Chapter 4

Mobile Health Monitoring

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Additional information is available at the end of the chapter

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Abstract

Chronic diseases impose heavy burden and costs on the health industry in many countries. Suitable health procedures, management, and prevention of disease by continuous monitoring through modern technologies can lead to a decrease in health costs and improve people empowerment. Applying remote medical diagnosis and monitoring system based on mobile health systems can help significantly reduce health care costs and correct performance management particularly in chronic disease management. In this chapter, mHealth opportunities in patient monitoring with the introduction of various systems specifically in chronic disease are expressed. Also mHealth challenges in patient monitoring in general and specific aspects are identified. Some of the general challenges include threats to confidentiality and privacy, and lack of information communication technology (ICT), and mobile infrastructure. In specific aspect, some difficulties include lack of system interoperability with electronic health records and other IT tools, decrease in face-to-face communication between doctor and patient, ill-functioning of system that leads to medical errors and negative effects on care outcomes, patients, and personnel, and factors related to the telecommunication industry include reliability and sudden interruptions of telecommunication networks.

Keywords: monitor, challenge, advantage, mobile health, chronic disease

1. Introduction

Information technology, as a powerful tool, is the most important factor in increasing the efficiency and effectiveness of organizations. Various industries in order to maintain their existence in the current competitive environment and promotion of their outcomes have taken effective steps toward the use of these technologies. The health care industry is no exception from this rule. Different countries consider the information technology to promote the devel-

opment of health information and health system outcomes with regard to the importance of care industry, direct and indirect impacts on various aspects of community development [1].

Advent of mobile devices with capabilities of caring handy and easy is one of the modern effects of IT that application of them is growing especially in the industrial sector. Some of the mobile devices include cell phones, smart phones (mobile phones processing capabilities, storage, and intelligence communications), and personal digital assistants (PDA). These devices are equipped with communication capabilities such as the ability to connect through GSM/GPRS, Wireless LAN, and Bluetooth networks; hence their utilization will provide comfort for their users.

Using mobile devices seems inevitable because the health industry is facing challenges such as resource constraints like focusing resources on specific areas, for example, in large cities [2], rising health care costs, the need for immediate access to various health care data types such as audio, video, text for early detection and treatment of patients, especially in emergency situations, and difficult in rural areas, and increasing remote aid in telemedicine and home care [3].

A study in Denmark on the necessity of using mobile devices in hospital wards showed hospital staffs want to use mobile devices because of the need to participate in different physical locations, have instant access to information, and immediately contact specific individuals while serving the patients [4].

Easy to carry and quick access to information on mobile devices make them perfect tools for health care providers. Mobile devices provide opportunities and play an important role in consulting, diagnosis, treatment [5], medical education and research [6], conducting quick access to information during shift change sectors [7], chronic disease management [8], patient empowerment [9], rapid establishment of communication regardless of distance restraints [10], and lead to increase efficiency, effective management measures, and promotion of health achievements [11].

In a similar investigation at a cancer treatment center in Spain, it was found that short telephone calls for 3–5 min between medical staff and patients decreased emergency department visits and patients' visit to the center by 24–42% [12].

Wakadha et al. in Kenya showed in rural western Kenya mobile phone-based strategies and short message services (SMSs) are potentially useful to deliver reminders, cash transfers, and achieve high, timely, and sustainable immunization coverage [13].

Today, the use of health information systems which are fixed terminals just does not seem sufficient. Because these systems do not provide necessary information for health care providers in real time, the continuous rapid delivery of services to patients is interrupted [7]. Studies indicate that lack of timely access to patient information [14], discontinuity of the communication, and lack of coordination between service provider and health care team members [15] are the main causes of medical errors. The use of mobile devices in terms of emergency situation and telemedicine is crucial for instant access to patient information, entry and data processing of medical records on time, and when the shift health care services changes for providers of health services [16, 17].

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The use of mobile health programs is very interesting due to numerous benefits; however using these tools is still has many challenges. One of the approaches that significantly helps to reduce barriers is survey of advantages and obstacles of mobile devices usage. Studies of opportunities and strengthening them and identifying problems help to design proper planning and a roadmap for promoting the achievements of mobile health systems.

We begin the following section by discussing about the necessity of mHealth in chronic disease management especially in diabetes. In next part, the advantages of mobile health in patient monitoring at two groups of agent and nonagent based system are explained. After that, we describe the challenges of patient monitoring based on mobile health systems in general and specific aspects. Finally, we explain one project as a case study about developing framework for agent-based diabetes disease management system in national level based on user's perspective.

2. Chronic disease management: necessity of mHealth approach

In most countries, chronic diseases lead to high health care costs and reduced productivity of people in society [18]. Diabetes is a common chronic disease in nearly all countries [19] and one of the most common metabolic diseases with an increasing incidence. More than 15% of national health budget is dedicated to diabetic care [20]. Diabetes as a hidden disease causes many complications such as various types of heart disease, nephropathy, retinopathy, and so on, thus imposing direct and indirect high costs to society. In Iran, diabetes complications contributed to 53% of the aggregate excess direct costs of diabetes [21].

The quality of diabetic care improves, on one hand, if patient monitoring is done according to the nutrition program and physician orders that are placed with high quality [22]. On the other hand, fast and accurate diagnosis due to continuous monitoring through information communication technology (ICT) devices leads to prevent the death of diabetic patients [23]. Telemedicine as a main tool to remote health care delivery and home care has advantages such as real-time access to health information [3, 24], reducing medical errors [25], and increasing coordination and cooperation among health care teams [1], reducing travel of patients and their families in remote area [26], and useful education tool for patients, their families, and health care providers [27]. Therefore, this technology has a very important role in decreasing costs and taking appropriate management actions especially in diabetes management and other chronic disease [28, 29]. The use of innovative technologies such as mobiles to enjoy the most advantages of telemedicine is necessary. Mobile health systems can be a good option for health care industry because of reducing delay and error in patient treatment, avoiding test duplication, providing remote and timely access of health care professionals to organizational database and patient information especially in the emergency situations [26, 30].

3. mHealth opportunities in patient monitoring

In this study, electronic chronic disease management systems based on mobile technology were divided into two types: agent-based systems and nonagent-based systems. Some electronic health system based on agent that studied in this research are:

- Integrated mobile information system (IMIS) in Sweden through mobile network communication platform provides the possibility of self-treatment and home care supervision for the diabetic patient. This system has six databases: (1) database for patients including all necessary information about diabetic health care centers, medical journals, dietary, food habits, etc.; (2) database for care providers containing whole information about physicians, home care services; (3) tools or instrument base including all aiding functions for implementation health care such as visit reserve, alarms, monitor; (4) community network include all relevant actors like diabetes centers, consultation, and so on links to each other; (5) database for laws, rules, and norms applied in health care including all legal and cultural documents about health care therefore can help with privacy, security, and quality of services; and (6) database for labor division in health care that determines who (health care provider) and what to do, this ensures to provide all the different patient needs [31–34].
- M2DM Telemedicine Service system in European Commission with the aim of presenting correct knowledge to correct people at correct time. Two types of agents are used in the M2DM: (1) communication server that is responsible for communication between different user terminals and (2) application server that is responsible for data analysis and processing. The architecture of this system includes multiaccess server, common database management system (DBMS), multiaccess organizer, communication server agent, and application server agent. The overall goal of M2DM is increasing quality of care through improving communication between patient and health care providers [35, 36].

Also other nonagent and useful e-health system survey in this section are:

- Personal Health Monitor (PHM), University of Sydney, Australia, uses PHM with focus on e-health services based on mobile devices at local level for monitoring patient in various situations therapeutic. Architecture of PHM comprises BAN devices, sensor front end, mobile base unit, back end [37, 38].
- Mobi Health and Body Area Network [BAN], most of the European countries use this system for remote patient monitoring and provide appropriate care to patients. A consortium of 14 European countries was set up to implement the health system project [39]. This project has been implemented in four countries: Spain, the Netherlands, Sweden, and Germany for different groups of patients, including home care and trauma, where the patient is located in an outdoor center. It aims to improve patients' quality of life and freedom in their daily activities and complete mobility. BAN devices, sensor front end, mobile base unit, and back end are the architecture elements [37, 40–42].

- In 2009, the first virtual diabetes clinic in Iran was inaugurated at Tehran University of Medical Sciences with common database, multiaccess server architecture, and organizer server is discussed in this chapter [43–45].

Some benefits of nonagent-based system in **Table 1** include disease prevention improvement, better self-care, increased life style quality, reduce unnecessary [re]hospitalizations, possibility of teleconsultation, and provide patients mobility to perform their daily works. Diabetes virtual clinic is used for monitoring system and as a proper tool that provides up-to-date, useful, relevant, and accurate information used to suitable self-care and remote health care. Access of all users to useful and necessary information about prevention, treatment, side effects, and ways to control diabetes and providing teleconsultation are most important advantages of a virtual clinic.

In PHM, data processing is done locally, and in Mobi health BAN processing can be done at server side. Some of the studied system implemented on PDA and mobile phone platforms,

System	Multi-agent	Development method	Usage	Access to data technology	Devices	Type of communication	Some of the capabilities
Integrated mobile information system (IMIS) [31–34]	Yes	User centered	Diabetic homecare, chronic, elderly care	Internet, SMS	Mobile computers, Nokia communicator, PDA, stationary computers home	Wired/wireless communications	(1) Integrate and co-ordinate various healthcare activities under the same fundamental activity system, (2) self-treatment, (3) preparation before face-to-face diagnoses, (4) access and share the same and right information on right time for a seamless co-operative work among organizations and among persons
M2DM Telemedicine service [35, 36]	Yes	Merging of telemedicine with knowledge management	Diabetes	Internet, WebTV, SMS, WAP,GPRS	Mobile computers, PDA, palmtops,	Wired/wireless communications	(1) Telecare, (2) visit management, (3) management of HER, (4) automatic generation of reports, (5) intelligent alarms, (6) tele-education, (7) intelligent knowledge management
PHM: Personal health monitor [37, 38]	No	Local, personal mHealth services	Cardiology, general well-being, chronic disease management, rehabilitation, monitoring: cardiac rhythm monitoring, cardiac rehabilitation, primary prevention	GPS,GSM,SMS,3G, Internet	Mobile phone	Wired/wireless communications (Bluetooth)	(1) Triage of life data which can be personalized to the application domain, (2) data processing Viewing and reporting for physician, (3) physician can update sensor thresholds, (4) remote management of PHM equipment and patients, (5) password protected viewing by the patient [limited view], (6) synchronization between MBU and Back End
Mobihealth BAN [37, 40–42]	No	Telemonitoring or teletreatment services	Cardiology, obstetrics, trauma care, rheumatology, psychiatry, pulmonary medicine, gerontology, neurology, telemonitoring, teletreatment	SMS, WIFI, GPRS, Internet, GPS	Mobile phones, PDA, UMTS, Any mobile platform capable of running Java VM and RMI	Wired/wireless communications (Bluetooth)	(1) Application functionality specific to each individual clinical application and patient and HP user requirements, (2) BAN devices have alarm button, (3) viewing, streaming and management services for BANs and BAN data, analysis and interpretation algorithms, alarms, geospatial and location-based services, (4) various security and access control mechanism
Diabetes virtual clinic [43–45]	NO	User center	Diabetes	SMS, WIFI, Internet	Computers, mobile, PDA	Wired/wireless communications	(1) Self-care, (2) e-learning, (3) tele consultation, (4) integrate and co-ordinate various health care activities under the same fundamental activity system

Table 1. Electronic health system characteristics in chronic disease management.

and others implemented on mobile phone. Sending alarm to patients and health care providers and identify place of patients with GPS are possible in some of the studied systems. Wired and wireless communication in all system studied can be useful especially when mobility is desired.

Recently, health care systems shift toward fast achieving to right decision to solve problems with spending least costs. So to reach this goal, find suitable information from useful and reliable resources in the fastest time and the least possible effort for information searching, analyzing, and filtering is very important.

This requires high interoperability among different professionals and systems in various places. In fact for providing effective health care and shared information, all actions need to be coordinated. Facilitated decision making requires interoperability and effective communications between professionals. Finding standard software as a suitable solution for complex health challenges is not easy. Electronic health systems must be proactive in anticipating the health information needs and supporting communications.

Because of potential capabilities of agent technology like mobility [44], autonomy, interoperability, scalability and re-configurability, integrating disparate systems, improving distributed data and resources management, handling the complexity of solutions, modeling and organizing the interrelationships between components [31–36, 46–51], is very valuable tool for telemedicine and telecare.

Agent-based systems in this table increase quality of care management. For example in IMIS system, tasks were delegated and all users in each level can communicate with one another and share the relevant data. In M2DM system, various analytic ways through knowledge agent were combined and used for the identification of abnormal situations. Also sending alarms, analysis results and real-time feedbacks to users are some benefits of this system [31–36]. Agents can be implemented on portable and mobile devices like PDA and use web services to interact with other systems.

The IMIS platforM is based on the Internet and will be accessible by PC or wireless network PDA. Accessibility should be regulated by groups of users. Each step in this system by the user is followed with instant feedback. M2DM can be activated in three ways: based on user needs, with receiving data, and by system. This system uses inexpensive and widely accepted technologies. This system applies technologies such as WEB, WEB TV, and SMS that are supported with computers or mobile terminals. Also it combines innovative and advanced technologies like PDA, WAP, GPRS, and PALMTOPS. The use of such technologies is limited in small groups of users because of costs, accessibilities, and user skills required.

Overall, according to multiagent health systems advantages in comparison to other type of systems and challenges in health care systems especially in diabetics care management, it can be said that the use of agent technology as a new and modern technology to reach full advantages of telemedicine and telehealth is essential, and health systems in the world must move toward agent-based applications.

4. mHealth challenges in patient monitoring

Although mHealth technology has a key role in health care systems, yet its uptake has faced with general and specific challenges. Some problems in general dimension include organizational challenges like organizational culture, support of high-level management; technological barriers such as lack of ICT and mobile infrastructure [52]; human challenges, for example, lack of trained and skilled personnel at health care centers in this field [28], user attitudes, technology acceptance [53, 54], user characteristics like age, economic, social, and educational status [55]; and threats to confidentiality and privacy, legal, ethical, and administrative barriers, costs of system implementation and maintenance [28], dependence on IT [56], the cost of updating, costly modern systems [57], sufficient investment, delays in implementation and providing electronic devices and software [58]. Some barriers from specific aspects also include problems in interoperability between other health systems and information technology tools, poor and inappropriate design and implementation [59], effect on face-to-face communication between health care providers and patient [60], causes omission of human relationship and the negative effects of technology on relationships between individuals and social processes [56], designing of mHealth services content [55], failure to meet targets [58], virtual information control [61], medical errors due to malfunctioning of system [62], fault documentation [59] like data manipulation and rewriting, misrepresentation, and violation of patients' legal rights. Difficulties related to telecommunication industry such as reliability, sustainability of connections, sudden interruptions of telecommunication networks [63], device and sensor type that can be used, type of data and language presentation [56], scalability in terms of data rate, power and energy consumption; antenna design, quality of service, energy efficiency [64, 65] wearable devices weight, type of devices that used for patient monitoring that sometimes lead to problem in data processing, accuracy of gathering information depends on where data were collected, and user training to use wearable system [66].

As aforementioned, one of the items that can help mHealth infrastructure development is application of agent-based systems in patient monitoring. We perform research in Iran about diabetes as one of the most challenging chronic diseases. The aim of this research is developing framework for agent-based diabetes disease management system through mHealth according to user's perspective. Some of the most important results are as follows:

5. Case study

Endocrinology and metabolism research institute of Tehran University of Medical Sciences in collaboration with Health Information Management Research center in this University conducted a research in 2012–2013. The goal of this research was to provide a model based on mobile health and agent technology in national level for diabetes management information. This framework must have capabilities of agent and support decision-making, create alerts and remote monitoring of patient status, and provide appropriate treatment and preventive recommendations for diabetes.

A questionnaire was designed with a study of library resources and operation of major organizations in and out of the country and interviews with relevant medical experts.

To determine the validity of a questionnaire distributed among experts in three areas after analyzing the results, the reliability was evaluated. Questionnaire includes three parts. First section covers personal identification. Second section questions about the general features of agent-based systems for the management of diabetes. Finally, third section examines the specific features of the systems in hospitals. At the end of questionnaire, an open question captured the opinions of experts concerning diabetes management system structure based on agent technology. Results of the questionnaires were analyzed with SPSS17 and were plotted with FREEPLANE mind map software. Finally, essential agents according to tasks of diabetes management system were determined. Some of the results obtained from this study are explained below.

Most diabetics must monitor and measure their blood glucose levels during the day. Like measuring glucose after every insulin injection and record it, along with the amount of daily insulin injections and diet and information about their lifestyle. Using information technology tools and a telemedicine system helps process management of health service, allows real-time monitoring, and provides early treatment for diabetes. To achieve these goals are possible through multi agent systems can be performed with using different agents. Based on this study, a diabetes management system has necessary business process including:

1. Information processing
2. Monitor patient status
3. Consultation
4. Diagnosis
5. Archiving relevant documents and patient records
6. Decision support system
7. Appropriate interface for communication between patients and health electronic systems
8. Monitoring operations and service delivery and allocate tasks to perform

Important services and processes through the implementation of software systems in the field of diabetes management from the experts, perspectives are plotted (see **Figure 1**).

From the experts' point of view in this research, proposed framework must be used in priority order for home care, outpatient, and inpatient. Best development method to such system in priority order is telemonitoring or teletreatment services, user centered, merging of telemedicine with knowledge management, local and personal health services. Access to data technology in this system in priority order is mobile, SMS, Email, Internet in devices including web, phone, WIFI, and PDA. Also according to studies, to provide better health services, the communication should be used through wired or wireless connection tools.

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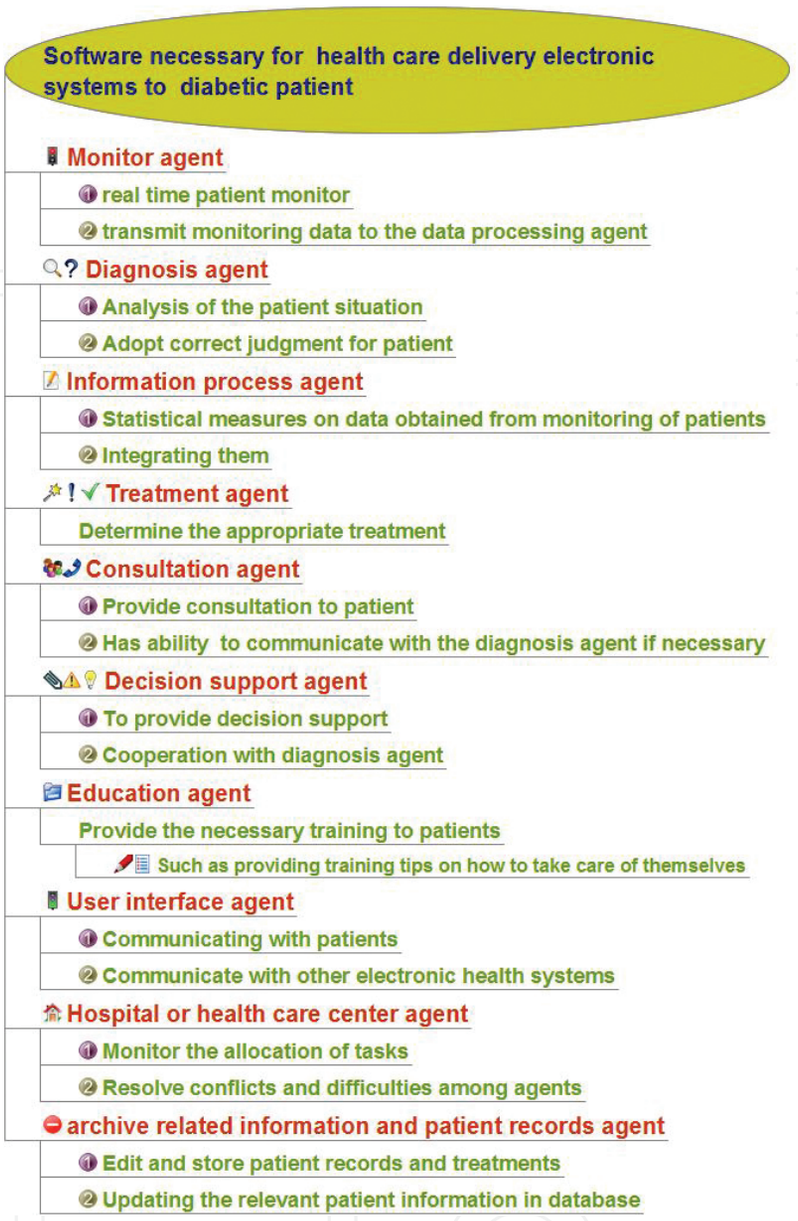

Figure 1. Software necessary for health care delivery electronic systems for diabetic patients.

Capabilities for diabetes management system based on agent technology in medical centers and hospitals section based on research findings with FREE PLANE software are depicted in **Figure 2**.

Also capabilities for diabetes management system based on agent technology for health care personnel based on research findings are: (1) remote education, (2) knowledge management, (3) intelligent alarms, and (4) electronic health records management. From the experts' point of view, diabetes management system based on agent technology must have these abilities for patients in the following order: (1) remote education, (2) intelligent alarms and reminders, (3) patient monitoring, (4) self-management, and (5) determining the exact location of medical centers and hospitals.

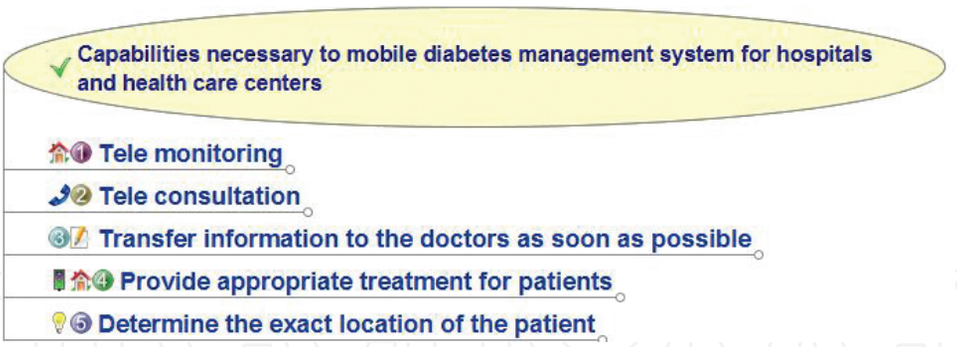

Figure 2. Capabilities necessary for mobile diabetes management system for hospitals and health care centers.

Experts in this research believed that proposed framework must be delivered through remote education to diabetes patients. Suitable remote education formats recommended in order of priority include imaging, audio, model questions and answers, and text tutorials. Patients on remote education should be able to search based on their needs, choice of content, and personalization and have the possibility to download the contents.

The weakness of this project is that benefits of experts surveyed only from health information management, software and physician in diabetic research center fields. To design and implement more appropriate conceptual models, involved experts should be from various fields such as telecommunication and addressing various aspects are very helpful, and the gained result is a more practical.

6. Discussion

Nowadays real-time access to reliable and proper information in order to deliver continuous health care and increase quality of care is very much in demand. So in order to achieve this goal, interoperability and coordination among providers involved in patient treatment for exchange of health information is a critical need. Chronic disease management especially diabetes based on IT tools has impressive benefits and some challenges. In this chapter, diabetic management system is classified into two groups: agent-based system and nonagent-based system.

Better self-care, improved prevention, increased quality life style, and teleconsultation are most important benefits of nonagent-based systems. Also these systems confront some challenges. The use of agent systems as a modern technology to decrease these barriers and take full advantages of telemedicine is essential and health systems must move using agent-based applications. In the second group, some of the benefits of agent technology in telemedicine services delivery include providing immediate feedback to patients, promoting interaction of the patient with organization that provides remote health care, reinforcing their motivation for the use of telemedicine systems and patients, and clinicians focusing on abnormal data that will prevent future occurrence of dangerous situations.

Agent-based systems improve interoperability, maintain the autonomy of the collaborating participants, communicate between themselves for exchanging health information, provide expert knowledge management, and improve e-learning. Multiagent systems are inherently compatible with mobile devices. Architecture of these systems allows high interoperability and quality information management and appropriate sharing data. Diabetes virtual clinic in Iran is one of the nonagent systems that provides some important health services to the people and assist them to improve knowledge about diabetes care. This system needs to move toward the use of artificial intelligence tools and expert systems like agents for further development and increased capabilities. Our finding in 2013 research showed that to accelerate the development of diabetes management systems based on artificial intelligence tools, we must consider these items: (1) promote organizational cultural, (2) note to suitable technical infrastructure, (3) provide appropriate security and privacy, (4) adequate investment, (5) user participation, and (6) involvement of private sections. Also note to structure, proper system, and database design that can support different kinds of training formats and tasks, and provide backup are very important. Ease of use and user friendliness of system should be considered especially for elderly people. Also design of drug and injection reminders for patients in addition to the built-in alarm system is a key factor.

It should be noted that the use of agent systems only with technical view does not lead to elimination of obstacles. In delivering health care to diabetic patients or other chronic disease patients, paying attention to human aspect and social dimension is very important. Some users dislike computers and do not trust them. So these challenges in designing diabetes system based on mobile devices must be considered. In other words, note to all dimensions for implementation of mobile health systems especially agent system like user satisfaction, user acceptance, costs, motivation, structural and organizational factors, and standards, individual's affordability, identification challenges and opportunity, and so on are necessary. Also accelerating the application and implementation of multiagent diabetes management systems and use of mobile devices need to development of strategies to encourage health care providers for make greater use of mobile devices in deliver health care services to patients and providing the necessitate infrastructure and appropriate readiness. Stakeholders' support to apply of agent technology is essential.

7. Conclusion

Application of electronic health systems for patient monitoring has significant advantages. The use of these tools in health care organizations needs to study about these technologies, compare their benefits and limitations, note to organizational resources including human, technical, financial; suitable planning, and affordability of these facilities. Determining and decreasing challenges and identifying opportunities that affect on successful implementation of these technologies have critical roles in proper application of each of these systems.

Health care systems based on mobile technology are faced with important limitations such as user attitude and acceptance, budget, technical standard, equipment, and tools required for

mobile communication, security and good infrastructure, increasing the accuracy of critical signals, interoperability between different systems, bandwidth limitations, quality of health services, battery life limited tools, and so on.

User acceptance is improved through the provision of advisable training and cultural awareness. It also provides an environment in which innovations in organizations are appreciated. Key factors to increase user acceptance include staff participation and involvement in all stages of the process from planning to implementation, clear and effective communication between managers and all staff members involved in the project, describing the advantages of technology and change management.

Note to important factors such as adequate bandwidth, preparation of standard tools that provide maximum mobility and flexibility for users, decreasing obstacles which interrupt network communications, insurance coverage, and supporting patients who use remote monitoring devices, data encryption while transferring, paying attention to legal and ethical aspects are all necessary in the success of these systems in health care organizations.

8. Future trends

For future work, we suggest that try to provide inexpensive mHealth services, so that more people can use these services. Insurance companies especially in developing countries consider situations and are motivated to cover these types of health care services. Decreased dependence of communication protocols with mobile device types can help generalize and extend the use of mobile health devices.

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References

[1] Safdari R, Mohammadzadeh N. Multi-agent systems and health information management. In 2nd eHospital and Telemedicine Conference. Tehran University of Medical Sciences. Tehran. Iran. 2011.

[2] Kahn GJ, Yang SJ, Kahn SJ. 'Mobile' health needs and opportunities in developing countries. Health Affairs 2010.29(2):252–258. doi:10.1377/hlthaff.2009.0965.

[3] Tan J. Medical Informatics: Concepts, Methodologies, Tools, and Applications, Volume 1, Chapter 7.5. Securing Mobile Data Computing in Healthcare, Hershey, New York. 2009. p: 1930.

[4] Bøne E, Hasvold P, Henriksen E, Strandenæs T. Risk analysis of information security in a mobile instant messaging and presence system for healthcare. International Journal of Medical Informatics 2007.76:677–687. doi: http://dx.doi.org/10.1016/j.ijmedinf.2006.06.002

[5] World Health Organization. mHealth New horizons for health through mobile technologies. 2011. ISBN 978 92 4 156425 0. Available from: http://www.who.int/goe/publications/goe_mhealth_web.pdf [Accessed: 5 June 2013]

[6] Pawar P, Jones V, van Beijnum BJ, Hermens H. A framework for the comparison of mobile patient monitoring systems. Journal of Biomedical Informatics 2012.45(3):544–556. doi: 10.1016/j.jbi.2012.02.007.

[7] Prgomet M, Georgiou A, Westbrook JI. The impact of mobile handheld technology on hospital physicians' work practices and patient care: a systematic review. Journal of the American Medical Informatics Association 2009.16:792–801. doi: 10.1197/jamia.M3215.

[8] Strandbygaard U, Thomsen SF, Backer V. A daily SMS reminder increases adherence to asthma treatment: a three-month follow-up study. Respiratory Medicine 2010.104(2):166–171. doi: 10.1016/j.rmed.2009.10.003.

[9] Suter P, Suter WN, Johnston D. Theory-based telehealth and patient empowerment. Population Health Management 2011.14(2):87–92. doi:10.1089/pop.2010.0013.

[10] Warren I, Weerasinghe T, Maddison R, Wang Y. Odin telehealth: a mobile service platform for telehealth. Procedia Computer Science 2011.5:681–688. doi:10.1016/j.procs.2011.07.089.

[11] Bellini P, Boncinelli S, Grossi F, Mangini M, Nesi P, Sequi L. Mobile emergency, an emergency support system for hospitals in mobile devices: pilot study. JMIR Research Protocols 2013.2(1):e19. doi:10.2196/resprot.2293.

[12] Ferrer-Roca O, Subirana R. A four-year study of telephone support for oncology patients using a non-supervised call centre. Journal of Telemedicine and Telecare 2002.8(6):331. doi:10.1258/135763302320939211.

[13] Wakadha H, Chandir S, Were Elijah V, Rubin A, Obor D, Levine OS, Gibson DG, Odhiambo F, Laserson KF, Feikin DR. The feasibility of using mobile-phone based SMS reminders and conditional cash transfers to improve timely immunization in rural Kenya. Vaccine 2013.31:987–993. doi:10.1016/j.vaccine.2012.11.093.

[14] Martins M, Henrique G. Mobilizing Health Information to Support Healthcare-related Knowledge Work. INSTICC Press: Portugal. 2009. p. 69

[15] Khairat S, Gong Y. Understanding effective clinical communication in medical errors. Studies in Health Technology Informatics 2010.160(Pt 1):704–708. doi: 10.3233/978-1-60750-588-4-704.

[16] Goldbach H, Chang AY, Kyer A, Ketshogileng D, Taylor L, Chandra A, Dacso M, Kung SJ, Rijken T, Fontelo P, Littman-Quinn R, Seymour AK, Kovarik CL. Evaluation of generic medical information accessed via mobile phones at the point of care in resource-limited settings. Journal of the American Medical Informatics Association 2014.21(1): 37–42. doi:10.1136/amiajnl-2012-001276.

[17] Tubaro M. An organized system of emergency care for patients with myocardial infarction: a reality? Future Cardiology 2010.6(4):483–489. doi:10.2217/fca.10.25.

[18] Engelgau M, Rosenhouse S, El-Saharty S, Mahal A. The economic effect of noncommunicable diseases on households and nations: a review of existing evidence. Journal of Health Communication: International Perspectives 2011.16(2):75–81. doi: 10.1080/10810730.2011.601394.

[19] Zhang P, Zhang X, Brown J, Vistisen D, Sicree R, Shaw J, Nichols G. Global healthcare expenditure on diabetes for 2010 and 2030. Diabetes Research and Clinical Practice 2010.87(3):293–301. doi:10.1016/j.diabres.2010.01.026.

[20] World Health Organization. Global status report on non communicable diseases 2010. World Health Organization 2011 Reprinted 2011. ISBN 978 92 4 156422 9. ISBN 978 92 4 068645 8 (PDF). Available from: http://www.who.int/nmh/publications/ncd_report_full_en.pdf [Accessed 30 June 2013].

[21] Esteghamati A, Khalilzadeh O, Anvari M, Meysamie A, Abbasi M, Forouzanfar M, Alaeddini F. The economic costs of diabetes: a population-based study in Tehran, Iran. Diabetologia 2009.52:1520–1527. doi:10.1007/s00125-009-1398-4.

[22] McAndrew LM, Napolitano MA, Pogach LM, Quigley KS, Shantz K, Vander Veur SS, Foster GD. The impact of self-monitoring of blood glucose on a behavioral weight loss intervention for patients with Type 2 diabetes. The Diabetes Educator 2013.39(3):397–405. doi:10.1177/0145721712449434.

[23] Paré G, Moqadem K, Pineau G, St-Hilaire C. Clinical effects of home tele monitoring in the context of diabetes, asthma, heart failure and hypertension: a systematic review. Journal of Medical Internet Research 2010.12(2):e21. doi:10.2196/jmir.1357.

[24] Barjis J, Kolfschoten G, Maritz J. A sustainable and affordable support system for rural healthcare delivery. Decision Support Systems 2013.56:223–233. doi:10.1016/j.dss.2013.06.005. Available from: http://dx.doi.org/10.1016/j.dss.2013.06.005 [Accessed 24 June 2013].

[25] Skolnik NS. Electronic Medical Records: A Practical Guide for Primary Care. New York: Springer Humana Press; 2011. p: 1.

[26] Finn N, Bria W. Digital Communication in Medical Practice. London: Springer-Verlag; 2009. p: 70–73.

[27] Toledo FG, Triola A, Ruppert K, Siminerio LM. Telemedicine Consultations: an alternative model to increase access to diabetes specialist care in underserved rural communities. JMIR Research Protocols 2012.1(2):e14. doi:10.2196/resprot.2235.

[28] Khoumbati K, Dwivedi Y, Srivastava A, Lal B. Handbook of Research on Advances in Health Informatics and Electronic Healthcare Applications: Global Adoption and Impact of Information Communication Technologies. Hershey. New York: Medical Information Science Reference; 2010. p: 91, 10, 156.

[29] Safdari R, Mohammadzadeh N. Patient Health Monitoring Through Mobile Health Systems. Lecture in International Conference on 2012 Electronic Health (ICEH 2012). Medical Council of Islamic Republic of Iran. Tehran. Iran.

[30] McDaniel J. Advances in Information Technology and Communication in Health. Amsterdam: IOS Press; 2009. p: 467–471.

[31] Integrated Mobile Information Research. 2010. Available from: http://www.bth.se/research/imis/ [Accessed 4 July 2013]

[32] Shaheen A, Ahmad Khan W. Intelligent Decision Support System in Diabetic eHealth Care From the perspective of Elders. [Master Thesis]. Computer Science. Blekinge Institute of Technology. Sweden. 2009. Available from: http://www.bth.se/fou/cuppsats.nsf/all/89449be91369ee27c12575d60071c747/$file/Master_thesis_asma.pdf [Accessed 4 July 2013]

[33] Zhang P. Multi-agent Systems in Diabetic Health Care. Blekinge Institute of Technology Licentiate Series. Issue 5. Karlskrona: Blekinge Institute of Technology. ISBN: 91-7295-060-9. 2005. Available from: http://www.bth.se/fou/forskinfo.nsf/all/07625d65f3f89ee6c1256fef00220c36?OpenDocument [Accessed 4 July 2013].

[34] Bellazzi R, Carson ER, Cobelli C, Hernando E, Gomez EJ, Nabih-Kamel-Boulos M, Rendschmidt T, Roudsari V, et al. Merging Telemedicine With Knowledge Management: The M2DM Project. Published in: Engineering in Medicine and Biology Society.

Proceedings of the 23rd Annual International Conference of the IEEE, Volume 4, 2001. p: 4117–4120. doi:10.1109/IEMBS.2001.1019762.

[35] Hernando M E, Garsia A, Javiar Perdices F, Torralba V, Gomez E J. del Pozo F. Multi agent architecture for the provision of intelligent telemedicine services in diabetes management. Available from: http://cyber.felk.cvut.cz/EUNITE03-BIO/pdf/EHernando.pdf [Accessed 4 July 2013]

[36] Jones V, Gay V, Leijdekkers P. Body Sensor Networks for Mobile Health Monitoring: Experience in Europe and Australia. Accepted for 4th International Conference on Digital Society, ICDS 2010, February 10–16, 2010, ICDS '10. Fourth International Conference on. Netherlands: Digital Society; 2010.

[37] Leijdekkers P, Gay V. A Self-Test to Detect a Heart Attack Using a Mobile Phone and Wearable Sensors. 21st IEEE International Symposium on Computer-Based Medical Systems; 2008. p: 93-98. ISBN: 978-0-7695-3165-6.

[38] Jones M, Bults G, Konstantas D, Vierhout P. Healthcare PANs: Personal Area Networks for trauma care and home care, Proceedings Fourth International Symposium on Wireless Personal Multimedia Communications. [WPMC], Sept. 9–12, 2001, Aalborg, Denmark. 2001. Available from: http://wpmc01.org/, ISBN 87-988568-0-4.

[39] Otto C, Milenkovic A, Sanders C, Jovanov E.System Architecture of a wireless body area sensor network for ubiquitous health monitoring. Journal of Mobile Multimedia 2006.1(4):307–326.

[40] Halteren Aart V, Bults R, Wac K, Konstantas D, Widya I, Dokovsky N, Koprinkov G, Jones V, Herzog R. Mobile patient monitoring: the MobiHealth system. Journal on Information Technology in Healthcare 2004.2(5):365–373. ISSN 1479-649X.

[41] MobiHealth—Shaping the Future of Healthcare. Available from: http://www.ltu.se/cms_fs/1.90345!/file/Mobihealth%20brochure.pdf [Accessed 4 July 2013].

[42] Inaugurate first diabetes virtual clinic in Iran at Tehran university of medical sciences (in Persian). Available from: http://publicrelations.tums.ac.ir/news/detail.asp?newsID=13114 [Accessed 4 July 2013].

[43] For the first time in Iran, virtual clinic for diabetes opening in Shariati hospital. (in Persian). Available from: http://www.pezeshkan.ir/view.asp?id=99119 [Accessed 4 July 2013].

[44] Diabetes Virtual Clinic. Available from: http://emri.tums.ac.ir/pages/mainpage.asp?I=S54M5P2C1 [Accessed 4 July 2013].

[45] Annicchiarico R, Cortés U, Urdiales C. Agent Technology and e-Health. Switzerland: Birkhäuser Verlag; 2008. p: 141–148.

[46] Isabelle B, Sachin V, Ashlesha J, Lakhmi J.Computational Intelligence in Healthcare 4. Berlin: Springer-Verlag; 2010. p: 25–48.

[47] Sánchez D, Isern D, Rodríguez Á, Moreno A. General purpose agent-based parallel computing. In: Omatu S, Rocha MP, Bravo J, Fernández F, Corchado E, Bustillo A, Corchado JM. [eds.] IWANN. LNCS, Heidelberg: Springer; 2009. vol. 5518, p: 231–238.

[48] Mohammadzadeh N, Safdari R. Artificial intelligence tools in health information management. International Journal of Hospital Research 2012.1(1):65–70.

[49] Isern D, Sánchez D, Moreno A. Agents applied in health care: a review. International Journal of Medical Informatics 2010.79:145–166. doi:10.1016/j.ijmedinf.2010.01.003.

[50] Safdari R, Mohammadzadeh N. Electronic Health Information Systems. Tehran: Mirmah; 2011. p: 152–156 (in Persian).

[51] Cripps H, Standing C. The implementation of electronic health records: a case study of bush computing the Ngaanyatjarra Lands. International Journal of Medical Informatics 2011.80(12):841–848. doi:10.1016/j.ijmedinf.2011.09.007.

[52] Cresswell K, Sheikh A. Organizational issues in the implementation and adoption of health information technology innovations: an interpretative review. International journal of medical informatics 2013.82(5):e73–e86. doi:10.1016/j.ijmedinf.2012.10.007.

[53] Venkatesh V, Thong J Y L, Xu X. Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. Forthcoming in MIS Quarterly 2012.36(1):157–178.

[54] Hardiker NR, Grant MJ. Factors that influence public engagement with eHealth: a literature review. International Journal of Medical Informatics 2011.80(1):1–12. doi: 10.1016/j.ijmedinf.2010.10.017.

[55] Taniar D. Mobile Computing: Concepts, Methodologies, Tools, and Applications. New York: Information Science reference; 2009. p: 791–792, 432–433 . ISBN 978-1-60566-054-7 (hardcover)—ISBN 978-1-60566-055-4 (ebook).

[56] Blumenthal D. Stimulating the adoption of health information technology. The New England Journal of Medicine 2009.360:1477–1479. doi:10.1056/NEJMp0901592.

[57] Lucas H. Information and communications technology for future health systems in developing countries. Social Science & Medicine 2008.66:2122–2132. doi:10.1016/j.socscimed.2008.01.033.

[58] Lawler EK, Hedge A, Pavlovic-Veselinovic S. Cognitive ergonomics, socio-technical systems, and the impact of healthcare information technologies. International Journal of Industrial Ergonomics 2011.41:336–344. doi:10.1016/j.ergon.2011.02.006.

[59] Viitanen J, Hyppönen H, Lääveri T, Vänskä J, Reponen J, Winblad I. National questionnaire study on clinical ICT systems proofs: physicians suffer from poor usability. International Journal of Medical Informatics 2011.80(10):708–25. doi:10.1016/j.ijmedinf.2011.06.010.

[60] Lluch M. Healthcare professionals' organizational barriers to health information technologies: a literature review. International Journal of Medical Informatics 2011.80(12):849–862. doi:10.1016/j.ijmedinf.2011.09.005.

[61] While A, Dewsbury G. Nursing and information and communication technology (ICT): a discussion of trends and future directions. International Journal of Nursing Studies 2011.48:1302–1310. doi:10.1016/j.ijnurstu.2011.02.020.

[62] Nykänen P, Brender J, Talmon J, de Keizer N, Rigby M, Beuscart-Zephir M, Ammenwerth E. Guideline for good evaluation practice in health informatics (GEP-HI). International Journal of Medical Informatics 2011.80:815–827. doi:10.1016/j.ijmedinf.2011.08.004.

[63] Aggarwal NK. Applying mobile technologies to mental health service delivery in South Asia. Asian Journal of Psychiatry 2012.5:225–230. doi:10.1016/j.ajp.2011.12.009.

[64] Patel M, Jianfeng W. Applications, challenges, and prospective in emerging body area networking technologies. IEEE Wireless Communications. 2010.17(1):80–88. doi:10.1109/MWC.2010.5416354.

[65] Klingeberg T, Schilling M. Mobile wearable device for long term monitoring of vital signs. Computer Methods and Programs in Biomedicine 2012.106:89–96. doi:10.1016/j.cmpb.2011.12.009.

[66] Chan M, Estève D, Fourniols J, Escriba C, Campo E. Smart wearable systems: current status and future challenges. Artificial Intelligence in Medicine 2012.56:137–156. doi:10.1016/j.artmed.2012.09.003