4(11%)	
Education Level	BS	6(17%)	
	MS	15(43%)	
	PhD	14(40%)	
Profession	Disaster management	4(13%)	
	Medicine	8(22%)	
	Information technology	23(65%)	

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Table 3. Key themes and subthemes of applicable telemedicine in disaster

Row	Key Themes	Subthemes
1	Telecommunication infrastructure	High-speed Internet
2		Communication network reliability (system design with plug-in equipment)
3		Bandwidth
4		The mobile network
5		The cable network
6		Satellite communication
7		Information Exchange Security
8	Technical infrastructure	The proper hardware
9		The proper software
10		Fast system installation
11		Possibility to move the system
12		User-friendly system
13		Compliance with system standards (audio and video transmission, etc.)
14		Compliance with information exchange standards
15		Providing simultaneous voice calling
16		Sustainable energy supply
17		Providing simultaneous video calling
18		Possibility of large-scale provision
19	Social and cultural infrastructure	Acceptance in society (the general public)
20		Acceptance and acceptability among service providers
21		Special training for servants
22		Public education for service recipients
23		Satisfaction of service providers
24		Satisfaction of recipients
25	Health infrastructure	Access to medical records and health of individuals
26		Observing the principles of medical ethics
27		Ability to communicate with specialized health center
28		Ability to communicate with the disaster affected area
29		Communication with CDC (Center for Disease Control and Prevention)
30	Financial infrastructure	Initial investment
31		Concurrent costs
32		Cost-effective service delivery
33		Fee for service providers
34	Organizational infrastructure	Legal considerations (definition of the law and instructions)
35		HTML Editor and Style Sheets
36		Compilation of the organizational chart of the operation process
37		Support for policy makers and managers
38		Ability to integrate matters into crisis response

Table 4. Descriptive statistics of key elements in the second stage

Statistics	Telecommunication Infrastructure	Technical Infrastructure	Financial Infrastructure	Health Infrastructure	Organizational Infrastructure	Social and Cultural Infrastructure
Mean	8.93	8.89	8.64	7.89	7.61	7.29
Median	10	9	9	8	7.5	7
Mode	10	10	10	8	7	9
Standard deviation	1.68	1.03	1.45	1.45	1.87	2.07

Health in Emergencies and Disasters Quarterly

In this phase, 5 subthemes were removed from the criteria because they obtained scores less than expectation. The "cable network" subtheme from telecommunication infrastructure theme, "acceptance in society" (the general public) and "public education for service recipients" subthemes from social and cultural infrastructure theme, the "cost-effective service delivery" and "fee for service providers" subthemes from financial infrastructure theme were removed from the criteria.

In the third phase, validation of the model was performed after rearranging subthemes. In this phase, the remaining 28 participated experts scored key themes and subthemes. Then, the highest priority went to telecommunication infrastructure with a maximum score of 9.24 and least priority to social and cultural infrastructure theme with a minimum score of 7.53 (Table 5).

According to the scores of themes and their subthemes, the final model was created with 6 key themes and 35 subthemes (Table 6).

In the final model, 2 subthemes obtained maximum scores, i.e. the communication network reliability of the telecommunication infrastructure theme and the initial investment of the financial infrastructure theme. The satisfaction of recipients' subtheme of the social and cultural infrastructure theme with the least score of 6.86 was placed in the bottom.

4. Discussion

In this study, we tried to create an applicable model of telemedicine in disasters for Iran, with the focus on earthquake. Given that earthquake is one of the most important natural disasters in our country, and about 93% of Iran are at risk of the earthquake [11], we need new technologies such as telemedicine to provide health services in the affected areas. Because of the rapid development of telecommunication industry in Iran with the improvement of communication all over the country, there is a good chance for using telemedicine [12].

There are many successful implementations of remote health services in the world from the beginning of their usage since the mid-1980s. Past experiences allow scientists to extrapolate how telemedicine will evolve to meet future needs in disasters [8]. From the first usage of telecommunication technology in Mexico City earthquake in 1985 to remote surgery in recent years, telemedicine has developed unbelievably. In recent years with the development of cellular phones, counseling and medical

Table 5. Results of prioritizing the key themes of applicable telemedicine in earthquake

Key Theme	Score	Rank
Telecommunication infrastructure	9.24	1
Technical infrastructure	9.22	2
Financial infrastructure	8.98	3
Health infrastructure	8.19	4
Organizational infrastructure	7.87	5
Social and cultural infrastructure	7.53	6

Health in Emergencies and Disasters Quarterly

Table 6. Ranked key themes and subthemes of applicable telemedicine in earthquake

	Key Theme	Subtheme	Mean	Median	Mode	SD
1	Telecommunication Infrastructure	Communication network reliability	8.93	10	10	1.33
2		Satellite communication	8.75	9	8	1.21
3		Bandwidth	8.39	8.5	10	1.61
4		Mobile network	8.04	8	8	1.75
5		High-speed Internet	7.61	8.5	10	2.68
6		Information Exchange Security	7.32	8	10	2.21
7	Technical infrastructure	The proper software	8.71	9	10	1.21
8		The proper hardware	8.68	9	9	1.19
9		Fast system installation	8.57	9.5	10	1.97
10		User-friendly system	8.57	9	10	1.55
11		Sustainable energy supply	8.57	9	10	1.67
12		Possibility to move the system	8.46	9	10	1.91
13		Providing simultaneous voice calling	8.04	8	10	1.55
14		Providing simultaneous video calling	7.68	7	7	1.91
15		Compliance with information exchange standards	7.29	8	8	1.94
16		Compliance with system standards (audio and video transmission, etc.)	7.14	7	7	1.96
17		Possibility of large-scale provision	6.96	7.5	9	2.41
18	Financial infrastructure	Initial investment	8.93	9.5	10	1.30
19		Concurrent costs	7.68	8	9	1.87
20	Health infrastructure	Access to medical and health records of individuals	7.11	8	8	2.23
21		Observing the principles of medical ethics	8	8	10	1.98
22		Ability to communicate with specialized health centers	8.14	8	8	1.60
23		Ability to communicate with the crisis management area of the region	8.75	9.5	10	1.38
24		Communication with CDC (Center for Disease Control and Prevention)	7.75	8	10	1.65
25	Organizational infrastructure	Legal considerations (definition of law and instructions)	8.07	8	10	1.80
26		HTML Editor and Style Sheets	8.61	9.5	10	1.77
27		Compilation of the organizational chart of the operation process (activation of the system)	8.21	9	10	1.77
28		Support for policymakers and managers	8.75	9	9	1
29		Ability to integrate matters into crisis response	8.14	8	8	1.41
30	Social and cultural infrastructure	Acceptance and acceptability among service providers	7.29	7	6	1.84
31		Special training for servants	8.32	9	10	2.11
32		Satisfaction of service providers	7.39	8	8	1.64
33		Satisfaction of recipients	6.86	7	8	1.96

Health in Emergencies and Disasters Quarterly

diagnostic interventions are available. Surgeons can do complicated operations with the help of reliable communication technology, such as long-term evolution [13].

In our study, the experts categorized key elements of a telemedicine application in 6 themes. Our study results indicated that having the appropriate telecommunication tools along with financing for the proper maintenance of the equipment is very important. The importance of these cases in other studies shows clearly the telemedicine conceptual framework. Innovation in Information and Communication Technology (ICT) with considerable investments in the field of healthcare informatics, resulted in improving and extending medical services in remote, unprivileged areas with important social and economic benefits [14].

To implement telemedicine in Iran, it is first necessary to identify the principle and partner organizations with a clear task description. Then the essential infrastructure should be developed according to specific goals. The most important infrastructures are the technical and telecommunication infrastructure (including telemedicine equipment, strong and efficient communications and the development of platforms, increased bandwidth and access to intranets and the Internet), social and cultural infrastructure (public education, special education for users, specialist physicians, medical and paramedical students and emergency aid staff), security infrastructure (coordination with network police, security information centers and electronic signatures), legal considerations (legal guidelines, rules and regulations related to health) and standardization infrastructure (information exchange standards, vocabulary, security, and system architecture).

Other studies also emphasized these obstacles in the implementation of telemedicine due to specific environments. In one study in India declared the role of ICT and the context of Indian society for implementing telemedicine. They noted the importance of telecommunication infrastructure along with economic and sociocultural infrastructure [15].

The vulnerability assessment of the equipment and facilities of the telemedicine infrastructure is very important. Reliable and persistent communication along with well-established devices in both side of telemedicine technology is mandatory. There are many automated solutions to help us control our telemedicine environment better [16].

5. Conclusion

In this research, due to the nature of the future and the novelty of the subject, the Delphi method was used to identify the key themes and subthemes of telemedicine implementation in Iran during an earthquake disaster. We believe that our model of telemedicine implementation is an appropriate model for Iran. We suggest that the results of this study be implemented as a theoretical model, or in the pilot study, in a region of the country. Then, the outcomes are investigated regarding the amount of mortality reduction. We also recommend that a comparative study is done for using telemedicine in other types of disasters.

Ethical Considerations

Compliance with ethical guidelines

There was no ethical considerations to be considered in this research.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. Farhad Fatehi received financial support from the Queensland Government through an Advance Queensland Research Fellowship.

Authors' contributions

All authors contributed in preparing this article.

Conflict of interest

The authors declared no conflict of interest.

Acknowledgments

The present paper has been extracted from a part of Master's dissertation of the first author at Faculty of Medical Engineering, Amirkabir University of Technology.

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