Knowledge Management Framework for E-Healthcare in Saudi Arabia

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Abstract--In the last decade, the government of Saudi Arabia has given high priority to developing and implementing e-healthcare services and technologies. However, it has met a number of barriers in implementing its healthcare initiatives. This paper describes these barriers and proposes an e-health knowledge management framework to overcome these barriers by integrating developments from knowledge management with knowledge discovery techniques. This framework should assist in the delivery of competitive e-healthcare services and improve intellectual capital to provide smart health services in the country. The proposed framework will be applied to the domain of diabetes.

Keywords-knowledge management; knowledge discovery; Saudi Arabia, diabetes mellitus.

I. BACKGROUND

Eysenbach defines e-health as 'an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the internet and related technologies' [1]. According to the World Health Organization (WHO) e-health refers to'...the use, in the health sector, of digital data - transmitted, stored and retrieved electronically- in support of health care, both at the local site and at a distance'.

In the last few decades, the Saudi Arabian government has given a high priority to improve its e-health services. A number of new initiatives have emerged focusing on many aspects of healthcare, ranging from creating electronic files for patients, statistical monitoring of infectious diseases, connecting all hospital systems using technologies of cloud computing and monitoring the arrival of pilgrims and vaccines given to each pilgrim in their home country [2]. However, the implementation of these initiatives has been impaired by many problems outlined as follows (as illustrated in Figure 1):

- ***Non-connectivity of information systems***. Though some regional directorates and central hospitals are using information systems [3], there is no effort to connect these information systems in order to build up a national healthcare system [4].
- ***Lack of technical expertise and computer skills***. Computer skills of healthcare staff and professionals are deficient due to their lack of experience in using computer applications [5]. No guidelines are provided to handle electronic medical records (EMRs), and many complain about poor maintenance of computers and networks and slow computers and terminals.
- ***Failure of adoption Health Information Services (HIS).*** There are critical issues associated with planning and adopting HIS, and its implementation in Saudi Arabia; some of these are caused by the poor technical support and over running of time and budget [5][6].
- ***Human barriers.*** This problem has been considered as the major reason for failing to adopt health information systems in Saudi hospitals [7]. Human barriers include negative beliefs of healthcare professionals towards technologies and lack of trust by medical staff towards computer based medical solutions. Therefore, many medical staff resists the change from traditional to computer based healthcare services.
- ***Cultural barriers.*** Cultural factors contribute to the failure in adopting e-health because of limited human interaction [6]. Aldraehim and Edwards [8] explain that Saudi Arabian people are extremely influenced by their culture and therefore prefer physical interaction to virtual contact.
- ***Medication safety***. According to Aljadhey et al. [9], medication safety raises two major e-health issues. The first issue refers to communication gaps among healthcare institutions, which contribute to medical mishaps and patients' medical historical issues. The second issue is limited use of technology whose consequences occur in illegible handwriting. Computerised Provider Order Entry (CPOE) can solve this problem; however, this is being adopted slowly.
- ***Financial barriers***. Transmitting traditional paper medical records to electronic system can be very costly [10]. Such high expenditure, which needs to be spent on the adoption of IT in health, may lead to the slow uptake of e-health applications.
- ***Security and Privacy***. This focuses on the easiness in accessing EMRs of patients due to the fact that some medical records of patients can be disseminated to others without permission of the patient or the doctor [5].

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Figure 1. E-health Barriers in Saudi Arabia

This paper is structured as follows. Section 1 presents the background regarding e-health barriers in Saudi Arabia. Section 2 explains the role of knowledge management and knowledge discovery in healthcare. Section 3 introduces the proposed framework to overcome e-health barriers in Saudi Arabia. Section 4 presents brief information about diabetes mellitus, which is set to be the domain of our study. Section 5 summaries the directions adopted by this project.

II. KNOWLEDGE MANAGEMENT AND KNOWLEDGE DISCOVERY

Nowadays, patients and health practitioners are connected to hospitals, clinics and pharmacies; they share knowledge in order to reduce administrative costs and improve the quality of care. Although the focus tends to be on managing health records and interoperability of IT healthcare systems, knowledge management plays an important role in providing high quality and effective healthcare system. It also allows the capture, representation and dissemination of knowledge of healthcare professionals such as their strategies, practices and insights. This knowledge is the power that enables organisations and individuals to select the best actions and strategies [11]. Utilisation of best practices provides significant advantage for organisations in term of competition and efficiency. Individuals keep their knowledge in their brain and those individuals have the brainpower or intellectual capital that every organisation desires [12]. Furthermore, their knowledge helps identify current problems as well as achieve desired results [13]. Consequently, many top managers are recognising the importance of capturing and managing knowledge of its healthcare professionals and developing systems to improve their services.

Knowledge Management is a useful mechanism to capture the intellectual capital of organisations, and healthcare establishments, in particular, so that they can deliver the best quality of care. It can help healthcare professionals cope with the fragmented and distributed nature of medical knowledge, the challenges caused by information overload and the importance to access local knowledge in making clinical decisions [14]. Additionally, it can provide healthcare practitioners with educational and training initiatives in terms of professional development and changing environment preparation [20][21][22]. Finally, dissemination of medical knowledge and best practices enable social learning initiatives where evidences can be disseminated to clinicians, nurses, and other healthcare workers [23][24][25] at national and international levels as well as to rural areas.

Knowledge management can provide a dynamic process of capturing, storing, sharing and creating both types of knowledge, explicit and tacit [21]. Explicit knowledge is communicable in systematic language whereas tacit knowledge is obtained through experience and cannot be articulated [22]. Nonaka and Takeuchi [22] suggest that knowledge changes from explicit to tacit and vice versa in two dimensional learning environments through four processes, known as SECI, in the form of a spiral. SECI includes four modes conversion procedures: Socialisation, Internalisation, Externalisation, and Combination (as illustrated in Figure 2). Socialisation enables the conversion of tacit knowledge via interaction among individuals and can be achieved through shared experience. Internalisation enables converting explicit knowledge to tacit knowledge, while externalisation enables tacit knowledge to be converted to explicit knowledge. It makes tacit knowledge understandable and can be recorded or saved by visualising it in an explicit form. Combination is the process of 'systematizing concepts into a knowledge system' [22]; for example, people synthesise different sources of explicit knowledge through meetings, conversations and exchange of documents [16][27]. Nonaka concludes that knowledge is created continuously by restructuring the existing knowledge through the synergy of these four processes. However, a number of issues have been raised regarding Nonaka's premises; consequently, other models have been developed and/or extended Nonaka's basic ideas. For example, Nissen [23] developed the knowledge flows model to capture the organisational knowledge dynamics and added two further dimensions to Nonaka: life cycle and flow time. Harsh [24] proposed a third dimension which accounts for knowledge reusability and where technology and human interaction can play a significant role in management of data, information and knowledge.

Figure 2. SECI Model [22]

Yao et al. [25] argue that SECI assumes that the only source of corporate knowledge originates from the staff within the organisation. In the healthcare sector, patients as well as healthcare workers contribute significantly to knowledge creation and knowledge sharing. Furthermore, tacit and explicit knowledge are not only embedded in people as new knowledge can also be extracted from external sources such as data, databases, and documents. These can be analysed in order to discover new knowledge. Knowledge discovery is another emerging discipline aimed at identifying valid, novel, understandable and useful patterns in data, texts, images, and other media [26]. It uses statistical and artificial intelligence techniques to analyse and process large amount of data [27]; it should be without or at least less human intervention [28]. Data mining is a subfield of knowledge discovery which discover novel and valid trends/associations using machine learning techniques [29]. Typical applications of data mining in healthcare include monitoring high risk of diabetic individuals so that appropriate messages can be communicated to them [30], predicting length of stay of patients with spinal cord injuries [31], and predicting hypertension from patient medical records with eight other diseases [32]. According to Berger and Berger [33] data mining is a useful approach for dealing with the rapid expansion of medical knowledge and healthcare data.

Whilst knowledge discovery can support the discovery of new knowledge from patients' healthcare data, knowledge management provides a forum to share and disseminate this new acquired knowledge and to combine it with the explicit and tacit knowledge acquired from healthcare practitioners. Such integration can address some of the problems discussed above and improve the quality and performance of healthcare services. Furthermore, it can assist healthcare organisations in making strategic effective decisions [34]. Hwang et al. [35] demonstrate how association rules can be applied to extract knowledge from patients' medical records along with medical rules of tumor associated diseases to develop guidelines for clinicians. These guidelines could be then shared among healthcare practitioners through a knowledge management system and deliver a better quality care to patients.

III. E-HEALTH KNOWLEDGE MANAGEMENT FRAMEWORK

It is important here to recognise that despite significant advantages in applying knowledge management in the healthcare sector, there are a number of barriers primarily caused by the absence of clear knowledge management strategy related to deficiency of effective team working, cultural barriers, poor IT infrastructure, degree of sectorial professionalisation, and political conflicts [41][42][43]. Finn and Waring [39] illustrated the importance of effective team working and stated that 'architectural knowledge' is fundamental for efficient team practice to ensure the delivery of safe and effective care to patients. As mentioned earlier, cultural barriers play also a negative role as some cultures do not encourage knowledge sharing; this constitutes an obstacle to knowledge management processes [40]. The healthcare sector tends to be mono-disciplinary and relationships of professionals within this sector are highly standardised, hence there is a resistance among doctors to share their findings and initiatives [37]. Strong governmental regulations and political and management conflicts can also hinder knowledge sharing among healthcare practitioners [41]. Guven-Uslu [38] described the clinician-managerial conflict as one of the important obstacles; the priority of managers is to minimise cost whereas the first priority of clinicians is to provide best care for patients.

To address the above issues, we propose a holistic framework approach to the healthcare knowledge management; this approach is still inspired by the SECI model of Nonaka, we are aware of the critical issues associated with the two dimensional approach to knowledge management. One of those issues is that the SECI model is embedded within the Japanese context. Saudi Arabian cultural is strongly influenced by the Arabic culture which should be taken into consideration when applying the SECI model of Nonaka and Takeuchi [23][42]. This framework is primarily designed to address some of the barriers highlighted above from four perspectives: Business, Human, Financial and Technology. By integrating knowledge discovery into knowledge management we aim at identifying, extracting and organising tacit and explicit knowledge related to problems and solutions from multiple sources and at providing a forum for generating and sharing consistently new knowledge by linking tacit and explicit knowledge to a specific medical domain and its literature. The proposed framework, referred herewith as e-health knowledge management system, is tailored initially to address the healthcare issues in Saudi Arabia and is focused on a specific medical domain (e.g. diabetes mellitus) to evaluate its viability and performance.

This section describes the four components of our framework (as illustrated in Figure 3). The Business component focuses on organisational issues and aims at extracting and managing the barriers associated with the failure of adopting health information services and medical safety such as poor technical support and unrestricted access to medications.

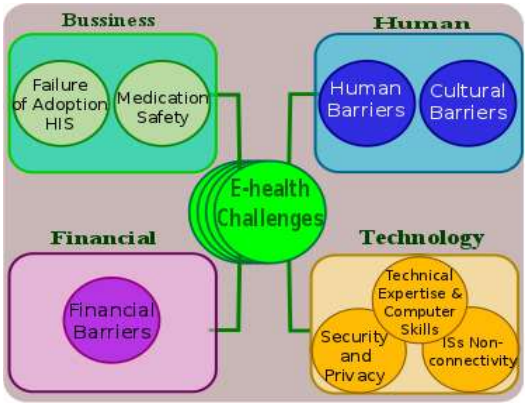

Figure 3. Components of e-Health Knowledge Management System

The Human component deals with the human barriers in relation to the use of technology from the healthcare workers and the cultural barriers from the patient perspectives; this will address the negative beliefs of healthcare professionals and patients towards the use of virtual contact and interaction with technological devices. The role of patients in the process of knowledge production and the computing skills of both, the healthcare professionals and patients, are critical to the success of our framework. To this end, the Technology component manages the non-connectivity issues and focuses on the technical expertise and computer skills, security and privacy issues. This component includes training aspects to address the limited/lack of computer skills among healthcare staff and professionals and their patients. Finally, the Financial component attempts to elicit the constraints and policies associated with the implementation, maintenance and monitoring of healthcare information services, namely the high cost of transmitting from traditional patients' paper records to electronic records. The proposed framework will elicit some of these problems and propose solutions (as illustrated in Figure 4).

Elicitation of problems and solutions will be accomplished through interviews and protocol analysis, and others via simulation and personal construct theory. Also card sorting will be employed to elicit the problems and potential solutions in order to promote best practices. The Saudi e-health data elicited from the four components will be then further analysed using machine learning techniques to elicit best practices and strategies.

Similarly, patients' data will be mined to extract useful trends and associations to improve the healthcare services. The acquired knowledge from these four components will be then represented into a knowledge management system, which will provide relevant knowledge to healthcare professionals who may be seeking or sharing best practices, strategies, guidelines and policies, and to patients who need to contact specific healthcare services or professionals for advice or help.

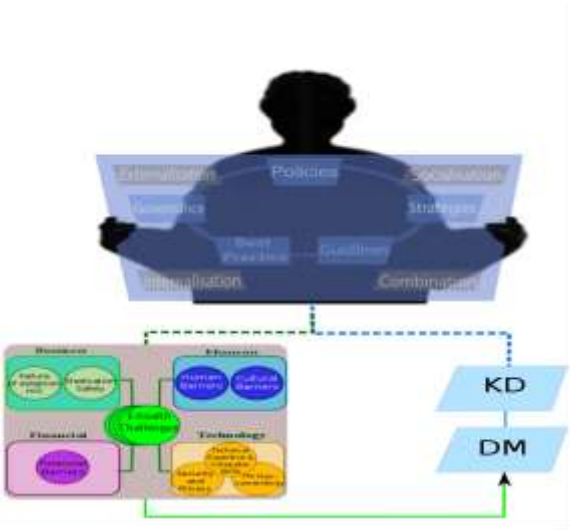

Figure 4. E-health Knowledge Management System

The proposed system will also provide access to academic papers related to specific problems to support healthcare professionals.

IV. DOMAIN OF APPLICATION

Diabetes mellitus, which is one of the highest chronic diseases in Saudi Arabia that affect patients from different genders, ages and weights, is to be used to validate our proposed framework. It can have severe complications such as stroke [47][48], heart attack [44], heart failure [45], kidney failures [44], Alzheimer disease [46] and mortality [47].

It is estimated that 382 million people have diabetes in the world, and by 2035 this will rise to 671 million. There were 3.6 million cases of diabetes in Saudi Arabia in 2013 [48]. According to Shaw, Sicree, and Zimmet [49], the prevalence percentage for diabetes mellitus in Saudi Arabia was 16.8% among adults in the ages of 20-79 years old, and it is expected to reach 18.9% in 2030. Over 96% of all Saudi medical healthcare budgets are attributed to diabetes by Saudi citizens and 4% incurred by non-Saudi nationals. The national healthcare financial burden has reached $0.87 billion, excluding (i) indirect costs such as absenteeism, lost productivity, unemployment from disease-related disability, lost productivity due to early mortality by disease, and (ii) healthcare system administrative costs, cost of medications, clinician training programs, and research and infrastructure development [50]. The proposed framework will include the financial costs and its impact on human and barriers components into the framework. It will also attempt to overcome the barriers by utilising technology components.

A number of data mining applications have focused on diabetes. For example Meng et al.[51] produced a model to detect diabetes using 12 risk factors and Chang, Wang, and Jiang [52] uses risk factors to identify hypertension and hyperlipidemia. Suh et al. [53] developed the WANDA system to remotely help monitor blood glucose, weight, and blood pressure. HealthOrg is an application to monitor high risk diabetic individuals so that appropriate message can be communicated to patients [30]. Roch et al. [54] recognise the need and the challenges that healthcare professionals and researchers face in developing a much needed comprehensive knowledge management support system for diabetes care. To the best of our knowledge, no integration of data mining and knowledge management for diabetes has been attempted.

V. CONCLUSION

Knowledge management and knowledge discovery are well developed research areas. However, the review of the literature has shown that there has been no systematic attempt at integrating them to address critical healthcare issues. The aim of our research project is to bridge this gap in order to improve the healthcare services and provide a forum for healthcare professionals to deliver the best healthcare to their patients. The first stage of this research will focus on the barriers associated with the healthcare of diabetes mellitus in Saudi Arabia. To this end, a survey is

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being undertaken to identify the current barriers and problems regarding e-healthcare faced by diabetic patients, healthcare professionals and IT specialists. This specific domain will be used to validate the proposed e-health knowledge management framework, which is ambitious in its approach. The proposed system is designed to support the recent government initiatives of the Saudi Ministry of Health in improving the national healthcare of its citizens.

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