Integrated Framework of Knowledge Discovery and Knowledge Management for E-health In Saudi Arabia: Supporting Citizens with Diabetes Mellitus

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Abstract

Saudi Arabia experiences insufficient effort in terms of patients' education in relation to a number of prevalent diseases, including diabetes mellitus, musculoskeletal disorders and upper respiratory tract infections. In addition, the number of studies related to e-health initiatives to support patients in the Kingdom are limited and only benefit patients of a few hospitals. This situation leads to deficient application of self-management and education strategies to empower patients to manage their diseases. Unfortunately, such a deficiency can affect the health status in the Kingdom negatively as diabetes mellitus is reported as the first cause of death in the Kingdom among all other prevalent diseases.

Although knowledge management has been proven to be a valuable approach to sharing knowledge and educating users to manage their illnesses, it has not been implemented appropriately to support the increasing number of diabetic citizens in Saudi Arabia. In this research, knowledge management is integrated with knowledge discovery to support specific needs of the diabetic community in the Kingdom. Such an integration constitutes an e-health initiative to support diabetic citizens and healthcare professionals to manage this expanding illness in Saudi Arabia. Knowledge discovery is implemented through data mining to elicit useful knowledge related to specific diabetes complications encountered by diabetic citizens in the Kingdom. The integrated framework applies the SECI model to capture and disseminate useful diabetes self-management and educational expertise to support the management of diabetes complications.

This integrated approach to knowledge management and knowledge discovery has provided a valuable tool implemented in terms of a web portal. This has facilitated the exchange and dissemination of tacit and explicit knowledge of the diabetic community in the forms of strategies, guidelines and best practices. It has also overcome the issues faced by the organisational and national cultures affecting knowledge management practice in Saudi Arabia.

Key words: knowledge management, knowledge discovery, diabetes mellitus, Saudi Arabia, e-health.

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Dedication

This research is dedicated to:

My mother, Aisha

My father, Nayef

My brothers and sister

My wife, Manahil

My daughter, Hanai

Publications

Almuayqil, S., Atkins, A.S. & Sharp, B. (2016). Ranking of E-Health Barriers Faced by Saudi Arabian Citizens , Healthcare Professionals and IT Specialists in Saudi Arabia. *Health*. (July). p.pp. 1004–1013.

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Awards

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Glossary

Abbreviation	Extended Name
CKO	Chief Knowledge Officer
CoP	Community of Practice
CPOE	Computerised Provider Order Entry
CRM	Customer relationship Management
DESMOND	Diabetes Education and Self-Management for On-going and Newly Diagnosed
DM	Data Mining
DSMKSA	Diabetes Self-Management in the Kingdom of Saudi Arabia
EHR	Electronic Health Record
EMR	Electronic Medical Record
HIS	Health Information Service
ICT	Information and Communication Technology
IS	Information System
KD	Knowledge Discovery
KM	Knowledge Management
KS	Knowledge Sharing
MOH	Ministry of Health
PHC	Primary Healthcare Center
SECI	Socialisation, Extenuation, Combination and Internalisation
WHO	World Health Organisation

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Chapter One: Introduction

1.1 Introduction

Saudi Arabia has been reported for the increased prevalence of a number of diseases, including diabetes mellitus. The prevalence of these diseases in the Kingdom requires daily monitoring and continuous care to prevent its complications. An effective way to manage these diseases is the application of self-management and education strategies. The term self-management in the medical domain is used to emphasise the patients’ role to control their diseases. However, its application in the Kingdom is deficient and doesn’t meet the required effort to control these diseases.

The application of self-management and education in healthcare can be supported by Knowledge Management (KM). KM can facilitate the sharing of knowledge among different organisations and individuals through communications. Despites its advantages, KM in Saudi Arabia face several factors related to national and organisational aspects that hinder its implementation and limit its practices in different domains including healthcare. Lack of KM practice in Saudi Arabia limits the application of several activities associated with self-management and education to support patients who have different diseases in the kingdom.

Nonaka and Takeuchi (1995) proposed the knowledge creation model that facilitates the interaction of tacit and explicit knowledge by applying the four conversion modes of socialisation, externalisation, combination and internalisation (SECI). The SECI model is a well-known approach in the area of KM and has been successfully applied to manage knowledge in a variety of domains including healthcare. The SECI model can be utilised to integrate KM and Knowledge Discovery (KD) to support patients and healthcare professionals in Saudi Arabia in managing several chronic diseases such as diabetes mellitus. Such an integration applies KD to elicit tacit complications encountered by diabetic individuals whereas KM helps overcome these complications through the transfer of useful guidelines and best practices among patients who have diabetes and healthcare professionals.

Data Mining (DM) implementation in healthcare is well documented in the literature. However, utilisation of the SECI model in the healthcare domain is still deficient. The model has been utilised in different domains for the purpose of knowledge creation and dissemination. Several studies have shown successful applications of the knowledge creation model. Nevertheless, the successful implementation in different domains requires similar application within the healthcare sector in Saudi Arabia, which is seen to have slower KM practice than other healthcare sectors in developed countries.

Although the SECI model is recognised as a valuable approach for knowledge creation, the concentration of the model tends to have a primary focus on social interactions to share human knowledge; yet there is rich knowledge embedded in databases and documents to be mined and shared using this model, making use of many available software tools. In this research, the focus is on how the SECI model can disseminate such knowledge using a set of web tools. Internet technologies are widely utilised in order to self-manage illnesses and learn from other patients' experiences. Therefore, the application of the SECI to support effective interaction between patients and healthcare professionals can be achieved through the utilisation of many related web tools. Such an approach can assist in promoting the sharing of guidelines and best practices among patients and healthcare professionals to manage diseases and improve their wellbeing.

This chapter introduces the situation of e-health and diabetes mellitus in Saudi Arabia. The chapter starts with describing the motivation of this study. The aim and objectives of this study are presented followed, by the research steps. The research contributions are also described. The current chapter also discusses the research methodologies utilised in this study and highlights the ethical consideration in this thesis. The final part of this chapter outlies the chapters of this thesis, with the perceived outcomes of each chapter.

1.2 Research Motivation

E-health has brought many advantages to the health sector, and the benefits of using Information and Communication Technologies (ICT) in health organisations and institutions to support patients with their illnesses are widely documented in the literature. In addition, e-health helps fill the gaps and addresses issues affecting traditional health services. Saudi Arabia is adopting e-health to benefit from its advantages and usefulness. 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 (Ram, 2014).

Saudi Arabia seeks to implement different e-health solutions in the healthcare domain. Such an implementation can produce several advantages in the Kingdom. One significant advantage of e-health is to help in controlling a number of the prevalence diseases in the Kingdom including diabetes mellitus, upper respiratory tract infection, musculoskeletal disorders, heart diseases, cancers and strokes.

The expenditure of the Ministry of Health (MOH) in Saudi Arabia is increasing yearly as a result of the MOH's aim to improve its services by adopting different ICT initiatives. The budget of the MOH in 2016 had an increase over £492,000 sterling from 2015 (Ministry of Health, 2016a). However, the healthcare sector in Saudi Arabia is still impacted by many hindrances related to e-health, as highlighted below.

- **Non-connectivity of Information Systems (ISs)**

Some healthcare organisations are using information systems (Almalki et al., 2011). However, the effort to connect these information systems in order to build up a national healthcare system is deficient (Altuwaijri, 2008).

- **Lack of Technical Expertise and Computer Skills**

This barrier is mainly related to the lack of experience in using computer applications among healthcare staffs and healthcare professionals. Other factors related to this barrier includes a lack of guidelines to handle Electronic Medical Records (EMRs), poor maintenance of computers and networks and slow computers, data entry problems, unfriendly designed interface, and insufficient computer terminals (Khalifa, 2013).

- **Failure of Adoption Health Information Services (HISs)**

This barrier refers to the gap between planning to adopt HIS's and the implementation in Saudi Arabia and poor technical support and over-running of time and/or cost schedules (Khalifa, 2013; Altuwaijri, 2011).

- **Human Barriers**

Human barriers include the negative beliefs of healthcare professionals, the resistance to change and lack of trust by medical staff in using technologies in healthcare (El Mahalli, 2015).

- **Cultural Barriers**

Cultural factors contribute to the failure in adopting e-health because of limited human interaction (Aldraehim et al., 2012). Aldraehim and Edwards (2013) explain that Saudi Arabian people are extremely influenced by their culture and therefore prefer physical interaction to virtual contact.

- **Medication Safety**

This barrier is related to two major e-health issues: communication gaps among healthcare institutions and the 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 (Aljadhey et al., 2013).

- **Financial Barriers**

Transmitting traditional paper medical records to electronic system can be very costly (Amatayakul, 2010). 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 (Khalifa, 2013).

- **Security and Privacy**

This focuses on the easy of accessing the 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 (Khalifa, 2013).

In Saudi Arabia, diabetes mellitus constitutes a major health issue as the Kingdom is in the list of the top ten countries in the prevalence of diabetes mellitus. The prevalence of diabetes mellitus in Saudi Arabia was 16.8% in 2010 (Shaw et al., 2010), whereas in 2014 the prevalence of this disease in the Kingdom constituted 20.5% of the population (International Diabetes Federation, 2014). In 2015, the prevalence of diabetes mellitus among people between 20 and 79 represented 20% of this age range (International Diabetes Federation, 2015b). Diabetes mellitus is causing a number of complications to diabetic citizens in Saudi Arabia and the disease is considered the first reason for death among all diseases (Centers for Disease Control and Prevention, 2016). Therefore, diabetes mellitus was chosen as the domain of application of the current thesis.

Diabetes mellitus constitutes another motivation of this research. The chronic disease is seen to be affecting over 350 million people globally and the number is expected to increase in the coming years (Lotfy et al., 2017). Diabetes mellitus can result in serious health complications such as heart and kidney failure, strokes, blindness and amputations. Nevertheless, people with this chronic disease struggle with its non-health-related complications. The later complications are associated with the adherence to medication and coexisting with the life style of diabetes mellitus.

Different diabetic individuals encounter one or more complications, including difficulties controlling eating habits, deficient knowledge in the correct way of using medications, doubt regarding insulin preciseness and time schedules for antidiabetics (Péres et al., 2007). In addition, patients with diabetes encounter problems in identifying the right medications and understanding prescriptions, especially when patients asked to change medication (Onwudiwe et al., 2014). Moreover, Blonde (2005) highlighted other non-health-related complications of diabetes mellitus, including patient failure to adhere to lifestyle measures and pharmacologic therapies, as the most common reasons cited for failure to achieve glycaemic goals. Blonde (2005) also indicated that diabetic patients may not be able to identify the right blood glucose target. Besides this, diabetic individuals in Muslim societies may face another non-health-related complication in the holy month of Ramadan where they are require to fast from sunrise until sunset for 30 days. These complications include identifying appropriate medication times and the right medication amount. Additionally, diabetic patients in Ramadan encounter a problem regarding finding an appropriate diet and eating habit (Hassanein et al., 2017).

The non-health-related complications of diabetes mellitus can result in serious health related complications. For example, poor adherence to diet and physical activities can cause diabetes complications including arteries diseases (Sharaf et al., 2013). Inappropriate usage of medication can lead diabetic patients to mortality. Onwudiwe et al. (2011) mentioned another disadvantage of these complications as inadequate health literacy, which can lead to an inefficient use of health services whereas deficient adherence to diabetes medication can result in cost waste in healthcare services.

Scholars have suggested solutions to overcome the non-health-related complications of diabetes mellitus. The mostly cited solutions is diabetes self-management and education where diabetic individuals can be educated to use their expertise and skills to self-manage their diabetes on an ongoing basis (Powers et al., 2017). This includes different aspects as patients' learn how to use medication and when, the appropriate diet and physical activities, and how to manage diabetes during Ramadan.

Different studies have studied the complications caused by diabetes mellitus, including studies underpinning the situation of diabetes mellitus in Saudi Arabia (Fareed et al., 2017 ; Sweileh et al., 2014 ; Aljumah et al., 2013 ; Appuhamy et al., 2013) . However, the literature lacks a discussion of diabetes non-health-related complications of diabetes mellitus in the context of Saudi Arabia, which is considered a major country in terms of diabetes prevalence. In addition, the effort on patients' education in relation to their diseases and how they can be managed is deficient in Saudi Arabia (Alshammari, 2016). Furthermore, e-health systems in Saudi Arabia to support patients with different diseases, including diabetic patients, are few and limited to few hospitals (Alsulame et al., 2016).

To investigate the issues that hinder e-health and empower diabetic citizens to self-manage their diabetes, this research has developed a framework to integrate KM and KD. The framework is an attempt at addressing some of the e-health challenges highlighted above. This integrated framework of KD and KM constitutes an e-health initiative to support not only diabetic citizens in Saudi Arabia, but also healthcare professionals who aim to help diabetic citizens control and manage their illness. IT professionals are also involved in the investigation to understand the barriers to e-health in the healthcare sector in Saudi Arabia. In this thesis, KD is limited to DM; other approaches, such as text mining, web mining and link mining are to be incorporated in future work.

In addition, this framework adopts a KM model for the purpose of disseminating valuable knowledge related to diabetes self-management and education extracted from diabetic citizens and healthcare professionals. The SECI model is applied as an appropriate model which can provide effective collaboration and dissemination of knowledge related to diabetes management and education. To demonstrate the viability of our approach, a web portal is developed with diabetic citizens and healthcare professionals in mind.

1.3 Aim and Objectives

The research attempts to answer the following research questions:

Q1. Can the integrated framework of KM and KD overcome the barriers in relation to e-health in Saudi Arabia?
Q2. Can the integrated framework of KM and KD address the difficulties of citizens with diabetes in Saudi Arabia?

The scope of the thesis is intended to support diabetic citizens in the Kingdom of Saudi Arabia. The aim of the research is to develop a framework to integrate KM and KD to support the e-healthcare of diabetes mellitus citizens and health professionals in the Kingdom.
The following objectives are to be carried out:

- To conduct a literature review and identify barriers to e-health in Saudi Arabia.
- To investigate e-health barriers in Saudi Arabia from the perspectives of citizens, healthcare professionals and IT specialists through a statistical study.
- To conduct a literature review for KM and KM models and applications in the healthcare sector.
- To conduct a literature review for KD to identify methods and applications in the healthcare sector.
- To conduct a literature review for diabetes mellitus and its complications and prevalence globally and in Saudi Arabia.
- To collect related data to investigate current non-health related complication for diabetes mellitus in Saudi Arabia.
- To carry out a DM analysis of the collected data of diabetes mellitus.
- To develop a framework of KM which can integrate DM analysis.
- To conduct a literature review for web tools that apply the SECI model.
- To build a web portal to support diabetes education and self-management in Saudi Arabia.
- To validate the developed framework.
- To evaluate the designed web portal.

1.4 Research Design

The research in the current thesis undertakes a set of sequential steps in order to achieve all its objectives. The steps of the research are listed as follows and summarised in Figure *1.1* afterward:

1. Literature review about e-health in Saudi Arabia. The literature review focuses on the healthcare situation in Saudi Arabia and identifies trends in relation to e-health implementation in the Kingdom through a secondary research. This step concentrates mainly on identifying barriers hindering e-health utilisation in the Saudi Arabian healthcare domain. This step of the research is presented in Chapter Two.
2. Literature review about KM. This step utilises secondary research to define knowledge and its management. In addition, this step concentrates on reviewing the SECI model and its challenges as a well-known and highly utilised KM theory. This step of the research is presented in Chapter Three.
3. Literature review about DM. This step utilises secondary research for the purpose of defining DM and reviewing its various methodologies, techniques and algorithms. This step of the research is presented in Chapter Three.
4. Statistical study of e-health barriers in Saudi Arabia. This step conducts a primary research to investigate e-health barriers from the perspectives of citizens, healthcare professionals and IT specialists via a questionnaire. This step of the research is presented in Chapter Five.
5. Literature review about diabetes mellitus. This step utilises secondary research in order to define diabetes mellitus and its types and complications. In addition, this step concentrates on the prevalence of diabetes mellitus globally and in Saudi Arabia. An important outcome of this research step is to identify non-health related complications of diabetes mellitus. This step of the research is presented in Chapter Two.
6. Development of the integrated framework of KM and KD. The framework integrates DM as a KD approach with the SECI model as a KM theory to produce an e-health initiative for supporting the community of diabetes mellitus in Saudi Arabia. This step of the research is presented in Chapter Four.
7. DM study. This step conducts a primary research to extract non-health related complications encountered by diabetic citizens in Saudi Arabia. The analysed data is acquired through a survey published to diabetic citizens in the Kingdom. This step of the research is presented in Chapter Six.
8. Literature review of SECI model application through web technology. This step focuses on identifying a number of web technologies to apply the four modes of the

SECI model from a secondary research. This step of the research is presented in Chapter Seven.

9. Diabetes portal design. This step concentrates on planning, designing and testing of a web portal. The web portal applies a number of web tools to simulate the modes of the SECI model. This step of the research is presented in Chapter Seven.
10. Framework validation. In this step, the framework is validated through a workshop with diabetic citizens, healthcare professionals and IT professionals in Saudi Arabia. This step of the research is presented in Chapter Eight.
11. Web portal evaluation. The evaluation study focuses on the implementation of the SECI model on the web portal. The evaluation study is conducted through a workshop with diabetic citizens, healthcare professionals and IT specialists. This step of the research is presented in Chapter Eight.

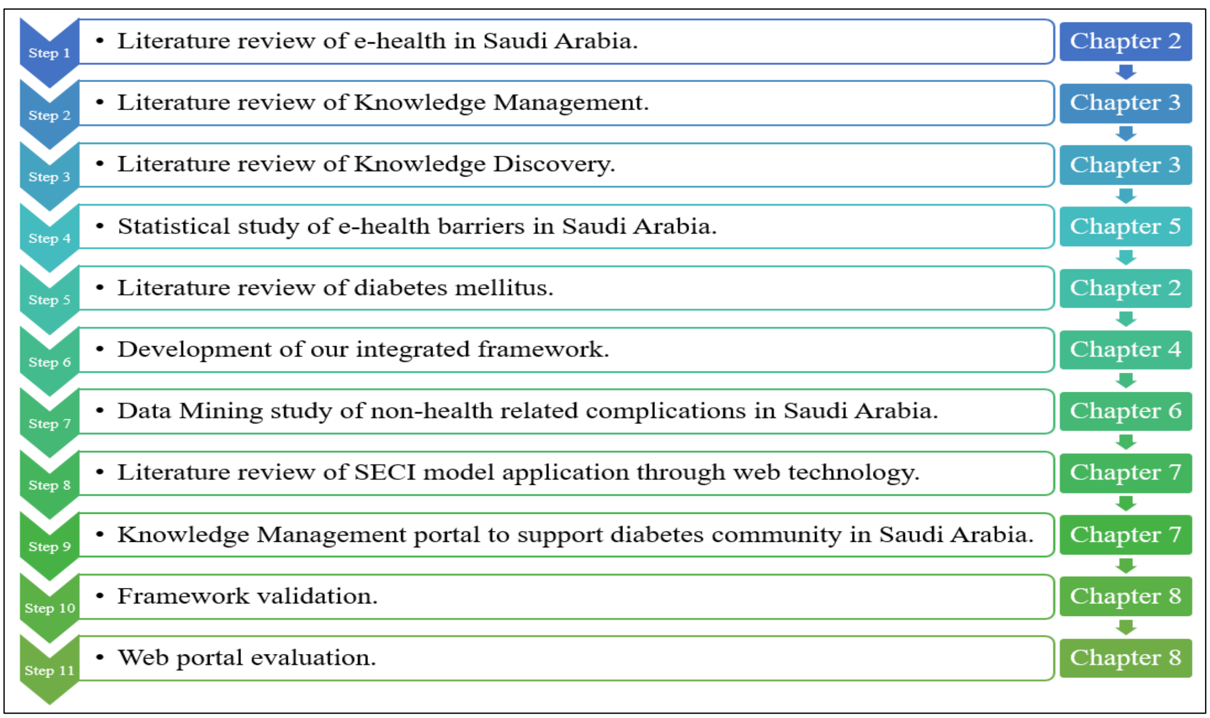

Figure 1.1 Research steps of the current thesis

1.5 Research Contributions

The research makes a number of academic contributions. The first contribution is the development of an integrated framework of DM and KM to support e-health in Saudi Arabia. The framework is the first to integrate the two separate fields in the domain of diabetes mellitus in Saudi Arabia. Besides the development of the framework, the research generates the following contributions to academic knowledge:

- Ranking of e-health barriers in Saudi Arabia from the perspectives of Saudi citizens, healthcare professionals and IT specialists.
- Increasing KM practice and applying the SECI model in the Saudi Arabian healthcare domain.
- The utilisation of DM to extract diabetes non-health related complications.
- Fulfilling the gap in relation to patients' education in Saudi Arabia.
- The implementation of the SECI model to disseminate useful knowledge related to diabetes self-management and education.
- Generation of an open-source dataset for diabetes research.
- Extension of the SECI model to convert and disseminate knowledge stored in technological media.
- Increasing studies in the area of e-health systems in Saudi Arabia.

Moreover, the current thesis make the following contribution to the clinical practice in the domain of diabetes mellitus in Saudi Arabia.

- Designing of a web portal to support the community who have diabetes mellitus using the SECI model.

1.6 Research Methodologies

In this research, we will utilise the Research Onion introduced by Saunders et al. (2009). The research methodologies discussed by Saunders and his collegues include research philoshophy, approaches, strategies, choices and time horizons. The selection of these aspects in relation to the current thesis is discussed in the following sub-sections.

1.6.1. Research philosophy

Saunders et al. (2009) explained that a research philosophy carries out assumptions related to how you see the world. There are four types of research philosophies. The choice to adopt any of them depends on the research question of the research. These are positivism, realism, interpretivisim and pragmatism.

In the positivism philosophy, the researcher works with an observable society and the researcher is acting as an independent in the data collection processes and has no pressure to alter the substance of the collected data and does not affect the study being undertaken. The positivist philosophy claims that the researcher is value-free and has no feelings towards the study. Realism philosophy is similar to positivism in that it assumes a scientific approach to the development of knowledge. This philosophy assumes that what we see as reality is the truth and the reality is always independent from the mind. The Interpretivisim philosophy, however, emphasise the differences between humans in our role as human actors. Pragmatism argues that the research question is the major determinant of epistemology, ontology and axiology. According to Saunders et al. (2009), pragmatism philosophy can be perfectly utilised when the research question does not suggest using positivism or interpretivisim philosophies.

In this research, the positivism philosophy is adopted. The chosen philosophy is suitable to study an observable social reality, such as the current thesis. In addition, the positivism philosophy allows us to undertake this research in a value-free way, which means the researcher is independent and has no impact on the study.

1.6.2. Research approach

Saunders et al. (2009) have described two approaches: deductive and inductive. The inductive approach is concerned with building a theory whereas the deductive approach is about testing an existing theory. The deductive approach is suitable for our study since it focuses on identifying e-health barriers and diabetes mellitus difficulties in Saudi Arabia from the literature review and overcomes them by using a web portal which will utilise our proposed framework.

1.6.3. Research method and time horizons

There are three major research methodologies: quantitative, qualitative, and mixed approach (Williams, 2007). The quantitative research approach is used by investigators who need to quantify numeric data and help in creating new knowledge. Methods of the quantitative approach tend to be descriptive research method, correlational, developmental design, observational studies, and survey research (Williams, 2007). The qualitative research methodology is an approach used to discover knowledge from actual experiences (Creswell, 2013). It is less structured and involves describing, explaining, and interpreting collected narrative data (Williams, 2007; Leedy and Ormrod, 2001). The third research methodology is the mixed approach where the collected data from quantitative and qualitative research approaches are analysed in a single research study (Creswell, 2003; Williams, 2007). Thus, the mixed approach uses numeric and narrative data types.

According to Saunders et al. (2009), the posistivism research philosophy is usually used with the quantitative research methodology, which is based on data collected through the questionnaire and analysed to extract important trends. Moreover, survey studies, which include questionnaires, are usually associated with the deductive approach. Consequently, the research choice for our study is multi-method quantitative, where we will use two questionnaires to collect appropriate data quantitatively. The first questionnaire investigates the barriers in adopting e-healthcare in Saudi Arabia, whereas the second questionnaire is related to the study of diabetes mellitus with respect to the barriers. The time horizon of the current study is cross-sectional, as the study is being undertaken in a particiular time and not aware of studying change or development. Figure *1.2* illustrates our research methodology choices for this thesis:

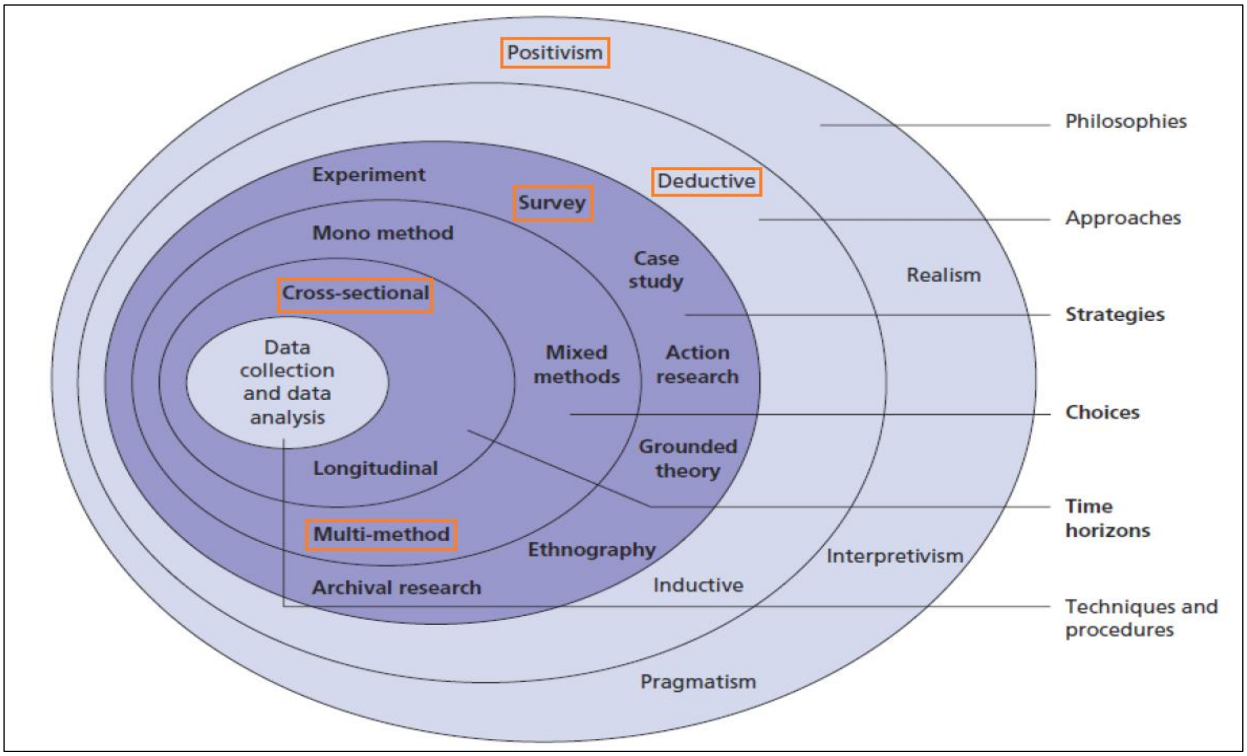

Figure 1.2. Research Onion with our selection of research methodologies for the current thesis

Source: (Saunders et al., 2009)

1.7 Ethical Consideration

The research complies with the ethical standards produced by Staffordshire University to prevent any ethical breaches. The ethics committee at Staffordshire University has approved two ethical forms (see appendices A.3 and B.1). The first ethical form was approved prior to the questionnaire study, whereas the second ethical approval was obtained before we started gathering data for the DM study. Participants in both studies were adults from Saudi Arabia and their participation was anonymous. In addition, participation in this study is optional and participants were allowed to withdraw their participation at any stage. This thesis does not seek any participation from children, people with communication or learning difficulties, patients, people in custody, people who can be considered vulnerable or people engaged in illegal activities.

Besides this, the framework validation and the web portal evaluation took place in a workshop at a Primary Healthcare Center (PHC) in Saudi Arabia. The PHC has granted us a written consent to access its facilities, for the participants who participated in both sessions (see Appendix C.3).

1.8 Thesis Structure

The thesis is organised into nine chapters (see Figure *1.3*). The content of each chapter are summarised as follows:

Chapter One: this chapter concentrates on the motivation of the current thesis. Chapter One also presents the aim and objectives as well as the research design of this study. In addition, Chapter One discusses the research methodologies used in this study, outlines its contributions and highlights its ethical consideration.

Chapter Two: this chapter provides a literature review of e-health and diabetes mellitus in Saudi Arabia. The e-health literature review concentrates on defining e-health along with its advantages, the situation of e-health implementation in Saudi Arabia and identifying e-health barriers in the Kingdom. The literature review of diabetes mellitus focuses on defining the diseases, its complications and the prevalence of the disease in Saudi Arabia. This chapter also provides an overview of Saudi Arabia and its healthcare system.

Chapter Three: this chapter underpins the theoretical bases of this research. Chapter Three provides a review of KM and DM. The KM review focuses on defining knowledge and KM. In addition, this chapter discusses KM advantages, KM hindrances, the SECI model and discusses its issues. The DM review defines DM and discusses its methodologies, techniques and algorithms.

Chapter Four: this chapter presents the integrated framework proposed in this thesis. The chapter also discusses the framework components, domain of application and provides a real case scenario to show how the framework should work in the real world. It also highlights the potential benefits of the framework, the embodiment of the framework in a web portal, the framework validation and contributions to knowledge generated by developing this framework.

Chapter Five: this chapter presents the questionnaire study of e-health barriers in Saudi Arabia. In this chapter, the barriers of e-health in Saudi Arabia are investigated and ranked from the perspectives of three stakeholders: citizens, healthcare professionals and IT specialists.

Chapter Six: this chapter presents the DM pilot study to analyse the non-health related complications encountered by diabetic citizens in Saudi Arabia. The chapter utilises a DM methodology, technique and algorithm in order to reveal frequent complications from the collected data.

Chapter Seven: this chapter demonstrates the design of a diabetes web portal. The web portal is designed to disseminate diabetes self-management and educational guidelines, best practices and strategies in order to support citizens and healthcare professionals of diabetes mellitus in the Kingdom. The web portal utilises a number of web tools to apply the four modes of the SECI model. Therefore, a variety of web tools are also reviewed in this chapter.

Chapter Eight: this chapter presents the validation and evaluation of this study. In this chapter, the framework is validated in a workshop in Saudi Arabia with nine participants. In addition, the designed web portal is also evaluated in this chapter in the same workshop and with the same participants.

Chapter Nine: this chapter summarises the research and discusses the research contributions. Moreover, this chapter highlights the challenges encountered through this research and identifies areas of future work.

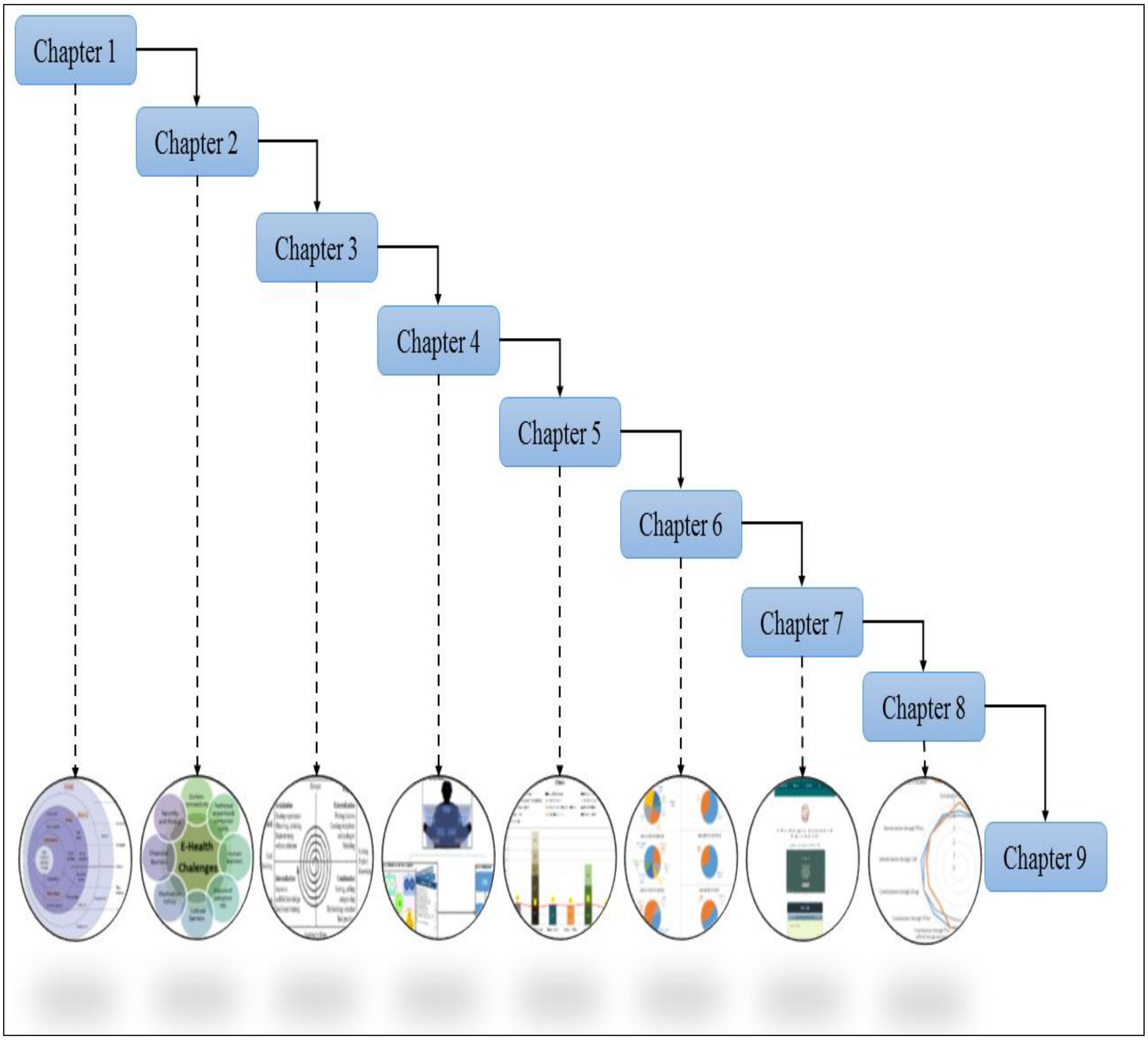

Figure 1.3 Thesis structure

Chapter Two: Literature Review of E-health and Diabetes Mellitus in Saudi Arabia

2.1 Introduction

E-health plays an important role in improving healthcare services in many countries. Saudi Arabia is one of those countries that aims to implement different e-health solutions to enhance its healthcare services. However, different barriers are seen to be affecting successful implementation of different e-health solutions. In addition, diabetes mellitus has a high prevalence in many countries including Saudi Arabia. Besides the health complications of this chronic diseases, diabetes mellitus has another type of complications related to adhering to medications and lifestyle. The first part of this chapter provides brief information about Saudi Arabia's healthcare system. This is followed by a discussion regarding its e-health status and a literature review of e-health barriers in Saudi Arabia. The last sections of this chapter cover diabetes mellitus and its various complications globally and in Saudi Arabia in particular as this is the domain application of this thesis.

2.2 Overview of Healthcare in Saudi Arabia

The Kingdom of Saudi Arabia is one of the largest countries in the Middle East area. Saudi Arabia is located in the southwest corner of Asia and it is the largest country in the Arabian Peninsula (see Figure *2.1*). According to the General Authority for Statistics in Saudi Arabia, the population of Saudi Arabia amounted 31,742 million in 2016 (General Authority for Statistics, 2017b). Saudi Arabia covers two million square kilometres, which equals one-fourth the size of the United States. Saudi Arabia is surrounded by Jordan, Iraq and Kuwait to the north; the Arabian Gulf, Qatar and the United Arab Emirates to the east; Oman and Yemen to the south and; the Red Sea in the west. Saudi Arabia has 13 districts. The capital of Saudi Arabia is Riyadh, which is located in the Riyadh district. The Kingdom has other major cities including the two cities of the two holy mosques, Mecca and Medina.

Figure 2.1. Location of Saudi Arabia

The flag of Saudi Arabia is designed with a green background with the Islamic testimony in the middle ‘There is no god but Allah, Mohammed is the messenger of Allah’ written in the Arabic language which is the official language of the country. An Arabic sword is placed underneath the testimony. The national emblem of Saudi Arabia consists of two crossed swords, which represents strength and sacrifice, headed by a palm tree, which represents prosperity and growth (see Figure *2.2*).

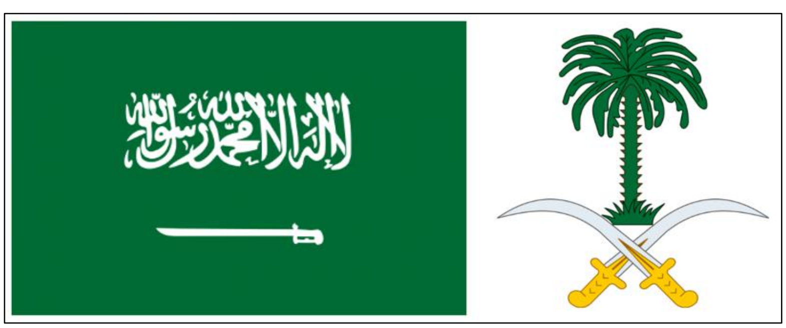

Figure 2.2. Flag and national emblem of Saudi Arabia
(General Authority for Statistics, 2017a)

The healthcare system in Saudi Arabia is given significant attention by the government of Saudi Arabia. The MOH is responsible for about 60% of health services in the Kingdom. These services are supported by 7.2% from the annual budget of the government of Saudi Arabia (Ministry of Health, 2016a). The MOH is organised in 13 general directorates of health affairs distributed among the 13 administrative regions of Saudi Arabia. The MOH plays a significant role in the development and improvement of healthcare services in Saudi Arabia. This includes ensuring that there is a sufficient number of healthcare facilities in the Kingdom to achieve a better quality of healthcare services. The number of PHCs reached 2282 in 2016. The number of hospitals increased from 271 hospitals in 2015 to 274 hospital in 2016. The total number of beds in these hospitals is 41,297, including 2,598 beds related to seven specialist hospitals and medical cities. The number of medical staff in the public healthcare sector is 122,323 in 2016 (see Figure *2.3*).

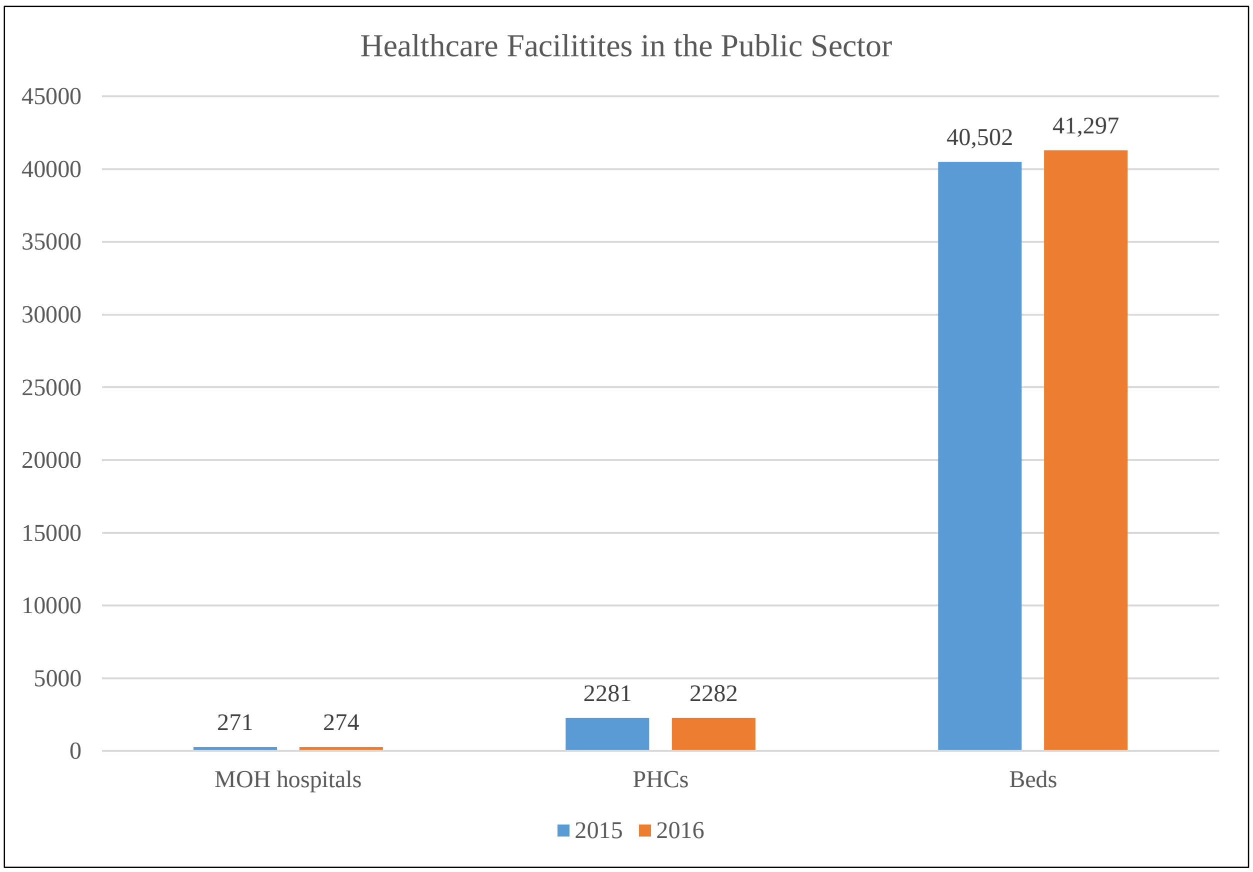

Figure 2.3. Number of healthcare facilitates provided by MOH in Saudi Arabia in 2015 and 2016

Source: (Ministry of Health, 2016a)

Besides the MOH, there are other governmental authorities that provide public healthcare services in Saudi Arabia. These governmental authorities are the National Guard Health Affairs, the security forces' medical services, army forces medical services, Ministry of Higher Education hospitals (teaching hospitals), Royal Commission for Jubail and Yanbu health services, ARAMCO hospitals, school health units of the Ministry of Education and the Red Crescent Society (Almalki et al., 2011). Other governmental sectors have provided 42 hospitals, with the capacity of 12,032 beds. Figure *2.4* compares the number of hospitals provided by the MOH and other governmental sectors in Saudi Arabia from 2010 to 2014.

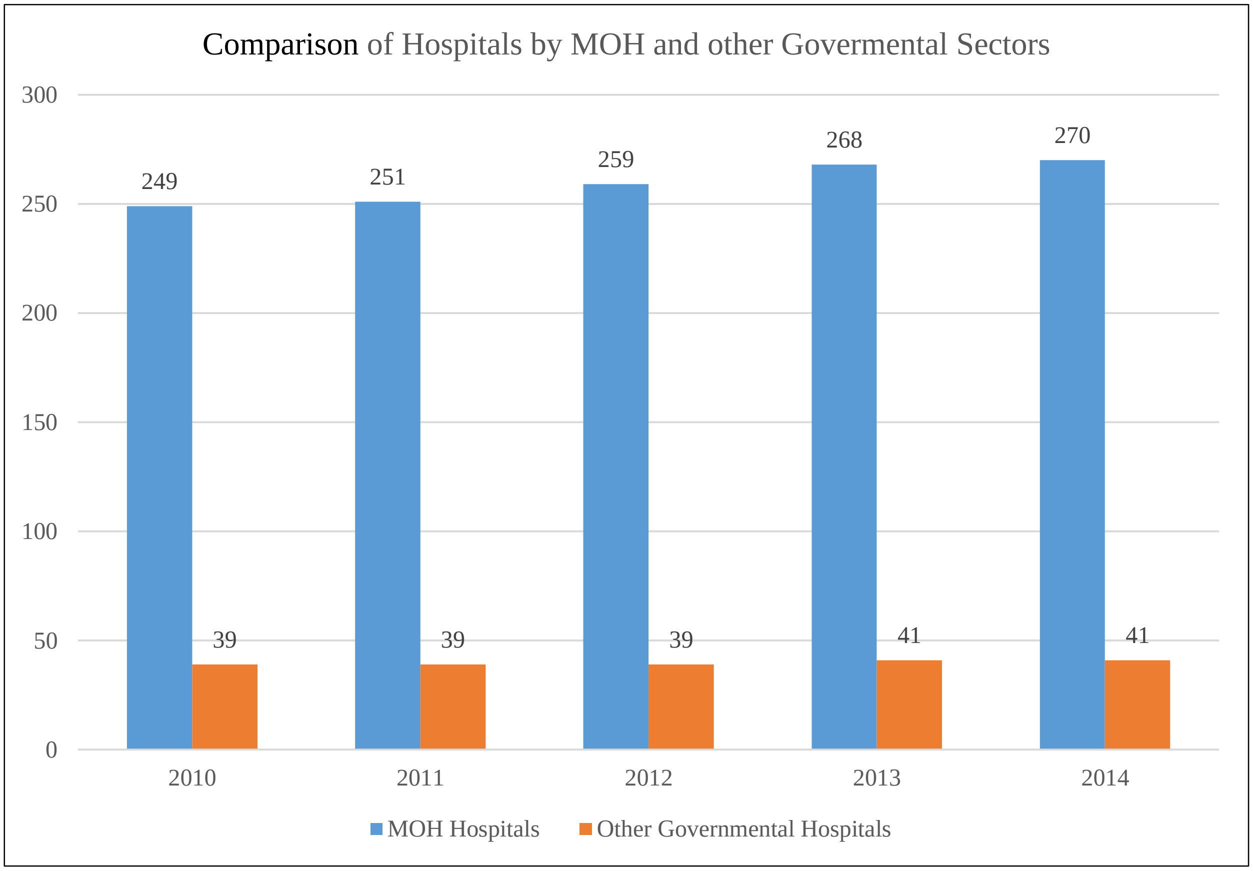

Figure 2.4. Hospitals provided by MOH and other governmental sectors in Saudi Arabia in 2010-2014

Source: (Ministry of Health, 2014)

Besides the healthcare services provided by the public sector, number of healthcare facilities are developed and provided through the private sector in Saudi Arabia. The kingdom witnessed increases in the number of healthcare facilitates provided through both sectors, public and private, over the last two years (see Figure *2.5*). According to the MOH (2016), the ministry has licensed many facilitites in the private sector in 2016. This includes licensing 145 hospitals, 1,670 medical complexes, 1,000 specialised medical compexes and 77 private clinics. Moreover, the MOH has liscensed other private facilitites including 104 laboratories and 96 physiotherapy clinics and 7,815 pharmacies (see Figure *2.6*).

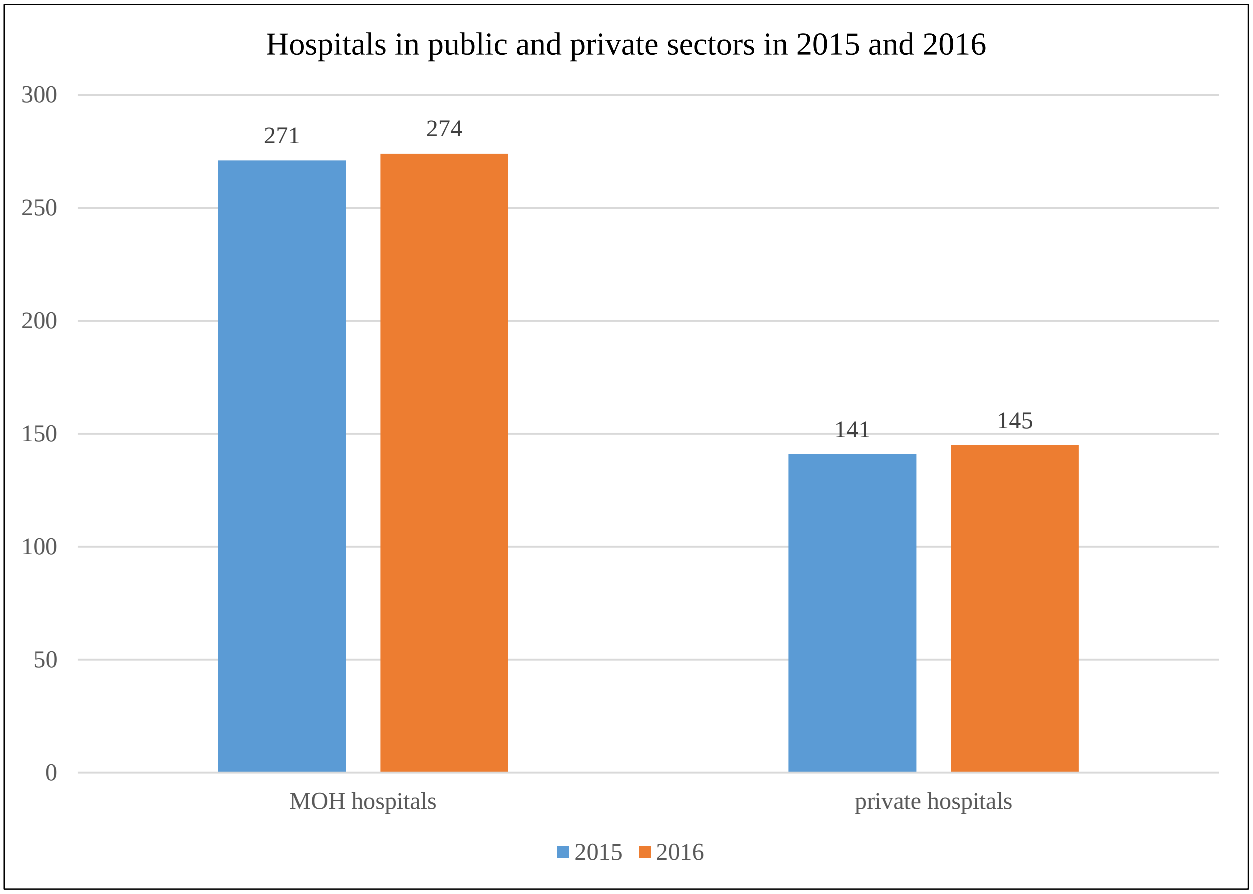

Figure 2.5. Hospitals provided through public and private sectors in Saudi Arabia in 2015 and 2016

Source: Ministry of Health (2016)

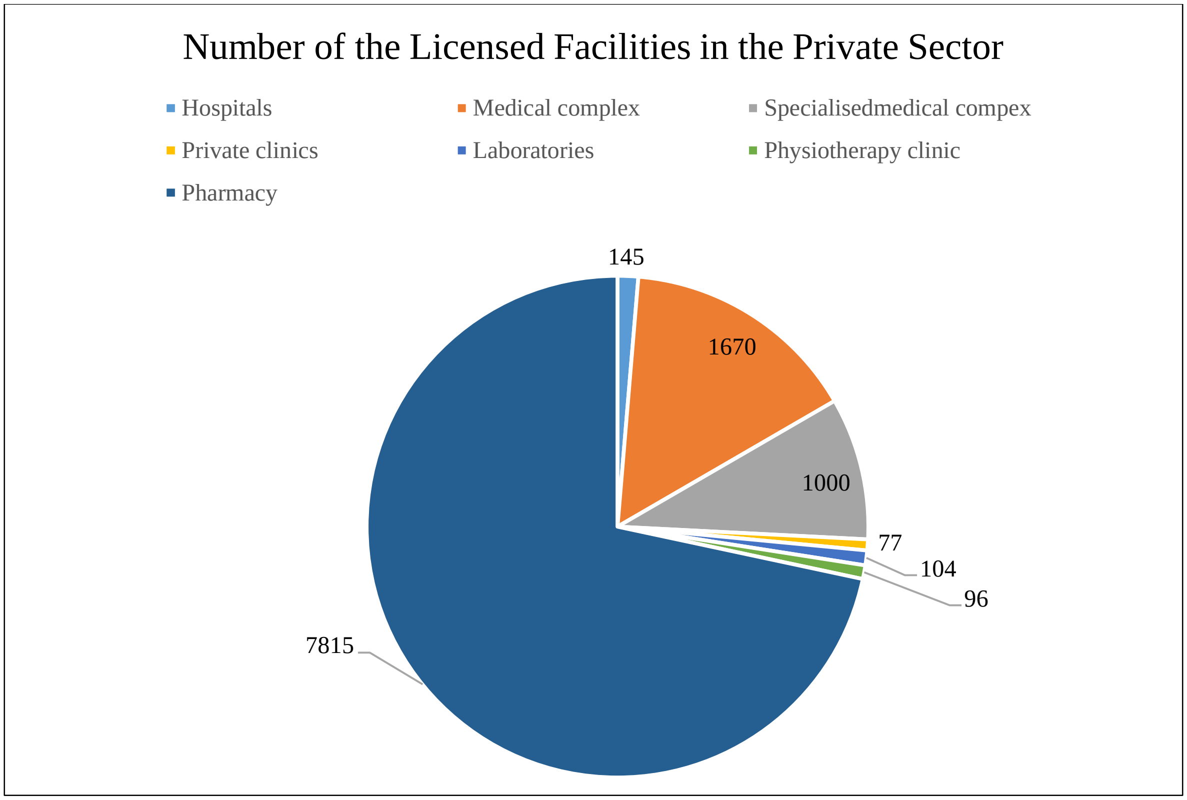

Figure 2.6. Private healthcare facilities licensed by the MOH in 2016

Source: (Ministry of Health, 2016)

2.3 Health Situation in Saudi Arabia

Despite the effort of providing different healthcare facilities, Saudi Arabia has reported a number of health diseases among people living in the Kingdom. Saudi Arabia indicated a considerable number of people with diseases visiting different healthcare facilities including PHCs, MOH hospitals and emergency departments of MOH hospitals. The variety of these diseases includes, but is not limited to, strokes, heart conditions, cancers, hypertensive diseases, infectious and parasitic diseases. However, the MOH has reported that most visits to PHCs in Saudi Arabia are associated with upper respiratory tract infection followed by musculoskeletal disorders and diabetes mellitus (Ministry of Health, 2011) (see Figure *2.7*). In this thesis, diabetes mellitus is chosen as a domain of application to overcome its complications through our proposed framework due to the prevalence of the disease and its mortality consequences. Upper respiratory tract infection and musculoskeletal disorders, however, can be addressed in future work as illustrated in Chapter Nine.

Non - Saudi غير سعودي		Saudi سعودي		عدد الزيارات No. of visits	Disease	المرض
F إناث	M ذكور	F إناث	M ذكور			
5797	10137	51642	58590	126166	Infectious and parasitic dieases	الأمراض الطفيلية والمعدية
5740	9745	64943	71652	152080	Intestinal helminthiasis	الديدان المعوية
23701	53062	895969	919033	1891765	Diabetes mellitus	مرض السكري
9288	8179	183309	107174	307950	Diseases of blood and immunity	أمراض الدم والجهاز المناعي
23453	37777	653735	553467	1268432	Hypertension	ضغط الدم المرتفع
1723	2965	38865	41568	85121	Cardiovascular diseases	أمراض القلب والأوعية الدموية
26167	58551	435172	472898	992788	Eye diseases	أمراض العيون
18426	32110	293565	316808	660909	Ear & mastoid diseases	أمراض الأذن والماستويد
222602	430022	4520350	5098887	10271861	Upper respiratory tract infections	التهابات الجهاز التنفسي العلوي
3379	6304	56008	62406	128097	Pulmonary infections	الالتهابات الرئوية
15568	30444	283846	369853	699711	Bronchial asthma	الربو
18825	40411	712819	691595	1463650	Dental and gum diseases	أمراض الفم والأسنان
39272	88488	662339	673047	1463146	Diseases of stomach, oesophagus and intestine	أمراض المعدة والمريء والأمعاء
18512	40228	335116	343733	737589	Diseases of colon, rectum and anal canal	أمراض القولون والمستقيم والشرج
16549	29041	296812	221778	564180	Urinary tract diseases	أمراض الجهاز البولي
4592	0	49666	0	54258	Diseases of female breast	أمراض الثدي لدى النساء
16814	0	288182	0	304996	Diseases of female pelvic organs	أمراض أعضاء الحوض لدى النساء
14263	0	364417	0	378680	Complications of pregnancy	مضاعفات الحمل
0	8590	0	48629	57219	Genital system diseases (men)	أمراض الجهاز التناسلي عند الرجال
37207	74630	554256	598027	1264120	Diseases of skin and subcutaneous tissue	أمراض الجلد والنسيج الخلوي
50750	152518	890357	968869	2062494	Dieases of the musculoskeletal system	أمراض الجهاز العظمي والعضلي
1591	3062	27273	27064	58990	Neurological and psychological diseases.	الأمراض النفسية والعصبية.
8789	39169	129212	271440	448610	Injuries, accidents and poisoning	الإصابات والحوادث والتسممات
3928	5766	34322	39892	83908	Burns	الحروق
14110	22938	199732	224978	461758	Diarrheal diseases	أمراض الإسهال
386321	420812	1316889	1238116	3362138	Others	أخرى
987367	1604949	13338796	13419504	29,350,616	Total	المجموع

Figure 2.7. Outpatients' visits to PHCs in Saudi Arabia

Source: (Ministry of Health, 2011)

The upper respiratory tract has a number of infections that can affect the nose, paranasal sinuses, pharynx and trachea which can be caused by different viruses and parasites (Sherif B, 2013; Masavkar and Naikwadi, 2016). According to the World Health Organisation (WHO), 235 million people suffer from diseases related to upper respiratory tract infection worldwide (WHO and Marko, 2017). In Saudi Arabia, the number of visits to PHCs due to respiratory disease was over 10,2 million visits in 2011 (Ministry of Health, 2011). Official reports from the MOH in Saudi Arabia lacks provision of the number of visits to its hospitals due to upper respiratory tract infections for the last five years. However, the number of emergency cases in the MOH hospitals shows similarity in the period from 2011 to 2014. (see Figure *2.8*).

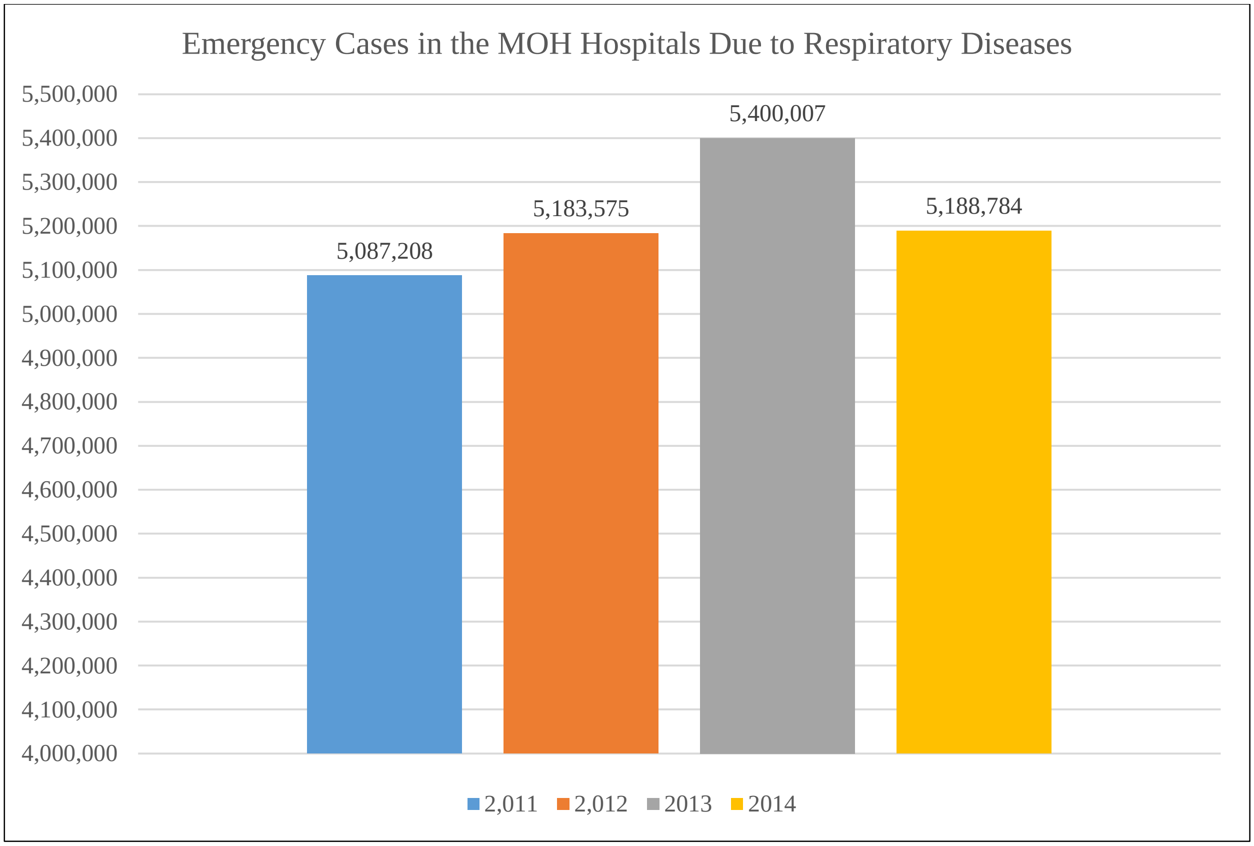

Figure 2.8. Emergency cases of respiratory diseases in MOH hospitals from 2011 to 2014

Source: (Ministry of Health, 2011, 2012, 2013, 2014)

Musculoskeletal disorders are common health conditions in many countries and include different syndromes such as tendon inflammations, nerve compression disorders, osteoarthritis, myalgia and lower back pain (Punnett and Wegman, 2004). The number of visits to PHCs in Saudi Arabia due to these disorders constituted over 2 million visits in 2011 (Ministry of Health, 2011). The number of visits to MOH hospitals due to Musculoskeletal disorders has risen from 1,089 million in 2011 to 1,095 in 2014 (see Figure *2.9*).

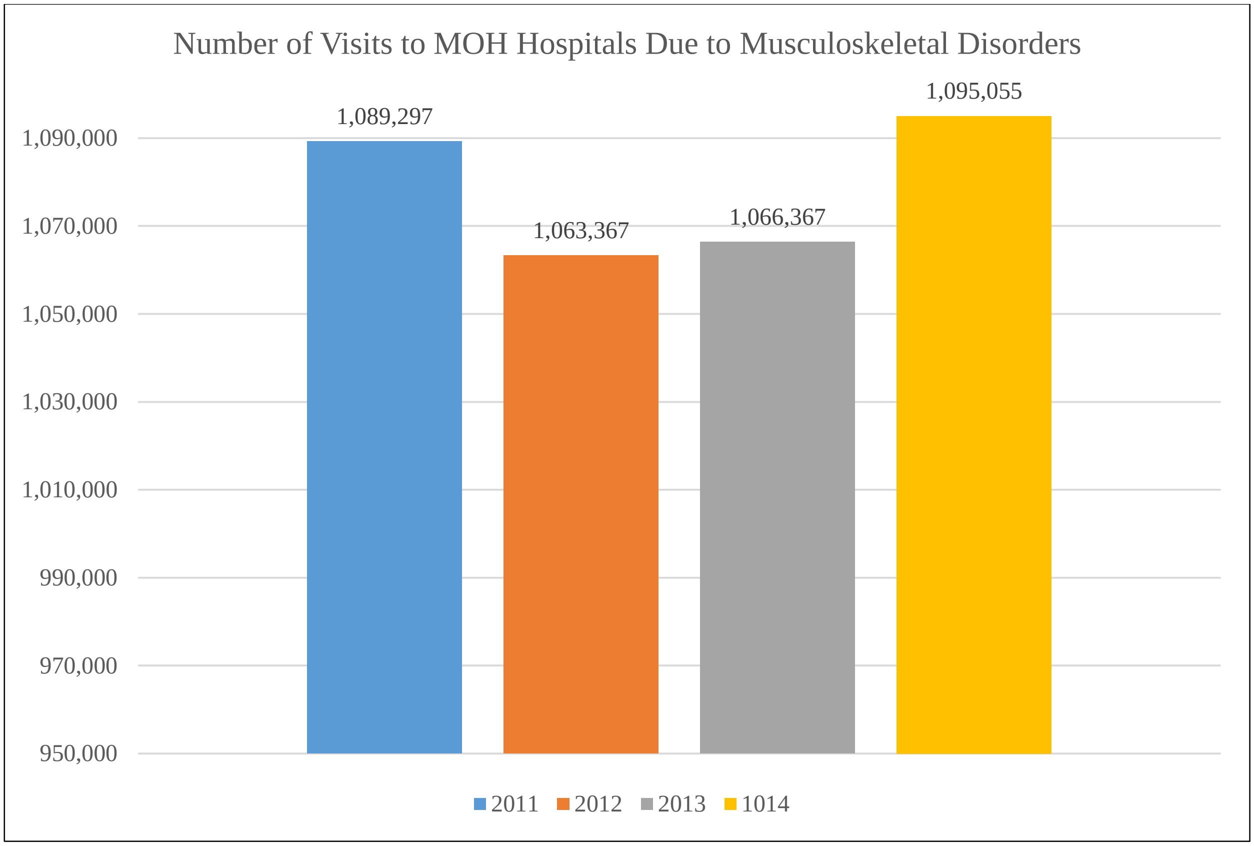

Figure 2.9. Visits to MOH hospitals due to musculoskeletal disorders from 2011 to 2014

Source: (Ministry of Health, 2011, 2012, 2013, 2014)

Diabetes mellitus is the third highest cause of visits to PHCs in Saudi Arabia in 2011. According to the MOH, the number of visits to PHCs due to this disease was over 1,8 million (Ministry of Health, 2011), placing this chronic disease in the third place as the most common health condition in the Kingdom. Despite the prevalence of this disease being after respiratory tract infections and musculoskeletal disorders, diabetes mellitus constitutes more of a life threat in Saudi Arabia. Global reports indicated that diabetes mellitus is the major cause of death, above all other diseases in Saudi Arabia according to the Centers for Disease Control and Prevention (2016), constituting a serious health issue in the Kingdom that can affect life expectancy records. More details about diabetes mellitus and its prevalence are discussed in Section 2.5.

2.4 E-health in Saudi Arabia

E-health plays an important role in the healthcare domain nowadays. Many healthcare organisations around the globe have started utilising e-health as part of their healthcare systems. E-health was defined in the literature review in different ways and different countries differ in the definition of e-health (Lau and Kuziemsky, 2016). However, the majority of e-health definitions agree on the utilisation of technology in the healthcare domain to improve healthcare services.

E-health is the term that refers to the use of technology in the healthcare sector. One of the most widely used definitions for e-health is from the WHO has stated “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.” According to WHO (2014), e-health is the transfer of health resources that includes the following:

1. Delivering health information via the internet and telecommunication.
2. Using IT and e-commerce to improve health services.
3. Managing health systems through using e-business and e-commerce practices.

WHO has further described e-health as the utilisation of ICT for health (WHO, 2014). E-health requires working with regional or global partners to increase the use of ICT as part of the development of the healthcare services.

The utilisation of e-health offers many advantages to patients, healthcare staffs and healthcare organisations over the traditional delivery method of healthcare services. These advantages include increased communication between patients and medical staffs, engagement of patients when providing information, reduced stigmatisation of drugs use and enhanced privacy (Carra et al., 2014, 2016). Moreover, e-health can increase commitments to drugs and facilitate the preventive strategies through taking advantage of electronic devices, which are commonly used by young people (Gustafson et al., 2014; Carra et al., 2016). Besides all these advantages, the literature has highlighted several potential benefits of e-health and ICT utilisation in the healthcare domain. These benefits are listed as follows:

- Improved quality of healthcare. Quality of care is defined as doing the right action at the right time and in the right way for the right person to get the best possible outcomes (Menachemi and Collum, 2011). New e-health technology plays a significant role in in this regard. E-health technologies such as Decision Support System (DSS) increase medics' adherence to the guidelines of provision of care to patients. In addition, electronic reminders to medication can increase patients' adherence to medications and vaccines. Furthermore, e-health solutions can reduce error in healthcare such as reducing prescription errors through the use of CPOE (Aljadhey et al., 2014).
- Facilitation of access to healthcare services and facilities. One of the major advantages of using ICT in healthcare is the increased accessibility and availability of healthcare services (Carra et al., 2014, 2016). New e-health technologies enable access to healthcare at any time. Electronic records, for example, facilitates access of patients to their medical records and enables them to access their medical history at any time. Telemedicine is another technology used in e-health and helps in providing healthcare services for people at a distance, such as those who live in rural areas, through the use of ICT (WHO, 2010). According to Aardoom et al., (2016), with the new technologies being adopted in healthcare there is no more need for face-to-face interview with healthcare professionals and e-health initiatives have introduced new method of diagnoses and treatments, some of which includes the intervention of internet-based technology to provide healthcare services for the treatment of different disorders.
- Cost reduction of healthcare delivery. The integration of ICT technologies in healthcare significantly reduces the costs of healthcare. For example, the implementation of electronic records prevents patients from performing redundant tests at more than one hospital. Electronic records, such as Electronic Health Records (EHRs), collect the medical history of patients. This includes all test results and medications the patients have received. The results of implementing such an initiative is the prevention of patients from taking redundant tests and therefore reducing the cost of healthcare services (Menachemi and Collum, 2011). Another way in which e-health reduces the cost of healthcare services is the reduction of billing errors. New

e-health technologies, such as electronic records, enable bills to be captured in a timely manner and this results in decreased billing error. In addition, electronic records improve revenue to healthcare organisations by increasing cash-flow, as well as reducing billing errors. Smit et al. (2011) indicated a clearer example of cost-effectiveness of e-health solutions. They introduced a new system using e-health intervention to curb alcohol use in the Netherlands. The findings from their study found that e-health intervention could save € 68 million compared to the face-to-face methods, with a slightly higher impact on people's health. The study concluded that e-health provides an increased return-to-investment on health compared to old healthcare systems using traditional methods.

- Increased research. Many ICT means being used in healthcare improve the ability to conduct research (Menachemi and Collum, 2011). The reason for this is the ability of e-health solutions to store patients' data electronically. For example, EHRs increases research as it increases the availability of data which is stored electronically. The potential of research in the medical domain is to provide better ways to monitor different health conditions and to improve surveillance of critical diseases (Kukafka et al., 2007).
- Raised life expectancy. According to the WHO, global life expectancy was 66.4 years in 2000 and has increased to 71.4 in 2015 (WHO, 2016c). This means that the percentage of people who reached the age of 60 or over has increased from 18.7% in 2000 to 20% in 2015. One interpretation of this increase is the utilisation of different computing innovations in the healthcare domain. New ICTs including monitoring systems, databases and web networking technologies play significant role in improving healthcare facilities and providing various ways to deliver better health services (Car et al., 2008). In Saudi Arabia, life expectancy can be considered through addressing prevalent diseases (see Section 2.3). Adopting e-health solutions to improve healthcare services can play a significant role in the treatment and prevention of these diseases. Consequently, life expectancy in Saudi Arabia can be raised significantly.

Many countries have adopted several e-health solutions to benefit from their advantages in healthcare. Saudi Arabia is one of those countries that have started implementing e-health in the healthcare domain. According to the MOH in Saudi Arabia, the ministry aims to take advantages of new ICT and is keen to implement these technologies in the healthcare sector. The MOH has already taken multiple steps in implementing e-health, including the adoption of a number of e-health projects such as telemedicine, PACS, health information systems, enterprise resources planning and information security projects in different hospitals in the Kingdom. The ministry is also working on more undergoing e-health projects, which shows the desire of the MOH in Saudi Arabia to take full advantage of e-health and its benefits (Ministry of Health, 2016a). A number of new initiatives have emerged focusing on many aspects of healthcare. However, the implementation of new e-health initiatives in the Saudi Arabian healthcare domain has been impacted by a number of barriers. The literature has indicated eight barriers that affect successful implementation of e-health solutions in the Kingdom (see Figure *2.10*). These barriers are outlined as follows:

- **Non-connectivity of Information Systems (ISs).** Some regional directorates and central hospitals are using ISs (Almalki et al., 2011). However, It has been witnessed that there is no communication between these ISs with each other or to others in the private sector, and there is no effort to connect these ISs in order to build up a national healthcare system (Altuwaijri, 2008). Binobaid et al., (2016) have studied the interoperability of different healthcare organisations and found several factors that can hinder connectivity of ISs including inconsistent formatting and ontologies among different ISs.

- **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. No guidelines are provided to handle EMRs, and many complain about poor maintenance of computers and networks and slow computers and terminals (El Mahalli, 2015). Users are not satisfied with using some technologies, data entry and retrieval problems, unfriendly design of interfaces and insufficient computer terminals (Khalifa, 2013). Moreover, another study has indicated that deficient readiness of ICT infrastructure is the major barrier to e-health adoption in Saudi Arabia (Uluc, 2016).

- **Failure of Adoption of Health Information Services (HISs)**. There is a big gap between planning to adopt HISs and their implementation in Saudi Arabia (Khalifa, 2013; Altuwaijri, 2011). Some of these are caused by the poor technical support and over-running of time and/or cost schedules. To overcome this problem, Khalifa (2013) suggested a strategic plan should be developed by the hospitals' management for the adoption of HISs.

- **Human Barriers**. This problem has been considered as the biggest reason for failing to adopt health information systems in Saudi hospitals (Altuwaijri, 2011). Human barriers include negative beliefs of healthcare professionals towards technologies and lack of trust by medical staff towards computer-based medical solutions (El Mahalli, 2015). Other healthcare staffs have low trust of e-health initiatives in relation to the privacy of patients' data (Uluc, 2016). Therefore, many medical staff resist the change from traditional to computer-based healthcare services.

- **Cultural Barriers**. Cultural factors have a negative impact on implementing e-services and result in failure of the adoption of e-health. The main reason for this is a lack of human interaction (Aldraehim et al., 2012). In general, culture has an impact on the computer mediation communication (Chadhar and Rahmati, 2004). Saudi Arabian people are influenced greatly by their culture and those people prefer physical contact more than virtual contact (Aldraehim and Edwards, 2013).

- **Medication Safety.** According to Aljadhey et al. (2013), 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' historical medical issues, by not communicating effectively. This issue was also mentioned by Binobaid et al., as they found a lack of use of communication technologies between medical staffs (Binobaid et al., 2016). The second issue is limited use of technology whose consequences occur in illegible handwriting. The lack of utilisation of e-health in medication result in deficient monitoring of medication refills and drug alerts in cases where there is a medication conflict or allergies to patients (El Mahalli, 2015). CPOE can solve this problem; however, this is being adopted slowly.

- **Financial Barriers.** Using IT in the healthcare sector has a considerable number of financial costs. Transmitting traditional paper medical records to an electronic medical record system requires high amount of expenditure (Amatayakul, 2010). These expenses may lead to the abstention of adopting IT in healthcare. In order to overcome this issue, studies have suggested feasibility studies to prove the worth and merit of costs in implementing EMR so that the expenditure on such systems are justified (Khalifa, 2013).

- **Security and Privacy**. Ease accessing EMRs of patients is critical, as some medical records of patients can be disseminated to others without permission of the patient or the doctor (Khalifa, 2013). El Mahalli (2015) has tested the impact of security and privacy on e-health in the eastern region of Saudi Arabia. He found that over 63% of participants believe that security and privacy are a major barrier to EHRs. Furthermore, the privacy of patients' data was also indicated as one of the major e-health barriers by physicians in Saudi Arabia (Uluc, 2016).

Figure 2.10. E-health barriers in Saudi Arabia

The eight barriers identified by literature review can be grouped into four categories: business, human, technology and finance (see Figure *2.11*). Barriers such as medication safety and failure of adoption of HISs belong to the business category. Human and cultural barriers belong to the human category. The category of technology includes barriers such as technical expertise and computer skills, non-connectivity of ISs and security and privacy. Finance is the last category and it includes financial costs of e-health.

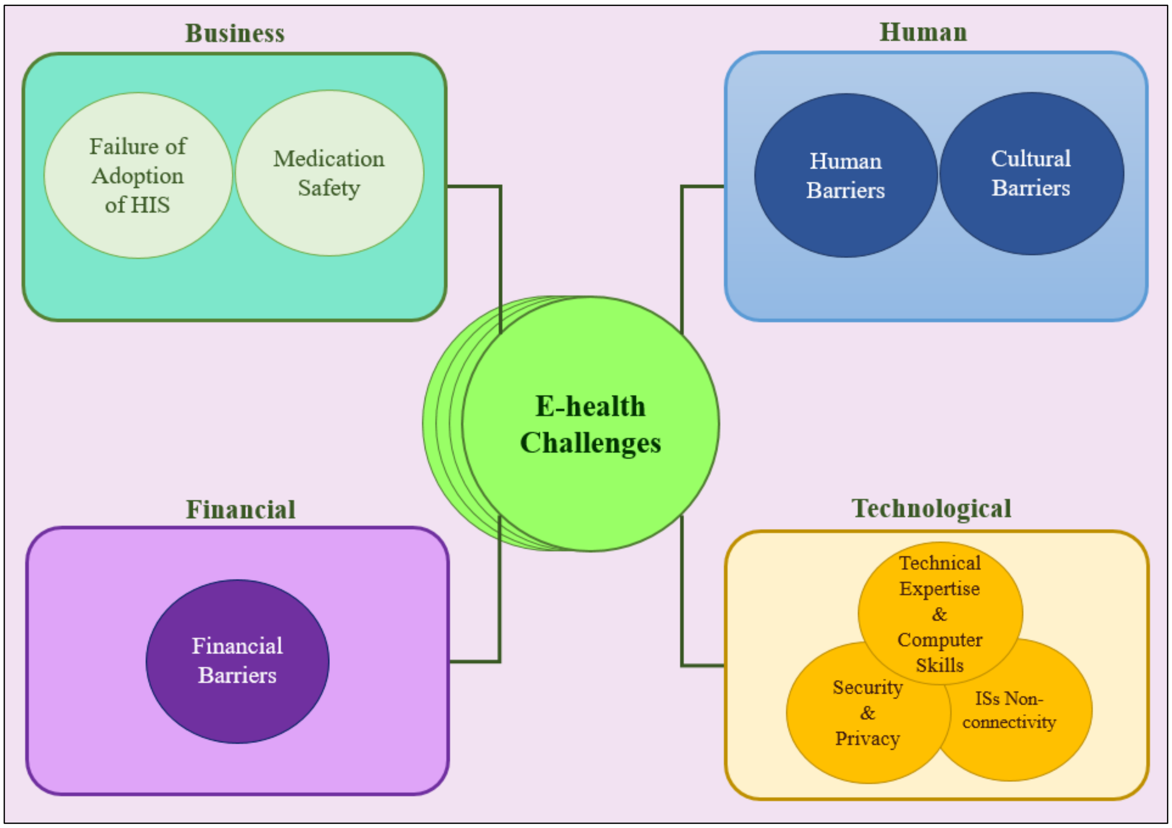

Figure 2.11. Categories of e-health barriers in Saudi Arabia

A considerable portion of MOH's spending is dedicated to implementing e-health solutions to improve healthcare services in the Kingdom. The budget of the MOH in Saudi Arabia rose from over 3,8 billion GBP (6% of the total state budget) in 2007 to over 6,6 billion GBP (6.9% of the total state budget) in 2011 (Ministry of Health, 2011). In 2016, the budget of the ministry had an increase of over 492 thousand GBP from the ministry's budget in 2015 (Ministry of Health, 2016a). However, the implementation of different e-health initiatives has become problematic due to several barriers. Understanding these barriers from diabetes patients and healthcare professionals as well as IT deliverers is critical when developing both, a framework to integrate KM and KD, and a web portal to demonstrate this integration. It is therefore extended to investigate these barriers from these three perspectives; this is discussed in Chapter Five.

2.5 Diabetes Mellitus

Diabetes mellitus is a chronic disease which affects many people around the globe. People of different ages, genders and in developing and even developed countries have been diagnosed with diabetes and the prevalence of diabetes mellitus is expected to increase internationally to 592 million in 2035 (Ministry of Health, 2016b).

Diabetes mellitus is a group of metabolic disorders known as hyperglycaemia which is caused by deficient insulin secretion and/or insulin actions (American Diabetes Association, 2013). Diabetes mellitus is developed in a human body for a number of reasons. One reason is the destruction of pancreas cells, which is responsible for insulin production. This results in a deficiency in insulin production. Another reason for diabetes development is the deficient insulin action, which includes insufficient insulin secretion and/or reduced insulin responses from different tissues of the human body. There are different symptoms of diabetes mellitus. Some of which are polydipsia, polyuria and weight loss. In addition, signs such as blurred vision and polyphagia can also be symptoms of hyperglycaemia.

There are two main types of diabetes mellitus: type 1 diabetes and type 2 diabetes. In addition, the WHO organisation have mentioned another type of diabetes mellitus and this is gestational diabetes (WHO, 2016a). The differences between the three types are summarised as follows:

1. **Type 1 diabetes:** caused by the destruction of B-Cells in the pancreas. This leads to absolute deficiency in insulin production. Type 1 diabetes appear in between 5% and 10% only of diabetic people in the world (American Diabetes Association, 2013).
2. **Type 2 diabetes:** caused by the resistance of insulin in the human body. This resistance usually is combined with insulin deficiency or defects in insulin secretion. This type of diabetes mellitus accounts for 90% to 95% of diabetic individuals in the world (American Diabetes Association, 2013).
3. **Gestational diabetes:** women with gestational diabetes are diagnosed with high

hyperglycaemia. However, the hyperglycaemia level is still below those who are diagnosed with type 1 or type 2 diabetes. Women with this diabetes type may encounter complications during pregnancy and/or delivery. Despite most cases being resolved after delivery, diagnosed women and their children are at a higher risk of type 2 diabetes in the future (American Diabetes Association, 2013; WHO, 1999).

Diabetes mellitus has a high prevalence all over the world, affecting a tremendous number of people from different ages, genders and nationalities. Currently, there are over 350 million people diagnosed with diabetes mellitus and one billion people are pre-diabetics who are at risk of getting diabetes (Lotfy et al., 2017). In 2014, the number of diabetic individuals has reached 244 million and increased from only 108 million in 1980 (WHO, 2016b). In 2012, it was estimated that diabetes mellitus has caused 1.5 million deaths whereas another 2.2 million deaths were attributed to high blood glucose levels. According to the International Diabetes Federation (2015), the prevalence of diabetes mellitus is increasing quickly and the number of diabetic people will reach 642 million in 2040.

Saudi Arabia, like other developing countries, has a considerable number of patients who are suffering from different kinds of chronic diseases. One of those diseases is diabetes mellitus, which has a high percentage of appearance among citizens in almost every part of the Kingdom. According to Shaw et al.(2010), Saudi Arabia is in third place among the top ten countries for diabetes prevalence. In 2010, the prevalence percentage for diabetes mellitus in Saudi Arabia was 16.8% among adults in the ages of 20 to 79 years old. This percentage is expected to rise in 2030 to reach 18.9% (Shaw et al., 2010). The number of outpatient visits made by diabetic individuals to PHCs is 1.8 million out of 29.3 million overall outpatient visits to HCCs in Saudi Arabia. This number of diabetic people's visits represents 6.44% of the overall number of visits to all PHCs in Saudi Arabia, and puts diabetic people in third place in the scale of all outpatient visits in the Kingdom (Ministry of Health, 2011).

Official reports from the MOH in Saudi Arabia show an increasing numbers of visits to public hospitals over the years. The number of visits to MOH hospitals due to diabetes mellitus was over 434 thousand in 2011 (Ministry of Health, 2011). The number has increased over four years to exceed 477 thousand visits to MOH hospitals in 2014 (Ministry of Health, 2014) (see Figure *2.12*).

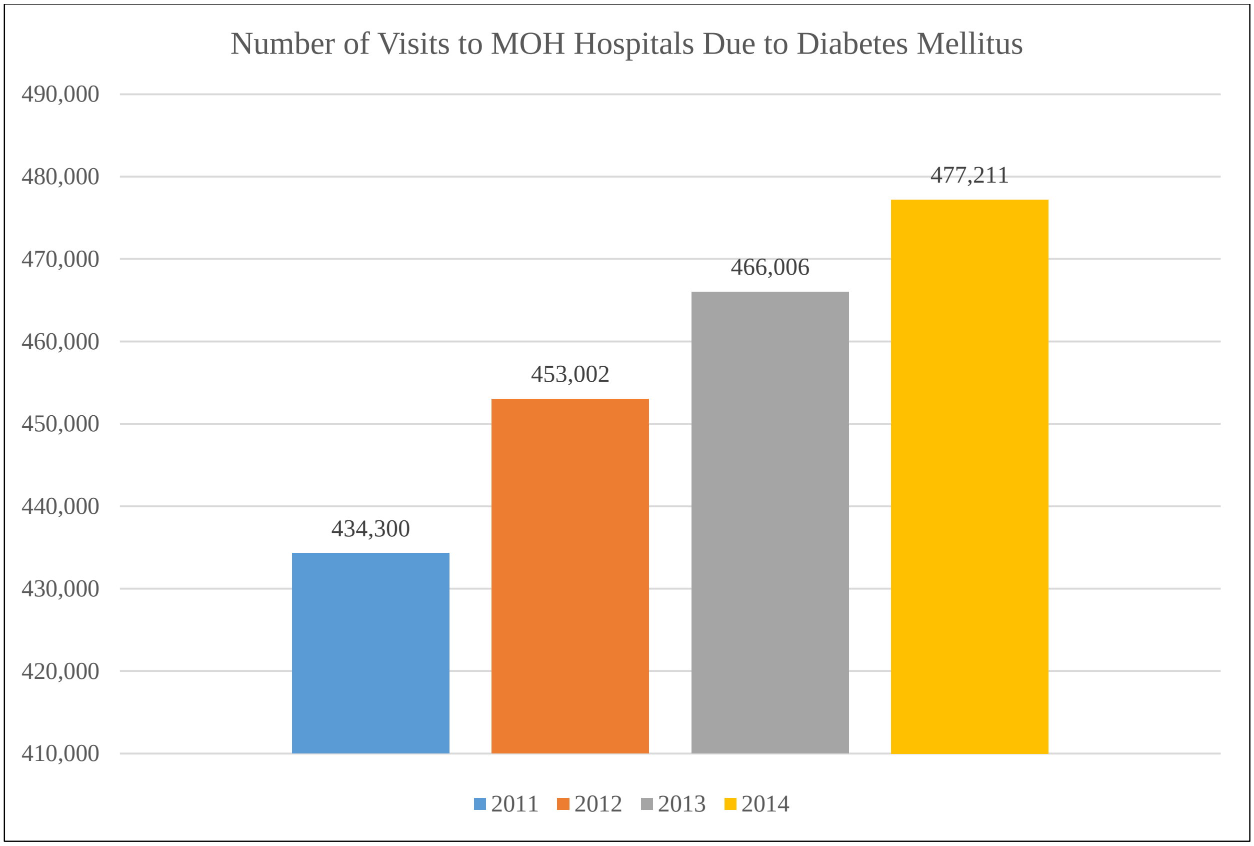

Figure 2.12. Visits to MOH hospitals due to diabetes mellitus from 2011 to 2014
Source: (Ministry of Health, 2011, 2012, 2013, 2014)

In recent statistics, the International Diabetes Federation revealed that Saudi Arabia had more than 3.8 million cases of diabetes mellitus in 2014 and the prevalence of this disease among individuals represents 20.5% (International Diabetes Federation, 2014). Those diabetic people are not limited to a particular age. In 2015, Saudi Arabia is in the list of top countries in terms of the prevalence of type 1 diabetes among children under 14 years old, with 16,100 cases (International Diabetes Federation, 2015b). In the same year, the prevalence of diabetes mellitus among people from 20 to 79 years old is 20%. Diabetic people in Saudi Arabia suffer from various complications of diabetes. However, the most serious complication encountered by diabetics in Saudi Arabia is mortality. According to the Centers for Disease Control and Prevention (2016), diabetes mellitus is considered the first cause of death in Saudi Arabia among all other diseases in 2013.

People suffering from diabetes mellitus could find themselves with consequential health conditions. Bouillon et al. (2013) found that diabetes risk scores, in particular the Finnish score, were associated with future frailty. Another study found that type 2 diabetes mellitus results in a small relative risk increase for depression (Hasan et al., 2013). Sánchez-Quesada and Pérez (2013) mentioned that cardiovascular disease derived from atherosclerotic conditions is the leading cause of death in patients with diabetes mellitus. People with diabetes are in 15 times greater danger of having leg amputations than people without diabetes (Holt et al., 2010). In addition, diabetes mellitus can cause heart failure (Hunt et al., 2009), in addition, and can cause blindness (Frank, 2013). Moreover, diabetic individuals are at higher risk of having kidney failure and strokes (Appuhamy et al., 2013).

Many lifestyle activities can help in terms of the prevention of diabetes mellitus and its consequences. These lifestyle activities include diet and physical activities (Fareed et al., 2017). Diet plans help diabetic individuals to meet the blood glucose level required. Different diet plans are recommended for those who have lower risk of diabetes mellitus. In particular, diet plans that include fibre and wholegrain are found in different studies to be associated with lower risk of developing diabetes or any of its risk factors (Aune et al., 2013 ; Hodge et al., 2004). Physical activities, on the other hand, benefit diabetic individuals by increasing insulin uptake in different muscles of the body and enhances the overall glycaemic control. Moreover, physical activities are very beneficial in postponing different cases of diabetes mellitus and its associated complications including neuropathy, retinopathy and nephropathy.

Beside many complications which could result from this disease, diabetic individuals also face other difficulties and issues related to controlling the disease and its consequences through different lifestyle activities. These issues are known by the non-health-related complications of diabetes mellitus (see Figure *2.13*). Péres et al. (2007) reported some of those challenges people with diabetes mellitus can have in their daily life, including difficulties controlling impulses related to eating habits, doubts in the correct way of using medications, refusal to take insulin because of concerns regarding dose preciseness and doubts regarding time schedules for antidiabetics. Blonde (2005), in addition, indicated patient deficiency in adherence to lifestyle measures and pharmacologic therapies as one of the most common reasons cited for failure to achieve glycaemic goals. Patients who have diabetes face problems in identifying medications and understanding prescriptions, especially when patients asked to change medication. Most patients could not remember their blood glucose and blood pressure target. According to Onwudiwe et al., (2014), the lack of knowledge of a desired blood glucose level is the major barrier of diabetes self-management. Another study suggested that appropriate knowledge about diabetes mellitus is essential to ensure patients' adherence to medication (Sweileh et al., 2014). The study found that diabetic individuals expressed their concerns regarding the adverse effects of multiple anti-diabetes medications. In addition, participants in the study believe that diabetes medications can be harmful, which suggests that assessment of patients' knowledge and education about diabetes mellitus prior medication intake to ensure adherence of patients prior to medications.

In addition to the above complications, diabetic patients in Muslim countries face difficulties related to controlling diabetes during the holy month of Ramadan. Since people in Muslim countries fast every day of the month of Ramadan from sunrise until sunset, Muslims who have diabetes mellitus might be at risk of considerable fluctuations in the blood glucose level (Zargar, 2017). Muslims in Ramadan change their eating routines, which includes changing the types and timing of almost all meals during this month. This can affect fasting people with diabetes mellitus in terms of identifying the appropriate diet, medication time and amount (Hassanein et al., 2017).

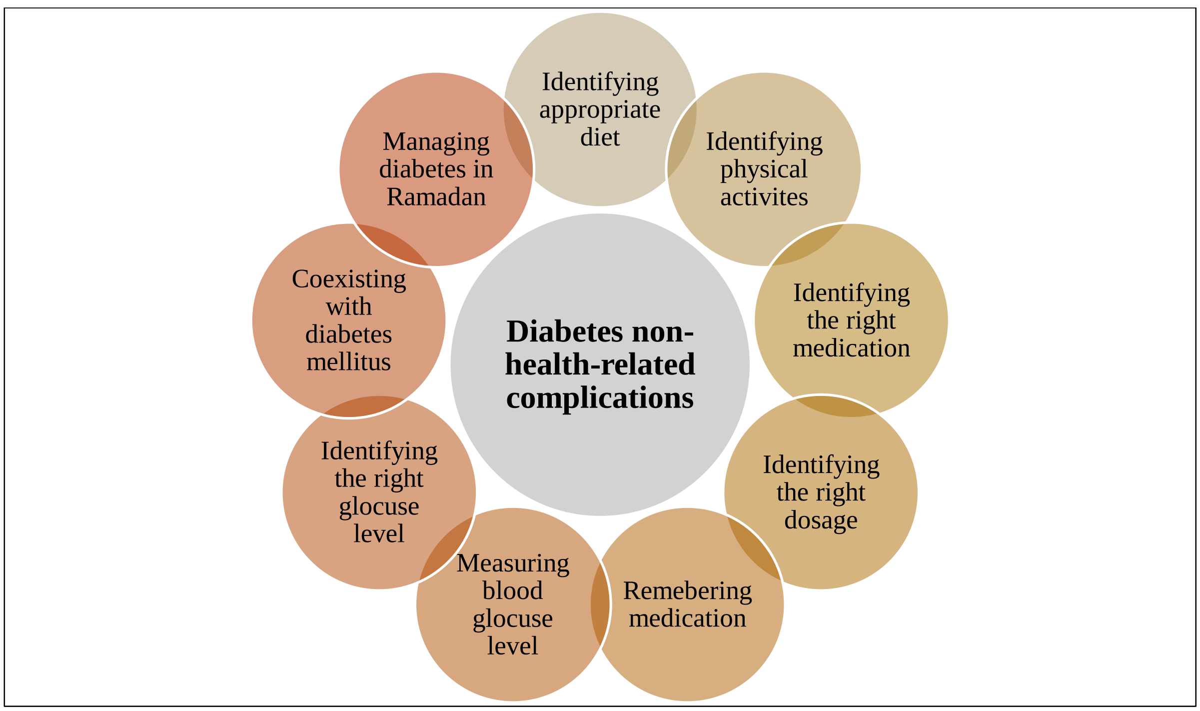

Figure 2.13. Non-health related complications of diabetes mellitus

The lack of education and management of diabetes mellitus has consequences with serious health complications. Deficient adherence to diet and physical activities are the most common cause of developing diabetes mellitus and its complications, along with other complications, such as hypertension and coronary artery diseases (Sharaf et al., 2013). In addition, poor execution of diabetes medication can result in serious health complications, including morbidity and mortality. Moreover, non-adherence to diabetes medication may result in increased loss to healthcare services (Sharaf et al., 2013).

Scholars have suggested solutions to overcome diabetic individuals' difficulties and problems. According to Onwudiwe et al. (2011) inadequate health literacy can lead to an inefficient use of health services. The WHO described health literacy as allowing access of people to resources and information in order to make appropriate decisions related to their health (Protheroe et al., 2017). Therefore, diabetes education and self-management are the two terms that have been highly cited in terms of overcoming diabetics' difficulties. The term self-management is known as the role patients managing their diseases. The term has been widely used in the healthcare domain to empower individuals to control their chronic illnesses, and its resulted complications, by increasing their knowledge, skills and confidence (Lorig et al., 2000). Furthermore, self-management enables people who suffer from particular diseases to manage their negative emotions and maintain better life health conditions. It has been applied globally and has proved its usefulness to a number of diseases, including different chronic conditions. In terms of diabetes mellitus, self-management and support are seen to have a positive impact on diabetic individuals by facilitating their knowledge and skills to increase diabetic individuals' abilities to take care of the diabetes by themselves on an ongoing basis (Powers et al., 2017).

Blonde (2005) stressed the importance of ongoing medical nutrition therapy and said that self-management education must be made available to all individuals with diabetes. Furthermore, Onwudiwe et al. (2011) defined diabetes education, knowledge and self-management as the key to successful diabetes management. Self-management education helps people with diabetes in improving knowledge, dietary habits, accurate glucose self-monitoring and weight (Deakin et al., 2005). In the United Kingdom, the National Institute of Clinical Excellence (NICE) guidelines recommend diabetes education programmes to be offered to diabetics and their healthcare providers, to assist patients in managing their condition. One example that is highly recommended in the UK is the Diabetes Education and Self-Management for Ongoing and Newly Diagnosed (DESMOND) which offers short courses through presentations and workshops, to develop patients' skills and knowledge to empower them to manage their illnesses.

One of the widely utilised methods for increasing education and self-management awareness among patients is the utilisation of internet technologies. The internet is used increasingly by people who suffer from chronic diseases in order to self-manage their illnesses and learn from other patients' experiences (Ziebland et al., 2014). The literature review conducted by Ziebland and Wyke (2012) revealed seven domains for accessing health experiences of others on the internet; (1) finding information, (2) feeling supported, (3) maintaining relationships with others, (4) experiencing health services, (5) learning to relate the story, (6) visualizing disease, and (7) affecting behaviour. In terms of diabetes mellitus, internet technology has been utilised to manage diabetes mellitus and its complications. Ramadas et al. (2011), for example, discussed the intervention of web-based technology for managing type 2 diabetes. They reviewed 13 web-based results on the positive impact of such intervention on the management of the disease. Another study showed how a web-based diabetes management system helped its users reduce their glycated haemoglobin (HbA1c) (Kwon et al., 2004). It offered educational programmes related to diabetes management, exercise, nutrition and recommendations for the patients with type 2 diabetes based on the information they entered, such as their medications and glucose levels.

Official reports showed promising indications in terms of utilising internet technology as an educational and self-management method. Internet penetration in Saudi Arabia rose from 13% in 2005 to 63.7% in 2014 and the number of internet users reached about 19.6 million (CITC Annual Reports, 2014). The internet is commonly used to search for health related information in Saudi Arabia (AlGhamdi and Moussa, 2012). However, the number of studies available about e-health initiatives in the Kingdom is limited to a few organisations and remains low (Alsulame et al., 2016). There is also a lack of e-systems to support diabetes patients in Saudi Arabia, and in Ramadan, in spite of the increasing number of people with diabetes mellitus in the Kingdom. In fact, studies available to support diabetes care in the kingdom are limited and related to specific healthcare organisations only and not tailored to support diabetic patients outside those organisations. There is a critical need to provide e-healthcare to support diabetic citizens to cope with their daily life difficulties and support healthcare professionals in providing quality and consistency of care to their patients.

The literature review has identified several studies undertaking various aspects of diabetes preventions and treatment in Saudi Arabia. In addition, studies have discussed different types of treatment of diabetes mellitus in the Kingdom. For example, Aljumah et al., (2013) compared the effects of the intervention of drug, diet, weight reduction, smoke cessation exercise and insulin on the treatment of diabetes mellitus. They concluded that diet control, weight reduction, exercise and smoking cessation are mutually essential for diabetes treatment. However, the literature review lacks in terms of identifying non-health-related complications in the Saudi Arabian context. In addition, the literature review witnessed a deficiency in relation to the self-management and education effort offered to diabetic individuals in Saudi Arabia. According to Alshammari (2016), Saudi Arabia is experiencing a deficient effort in relation to patients' education about their diseases along with its appropriate management. Moreover, a limited number of large hospitals in the Kingdom offer educational and counselling services to their patients. For example, Al-Ghamdi et al. (2012) assessed a medication counselling programme provided for discharged patents from a territory hospital in Riyadh to avoid adverse drug events. The study showed that the knowledge and education effort provided for patients prevented them from adverse drug events. In another study conducted at King Abdulaziz Medical City, another major hospital in the Kingdom, the education and counselling programme increased the medical knowledge of patients in relation to their recognition of medication and its side effects (Alkatheri and Albekairy, 2013).

In this study, we aim to fill this gap by investigating different non-health-related complications of Saudi Arabian diabetic citizens. In addition, we contribute to the concept of self-management and education in healthcare. Diabetes mellitus is the domain of application to apply appropriate diabetes self-management and education in the Kingdom, which is one of the major countries in the prevalence of diabetes mellitus worldwide.

2.6 Conclusion

E-health and diabetes mellitus are two major topics that are gaining more attention these days. The government of Saudi Arabia is making considerable efforts to implement different e-health solutions to improve its healthcare sector. However, a number of barriers are seen to be hindering the success of these solutions. The literature review in this chapter indicated eight barriers to e-health in the Saudi Arabian healthcare sector. These eight barriers, which relate to four quadrants: business, human, technology and finance, must be taken into consideration when developing an e-health framework to support patients in managing their illness.

Diabetes mellitus is a common disease in Saudi Arabia. The number of diabetic people in the Kingdom is increasing at an alarming rate. The prevalence of this chronic disease needs close monitoring and daily management activities. Despite the health related complications diabetes mellitus can cause, diabetic individuals struggle with complications that are related to their lifestyle and adherence to medication. Given the seriousness of this disease and the lack of e-health systems to support diabetic patients and healthcare providers, it became important to develop a framework to provide them with an effective KM based on their specific needs with respect to their illness and the e-health barriers identified. These need to be elicited using KD (e.g. DM) and integrated into a KM system. The next chapter discusses KD and KM.

Chapter Three: Knowledge Management and Knowledge Discovery

3.1 Introduction

KM and KD are two promising fields in e-health nowadays. The significance of KM is that it has empowerment capabilities to facilitate knowledge dissemination in comprehensive ways throughout an organisation. The dissemination of knowledge procedure provides multiple advantages to organisations and individuals. KD, on the other hand, has a set of useful tools to extract useful knowledge through various processes. One of the widely utilised tools in KD is Data Mining (DM), which concentrates on extracting useful knowledge from a large amount of data. The current study focuses on linking the two concepts by extracting useful knowledge through KD and then disseminating the extracted knowledge via KM. In this chapter, the two main components that support our integrated framework are discussed. The first part of this chapter discusses KM and its important aspects (see Section 3.2). Additionally, the SECI model is defined and discussed as it represents a major component of our integrated framework. In the second part, we concentrate on DM as a significant discipline of KD (see Section 3.3). DM methodologies, techniques and algorithms are illustrated and the utilisation of these aspects in healthcare are reviewed. Moreover, the second part of this chapter justifies our selections of DM methodologies, techniques and algorithms to be utilised in this study.

3.2 Knowledge Management

Davenport and Prusak (1998) define knowledge as a "fluid mix of framed experience, values, contextual information and expert insight that provide a framework for evaluation and incorporating new experiences and information". Utilisation of knowledge provides significant advantages for organisations in term of competition and improvement. Individuals store knowledge in their brains and those individuals have the brainpower or intellectual capital that every organisation desires (Liebowitz, 2001). Furthermore, knowledge helps in identifying current problems as well as achieving the desired results (Liao, 2002). Senior managers are considering the importance of knowledge and its advantages and making every effort to benefit from it. KD and KM provide useful vehicles to benefit from this valuable implicit knowledge.

KM is a dynamic process of capturing, storing, sharing and creating knowledge (Ni et al., 2010). The main aim of KM is to increase knowledge within an organisation through communication, offering opportunities to learn and the dissemination of knowledge (McInerney and Koenig, 2011). Various organisations nowadays have become aware of the importance of knowledge and its significance. To support the dissemination of knowledge in organisations, a new role in their workplace named Chief Knowledge Officer (CKO) is created (King, 2009). The responsibility of a CKO is to facilitate knowledge capture among employees and enhance KM performance within the organisation. As different factors can hinder KM in the workplace, a CKO is also responsible for overcoming those barriers in order to facilitate Knowledge Sharing (KS) among different departments. Bontis (2001) highlighted the importance of a CKO by reviewing different statistics supporting their presence in different organisations. A study was conducted to evaluate the prevalence of CKOs in organisations from different domains. The study concluded that 45% of the surveyed employees were familiar with the CKO position. Furthermore, 72% of the participants in the study anticipated an increased prevalence of CKOs in the future. Yaacob and Ahmad (2013) have illustrated the characteristics of CKOs in organisations. A CKO is an individual who is able to establish an effective KM strategy in the organisation. The developed KM strategy has the ability to empower KS and integration of technical knowledge through a KM vision in the enterprise. In addition, CKO should be knowledgeable regarding different KM technologies. The familiarity of those technologies enables CKOs to determine which technology to utilise in order to ensure effective sharing of tacit and explicit knowledge. Moreover, CKOs should maintain efficient communication skills. This feature enables CKOs to communicate with different leaders in the organisations, such as senior managers, therefore ensuring the implementation of the developed KM strategy through allocating sufficient KM budget, resources and training.

Utilisation of KM in the healthcare sector has several advantages, including creation, identification, acquisition and dissemination of healthcare knowledge, which is extremely fragmented, proliferative and crucial for decision-making (Nicolini et al., 2008).

Additionally, KM is providing healthcare sector practitioners with educational and training initiatives in terms of professional development and changing-environment preparation (Antrobus, 1997; Kenner and Fernandes, 2001; Martins et al., 2005). Besides, circulation of knowledge enables social learning initiatives where evidence is being transported to clinicians, nurses and other healthcare personnel (Lathlean and le May, 2002; Gabbay and le May, 2004; Tagliaventi, 2006).

The shared knowledge can be provided in various ways prior to its dissemination. KM can be integrated with different knowledge extraction tools to facilitate KS. KD, and in particular DM, is one of those tools for extracting useful knowledge from a vast amount of data. In fact, the integration of KM and DM can provide interesting KS experience in organisations, which empower organisational learning to different individuals, which is one of the main deliverables of this research. While DM can be utilised by healthcare organisations to analyse their datasets to discover valuable new knowledge about their patients to provide the best healthcare services, KM can be employed to capture and disseminate the best practices of healthcare professionals in order to provide efficiency and effectiveness in their healthcare services. Besides, such integration can be a powerful tool for making effective decisions (Li et al., 2010). As Wang and Wang (2008) explain, the usefulness of DM emerges in two main manners, to share common knowledge among individuals who perform data-mining tasks, and to extend human knowledge. More and more organisations are realising the merits of KM and DM to derive the best practices and improve their strategic decision-making based on the new knowledge extracted from their datasets. However, KM and DM seem to be employed separately. Knowledge management technologies and business intelligence technologies can now be combined to derive more value from the explosion of company data and textual information systems. For example, their integration can improve the company's marketing knowledge management framework as explained in the paper by Shaw et al. (2001). To the best of our knowledge, no such integration has been carried out by the health sector.

Despite the significant advantages that KM can bring to the healthcare sector, the barriers to such utilisation have been marked. Some of these relate to the absence of a clear KM strategy, cultural barriers, poor IT infrastructure, a degree of sectorial professionalisation and political conflicts (Sensky, 2002). The absence of a clear KM strategy is an organisational flaw related to a deficiency of effective team working. Finn and Waring (2006) illustrated the importance of effective team working, and stated that 'architectural knowledge' is fundamental for efficient team practice and ensures delivering safe and effective care to patients. Cultural barriers refer to a mistrust of computerised data and a deficiency of technology training and knowledge (Lorence and Churchill, 2005). In addition, some cultures do not encourage KS, which constitutes an obstacle to KM processes. Dean (2002) identified this issue, which is caused by the lack of feedback when a medical prescription error exists. Examples of prescription errors include lack of documentation of a medication's allergies and deficient justifications of the medication's uses. These errors can occur because of poor communication among team members who are responsible for medications' prescriptions. The degree of professionalisation in the healthcare sector is another barrier that hampers the dissemination of knowledge. The healthcare sector is mono-disciplinary and relationships of professionals within this sector are highly standardised; therefore, the resistance of doctors to circulate initiatives occurs (Ferlie and Fitzgerald, 2005). The same issue is emphasised by the strong governmental regulations that opposed KS (Currie and Suhomlinova, 2006). Political conflicts are the different preferences of priorities among practitioners. Nicolini et al. (2008) described the clinician-managerial conflict, as the priority of managers is to reduce costs, whereas the first priority of clinicians is to provide care for patients.

KM processes involve KS as an important step for creating knowledge (Leidner et al., 2010). KS is the activity of exchanging knowledge from one member to others in the organisation so that it can be re-used by the receiver. KS is an essential factor in the KM system, as it determines its success or failure. The literature review in KS has revealed several cultural factors that contribute to such a fate in the Arabic world context and others (Weir and Hutchings, 2005; Nazari et al., 2009; Al-Adaileh and Al-Atawi, 2011). The following paragraph provides an illustration regarding some of these cultural attributes, from national and organisational levels, influencing successful sharing and managing knowledge.

Studies have suggested that national cultural factors can influence KS practices (Schulte and Kim, 2007; Wang and Schulte, 2005). Scholars have documented the impact of national culture on KM activities in organisations (Holden, 2001; Ford and Chan, 2003).

- Cultures believed to be *individualistic* will have individuals with less opportunity to interact and communicate with co-workers, which negatively influences successful KM implementation. The individualistic style of work constitutes a major barrier for KS, as individuals in individualistic cultures believe that a reluctance to share knowledge leads to greater power (Ray, 2014). Those individuals believe this attitude can increase their productivity when compared with other colleagues in the organisation. McInerney (2002) stated the importance of collectivism in organisations where members who work together will have the opportunity to share knowledge.
- Some organisations have insufficient KS practice due to the *high power distance* barrier, which is an attribute driven by tradition (Hofstede, 2003; Hofstede, 2001). In high power distance cultures, managers normally control their employees, and workers in the workplace are reluctant to speak with their managers openly. Employees in those cultures fear communication with their managers because of the high level of inequality in power distribution among individuals. Consequently, sharing of knowledge is negatively influenced. Countries in the Arab world are regarded as high power distance cultures and this will affect externalisation and internalisation of knowledge (Ray, 2014).
- *Low uncertainty avoidance* is another cultural characteristic that hinders successful KM in organisations. Uncertainty avoidance can be defined as culture's magnanimity to ambiguity and uncertainty. Individuals in low uncertainty avoidance cultures have less ambiguity tolerance and prefer clear instructions (Hofstede, 2001). Cultures with low uncertainty avoidance are reluctant to undertake KM and have less interest in dissemination of knowledge (Ray, 2014).
- *Masculinity* is also seen to be hindering to KM acceptance in cultures where this factor arises. Masculinity cultures are more assertive and always emphasise accomplishments. In addition, masculinity cultures pay less attention to relationships and caring than feminist societies. High masculinity cultures have extreme competitiveness among individuals. Consequently, the KM process is affected in these cultures, as individuals may tend to prevent sharing the knowledge they acquire.

One of the widely considered key influences on the success of KM is the organisational culture (Zhang, 2006; Leidner et al., 2010; Chow et al., 2000). Schein (2004) defined organisational culture as a pattern of shared basic assumptions learned by a group and used to solve its problems successfully enough to be considered valid and, therefore, to be taught to new members in the organisation as a proper way to understand, think and feel towards those problems. According to the definition, the culture of an organisation provides sights of its success and effectiveness. The literature review in this context identified factors, which comprise the culture for organisations. These factors are described as follows, with brief details. While some of those factors are similar to the cultural factors illustrated above, the literature review indicated other different factors that are uniquely derived from the organisational culture in most organisations in the Arabic, Middle Eastern and Saudi Arabian Context.

- *Trust* is a strong factor that influences the sharing of knowledge among members in an organisation (Ridings et al., 2002; Al-Alawi et al., 2007). Trust creates the atmosphere necessary for engaging with others, especially when the regulations and rules insufficiently ensure their perceived behaviour (Ridings et al., 2002). The presence of trust among members is the core factor towards successful KS among them (Hutchings and Michailova, 2003). In addition, trust will enable the availability of knowledge to partners and colleagues, even though the individuals who own that knowledge prefer to keep it for themselves (Weir and Hutchings, 2005).
- *Openness to change* is important for promoting, managing and sharing knowledge (Gold et al., 2001; Alavi et al., 2015). Openness is defined by Bradley (2000) as improving performance or obtaining high absorptive capacity through recognising and responding to the needs for change.
- *Teamwork* is having the members of any organisation work as a team. Team working facilitates the success of the KS process by fostering members to contact and eventually learn from each other (Schein, 2004). Previous studies have shown the positive effect of working as a team and emphasised that it improves and enables KS and management among members (Park et al., 2004; Mowery, 2015). However, organisations in Saudi Arabia provide limited opportunities to engage members from different departments to engage in teamwork practices (Albrithen and Yalli, 2015).
- *Communication and interaction* between members inside and outside the organisation are essential for sharing knowledge (Al-Alawi et al., 2007). One of the barriers of KM practices in the Saudi Arabian context is the lack of effective organisational

communication (ALHussain, 2011). Glisby and Holden (2003) suggested that a cooperative work environment is necessary for KS. Individuals who experience competition in an organisation will feel the stress, leading to discouragement of KS in their organisation (Ray, 2014).

- *The structure of an organisation* is another factor in the organisational culture that influences KM practices in different organisations (Sabri, 2005). Middle Eastern cultures are considered to have high levels of bureaucracy that are likely to hinder KS activities within any organisation (Nazari et al., 2009).

Scholars have suggested tools and ways to overcome the above cultural and organisational attributes hindering KM practice. Examples of suggested solutions include reward systems (Bartol and Srivastava, 2002; McInerney, 2002), job rotation (Al-Alawi et al., 2007) and KM systems in particular, which are the focus of our research study (Abokhodiar, 2014).

As Nonaka and Takeuchi (1995) explain in their paper, though organisations actually create and manage knowledge dynamically, there is little understanding of how to capture it and share it. They propose a model of knowledge creation consisting of three elements: the SECI (Socialisation, Externalisation, Combination and Internalisation) process, knowledge creation through the conversion of tacit and explicit knowledge, the shared context for knowledge creation, and knowledge assets (Nonaka et al., 2000). The knowledge creation process is a spiral that grows out of these three elements and can lead to dialectical thinking. Using existing knowledge assets, organisations create new knowledge through the SECI process that takes place in the shared context; newly created knowledge becomes in turn the basis for a new spiral of knowledge creation. They identify two types of knowledge, explicit and tacit, and it is important to share and convert these types in order to create knowledge. Explicit knowledge is communicable in systematic language, whereas tacit knowledge is obtained through experience and cannot be articulated (Nonaka and Takeuchi, 1995) . The four SECI conversion modes are explained below and illustrated in Figure *3.1*.

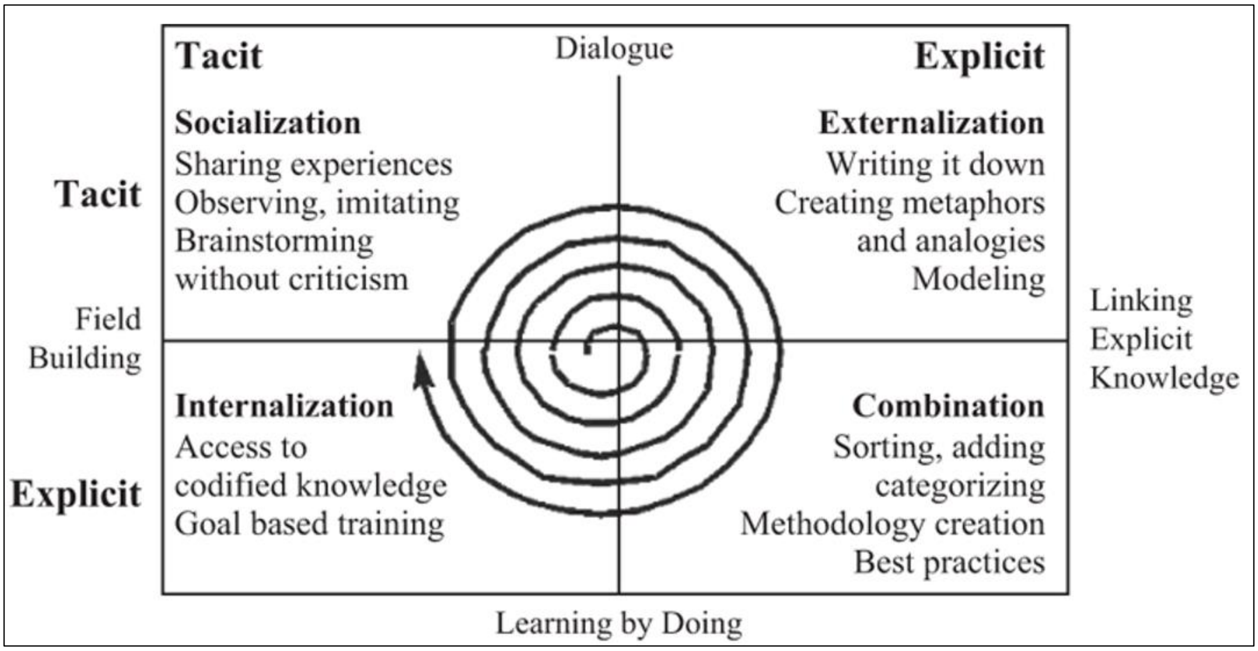

Figure 3.1 The SECI Model

Source: (Nonaka and Takeuchi, 1995)

Socialisation: socialisation is the first mode in the SECI model and involves social interaction to enable the conversion of tacit knowledge from one to another without the use of language (Nonaka, 1994). Observation, imitation and brainstorming are useful tools to perform such a conversion.

Externalisation: the second mode of the SECI model is externalisation, which enables the conversion from tacit to explicit knowledge (Nonaka, 1994). It translates tacit knowledge to forms to be understandable and interpretable by other users via interaction, namely dialogues and informal meetings. The newly produced explicit knowledge can then be codified and recorded through different means, such as documentation and recording.

Combination: the conversion of explicit knowledge to another explicit knowledge is the third mode of the SECI model (Nonaka, 1994). This process can be performed through combining different explicit knowledge and reconfiguring a new form of explicit knowledge. Formal meetings in organisations are considered very assistive combination tools (Nonaka and Takeuchi, 1995).

Internalisation: internalisation is the mode where explicit knowledge is converted to tacit knowledge and becomes part of an individual’s brain (Nonaka and Takeuchi, 1995). The implementation of internalisation involves “learning by doing” and indivisduals who successfully internalise tacit knowledge will eventually acquire “know-how” skills.

An important factor that must be considered when discussing the SECI model is the concept of ‘Ba’. Ba are platforms where each conversion mode of the SECI model takes place. There are four types of ba defined by Nonaka and Konno (1998). The first is originating ba, which is the space where individuals share their experiences, feelings and emotions. This type of ba offers the space where socialisation can be accomplished through physical and face-to-face interactions. The second is interacting ba, which is the space where mental skills are transformed into explicit form through dialogues. Communication skills and metaphors are essential in this stage of knowledge conversion for successful dissemination of knowledge with respect to its sensitive meanings. Cyber ba is the third space, where combination mode is accomplished through interaction in a virtual world instead of in real place and time. The combination mode is performed more efficiently through the utilisation of technology. The fourth type of ba is the exercising ba, which is the space that facilitates internalisation through training and practical learning.

Despite the fact that the SECI model has always proved to be a powerful tool in managing and disseminating knowledge, it has been widely criticised, and it has been suggested that the model lacks universal validity (Almuayqil et al., 2015). Nonaka and Takeuchi (1995) and other researches suggested that each mode can take place by specific tools and conditions that need to be there in order to achieve successful knowledge conversion processes. For example, socialisation can take place via observation and experience when individuals are willing to share knowledge. According to Tyagi et al. (2015), trust, respect and mutual understanding among the resources during communication are important requisites for socialisation. Moreover, Glisby and Holden (2003) mentioned other factors that must be provided in order to perform socialisation. Those factors are strong affiliation to the organisation, a cooperative working environment instead of a competitive one, developing relationships with those who share the same fate, external sharing of knowledge facilitated by networks of partnerships between organisations and close interrelationships. To externalise knowledge, dialogue among individuals and group commitment must occur in their workplaces. In addition, participation of internal competent members and external experts in the training programmes and seminars with little external control, such as minimal pressure from shareholders, are required for successful completion of externalisation (Tyagi et al., 2015; Glisby and Holden, 2003). For the combination mode, Nonaka and Takeuchi stressed the importance of lack of interdepartmental rivalry, polychromic task orientation, high personal commitment and permanent occupancy. The existence of the factors outlined above enables the combination through consultative decision-making, organisational redundancy and open source for organisational information. Internalisation mode can take place where there is minimal fear of mistakes occurring among individuals. This stage of knowledge conversion can be performed via job rotation which encourages movement of members of staff in the organisation and thereby innovates knowledge transfer and increases motivation (Al-Alawi et al., 2007).

The overwhelming success for the SECI model in Japanese organisations is well documented. However, the SECI model when applied to other countries does not necessarily indicate success as there are different cultural factors which can influence the outcome of the knowledge conversion of the model; According to Schein (2004), Nonaka and Takeuchi insist that the knowledge creation process needs social interaction which is influenced by cultural norms. Factors of organisational culture, such as trust and the style of the organisation's structure, are important to ensure KS (Al-Alawi et al., 2007). When considering factors suggested by Nonaka and Takeuchi for SECI model implementation, it is important to appreciate how much these factors are influenced specifically by Japanese culture. Close interrelationships between organisations, which are significant factors for socialisation, are specific characteristics of the Japanese culture only (Glisby and Holden, 2003). Low external control and group commitment, which are necessary requirements for externalisation, are features of the Japanese culture (Davies et al., 2008; Ziebland and Wyke, 2012). High personal commitment, permanent occupation and other conditions essential for combination are typical Japanese practices and therefore combination may have difficulties when implemented in other cultures (Andreeva and Ikhilchik, 2011). The same concept also applies to internalisation. Intensive job rotation is a typical Japanese practice because learning in Japan focuses on developing generalists in different areas rather than specialists in particular domains. Consequently, experimental learning or 'learning by doing' is widely accepted in Japanese organisations, which constitute the context of internalisation (Glisby and Holden, 2003).

Several studies have examined the validity of the SECI model in different cultures. Andreeva and Ikhilchik (2011) analysed the implementation of this model in the Russian context. Dialogues with senior management were seen to be problematic in Russian companies because of the authoritarian leadership style and the prevalence of top-down communication, where employees have limited opportunities to directly communicate with their managers or they lack the motivation to do so, due to fears of reprisal. These issues constitute a barrier for utilising the externalisation mode successfully in the Russian context. Furthermore, more effort is needed to perform combination in Russian organisations because of the presence of concentrated authority and decision-making. In another study published by Weir and Hutchings (2005), combination and internalisation do not work in the Chinese culture, in the way suggested by Nonaka and Takeuchi, due to the presence of interdepartmental rivalry and the fear of making mistakes.

In Saudi Arabia, the culture is formed by three main factors; religious, tribal or family systems and the Arab culture (Aldraehim et al., 2012). Islam influences the Saudi Arabian culture by setting moral principles among people in the country. Family is extremely valued in the Saudi Arabian culture, as it provides security to its members. Members of the Saudi Arabian family are expected to have good relationships with their relatives and this collectivism style ensures assistance, such as job opportunities, to be given to family members through the family leaders. Their belief is also influenced by the Arabic culture, which implies that all members in the family perform their roles in order for the family to continue its standing in society. Furthermore, the father in this culture is responsible for the family and always has the authority (Barakat, 1993). Saudi Arabia is also a high power distance culture and has a high level of uncertainty avoidance, collectivism and feminism (Bjerke and Al-Meer, 1993). In another study, cultural dimensions, such as extreme power distance, masculinity, low uncertainty avoidance, and extreme individualism, hinder the process of KS (Ray, 2014). Therefore, the processes of externalisation and internalisation may be hindered in the Saudi Arabian culture. Weir and Hutchings (2005) reviewed the utilisation of the SECI segments and concluded that socialisation and combination can be achieved in the Saudi Arabian world although there is a tendency to keep knowledge among themselves. Weir and Hutchings (2005) indicated that Saudi Arabian people are pre-socialised and this feature facilitates the socialisation mode easily. Combination can take place in the Arabic culture as familial structure applies, where knowledge from junior members is likely to contain valuable elements. The externalisation of tacit knowledge is affected in the Saudi Arabian context as Arabic people have high tolerance in ambiguity and they prefer to keep knowledge unless there is a need for discourse, or whether they trust their colleagues with whom the knowledge is to be shared. Similarly, Arab business people, in particular, prefer not to communicate/disseminate their tacit knowledge unless trust occurs, which depends on the nature of the relationship among individuals. Internalisation does not work effectively because of the lack of confidence and trust from the information outlined from the knowledge holder, because work life is still influenced by Saudi family culture and is not completely separated from the work environment. Although, job rotation is adopted in Saudi Arabia, it is not widely practised and tends to focus on developing deeper experience in the same field rather than widening an employee's competence in different domains.

Although there are cultural issues associated with the SECI model, the four modes of conversion offer a solid basis to underpin the research project. The SECI model can be tailored and adapted to meet the cultural constraints associated with the Saudi societies to ensure that Saudi organisations, and individuals, can survive in the knowledge-economy environment and that knowledge can be effectively managed and shared among their employees.

Solutions have been suggested to adapt the SECI model to the Arabic culture by several researchers at organisational and national levels (Almuayqil et al., 2015). The following suggestions can be used to improve successful utilisation of Nonaka's model in Saudi Arabia (see Table *3.1*).

- ***Socialisation***: citizens in Saudi Arabia are seen to be pre-socialised (Weir and Hutchings, 2005). Accomplishing strong relationships between senior managers and employees will emphasise socialisation in Saudi Arabian organisations. Trust is important in this stage of the SECI model. Therefore, religious and social events, such as Ramadan festivities, graduations and weddings, can reinforce trust among organisation's members. Establishing a reward system also has an impact on the socialisation mode. It reinforces the willingness of employees to share knowledge when considering the employees' different needs and objectives (AlGhamdi and Moussa, 2012). Rewards for KS can be tangible or in incorporeal forms. Self-worth is an example of an incorporeal reward, which means the individual who shares knowledge has the feeling of being valued and it includes personal acknowledgement and recognition in applying shared knowledge (Causes and Chait, 2008).

- ***Externalisation***: improving office design in the organisations in the Saudi Arabian context will allow higher interaction and communication between staff. This will give the opportunity for discourse in the work environment. Motivation can play a significant role in encouraging knowledge discourse among colleagues in organisations. Rewards such as incentives should be considered to encourage KS behaviour among individuals. As group commitment is a prerequisite for externalisation, workshops, training courses and seminars can be used to emphasise loyalty to workplace among members. This will help to separate private life from work life. Likewise, in socialisation, organisations can take advantage of the religious and social events to enhance trust and accomplish good relationships among members in order to strengthen externalisation.
- ***Combination***: as an Arabic community, Saudi Arabian culture is seen to have concentrated authority and decision-making. A useful solution to overcome this barrier would be to expand the level of participation in decision-making and remove centralised authority. This action will enable information flow vertically among all members, regardless of their importance or position in the organisation.
- ***Internalisation***: the literature review has suggested that job rotation has been adopted slowly in the Saudi Arabian culture. Increasing the adoption of such a solution by moving individuals in the organisation, can improve knowledge transfer, expertise, and increases motivation. Saudi Arabian organisations normally give their members opportunities to engage in training courses and different sessions of community of practice (CoP) which has to be distributed equally among members in the organisation to ensure internalisation is being implemented effectively.

Table 3.1 Suggestions to adopt the SECI model in the Saudi Arabian context.

Socialisation		Externalisation		Combination		Internalisation	
Suggestion	**Purpose**	**Suggestion**	**Purpose**	**Suggestion**	**Purpose**	**Suggestion**	**Purpose**
Accomplishing strong relationship among managers and employees.	Emphasise KS.	Improve office design.	Allow higher interaction between staffs.	Expand the level of participation in decision-making.	Reduce centralised authority and decision-making.	Increase the practice of job rotation.	Improve knowledge transfer, expertise and motivation.
Engage in religious and social activities.	Reinforce trust among colleagues.	Propagate motivation.	Encourage knowledge discourse among colleagues.			Engage members in training courses equally.	Ensure implementation of CoP to all members in the organisation.
Establish a reward system.	Reinforce KS among members with different needs and objectives.	Rewards and incentives.	Encourage KS behaviour among individuals.				
		Workshops and seminars.	Increase commitment of members to the workplace.				
		Engage in religious and social activities.	Reinforce trust among colleagues.				

Nevertheless, the model of Nonaka and Takeuchi is considered a paradigmatic theoretical approach for KM (Alipour et al., 2011; Gourlay, 2003). The SECI model is widely accepted and cited for KM in many domains. The reasons beyond the acceptance of the model are due to its intuitive logic and clear differentiation between tacit and explicit knowledge (Rice and Rice, 2002). According to Yoshimichi (2011), the SECI model can be used as a criterion to measure the activities of KM in organisations. In addition, the knowledge creation theory of Nonaka and Takeuchi is highly applicable to create knowledge in different organisational contests. Moreover, the SECI model is considered a theoretical implication that emphasises human communication as an essential component of KM.

3.3 Data Mining

KD, and DM in particular, has been applied widely in many domains in recent years. DM has significantly succeeded in domains such as banking, customer relationship management (CRM) and education. DM has become a promising tool in improving the quality of healthcare services and has been utilised to manage several diseases. The literature has shown that DM became an important part of the diagnosis, treatment and management of diseases such as cancer, liver diseases, heart conditions and diabetes mellitus. For example, Das et al. (2009) introduced DM software to diagnose heart disease. The diagnosing system utilised a neural networks classification algorithm and performed different diagnosing experiments, obtaining an accuracy rate of 89.01% (see Figure *3.2*). The importance of medicine and its impact in human lives made the implementation of DM in such a domain a must (Esfandiari et al., 2014).

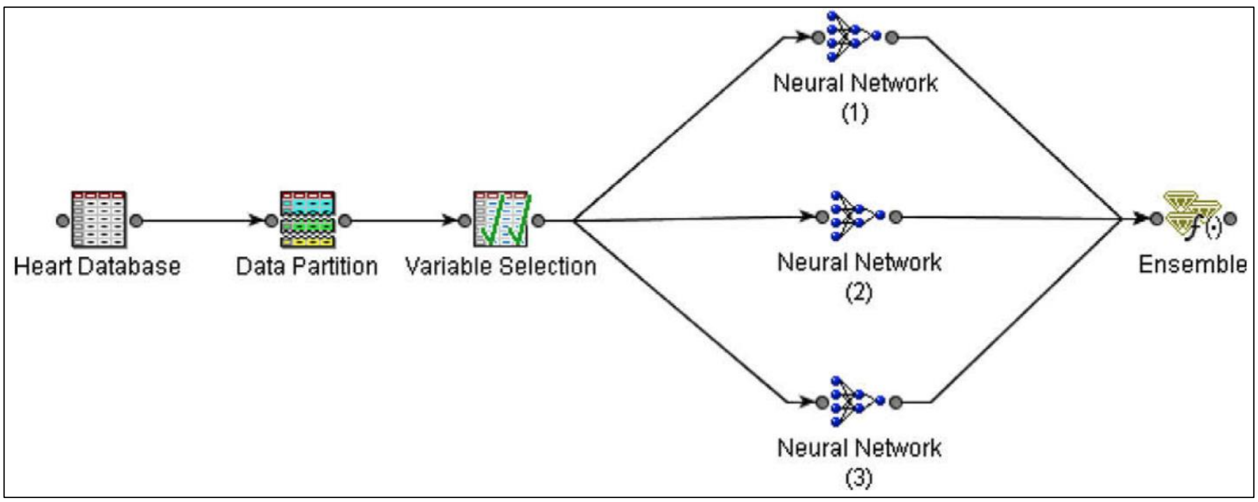

Figure 3.2. Heart disease diagnosing system
Source: (Das et al., 2009)

Mining medical data aims to promote healthcare services. We can define medical DM as the process of extraction of hidden, potentially useful and novel information from medical data for the purpose of improving accuracy, time and cost efficiency and decision support systems (Esfandiari et al., 2014). Mining data in the medical domain has multiple goals.

The primary goal of this process is to extract the desired knowledge, which can be used to identify valuable medical information, such as identifying risk factors of a disease. The literature has evidence of achieving this goal successfully in different diseases (Sallaberry et al., 2011).

Another goal of DM in the medical domain is the time and cost efficiency, which mainly means the decreased time and cost DM can provide. Data mining can deal with the time and cost issues that can hinder successful treatment of diseases. In treating different disease, some of them can be very harmful to patients if not treated in a specific time period. Uçar and Karahoca (2011) provided an example of this case in tuberculosis disease where its diagnosis is time-consuming and DM can facilitate temporary treatment until the test results are revealed. In this study, Uçar and Karahoca utilised a fuzzy interface system to predict the presence of mycobacterium tuberculosis in less than the original diagnosing time period of 45 days. The outcomes of their experiment showed accurate and reliable results. Other diseases can be costly for some healthcare organisations to treat and therefore the disease will be left without being treated. Glaucoma, for example, is usually diagnosed by using expensive methods such as optical coherence tomography and Scanning Laser Polarimetry, whereas some scholars proposed an automatic system that utilises DM (Mookiah et al., 2012). The system utilised Support Victor Machine (SVM) classifier to facilitate early and lower cost diagnoses of Glaucoma accurately. The proposal proved that DM can prevent expensive diagnosis of this disease efficiently.

A third goal of medical DM that we can identify from its definition is the empowerment of building Medical Decision Support Systems. Medical DM enables the establishment of such a system, which is useful in the automation of multiple medical care processes. Sut and Simsek (2011) provided an example of Medical Decision Support Systems where they estimated mortality in head injuries by using six different prediction algorithms. The study compared the performance of the six utilised DM methods and showed that the Boosted Tree classifiers and Regression (BTCR) achieved high performance accuracy (93.0%). Sut and Simsek (2011) concluded that BTCR is useful in decision-making for predicting mortality in head injuries. Other examples are the diagnoses and prognoses of chronic diseases through the utilisation of DM along with case-based reasoning (Huang et al., 2007). The study proposed a system that successfully acted as a medical expert system to support diagnosis and prognosis of different diseases via discovering various rules through DM.

Finally, the definition indicates that the utilisation of DM in the medical domain is promising in improving efficiency. DM reduces the number of human errors for particular chronic conditions, such as diabetes mellitus, cancer and heart diseases. In the case of diabetes mellitus, for example, mining medical patients' data improved the performance and results for the prediction of type 2 diabetic individuals through a classification technique (Patil et al., 2010).

DM have been utilised in the medicinal domain for many years. In general, such a utilisation provides healthcare professionals and organisations with great advantages by supporting different medical activities (Esfandiari et al., 2014; Jothi et al., 2015; Iru et al., 2016). DM has been complimented for its support to activities such as diagnosis, treatment, management, monitoring and other medical activities in many publications from different countries. The support of DM is significant to help many countries to overcome health conditions such as diabetes mellitus, heart disease, cancer, Alzheimer's disease, liver disease and many other serious and chronic illnesses. For diabetes mellitus in particular, different DM studies have been used in screening, diagnoses, treatment, prognosis and monitoring of diabetes mellitus.

Despite the advantages that DM can provide to support diabetic individuals, the literature search failed to extract studies of DM on diabetes self-management and education initiatives related to Saudi Arabia. Citizens in Saudi Arabia encounter a number of complications related to diabetes mellitus. Although those complications are not directly related to their health situation, they still have great impact on their lifestyles and daily routines. The non-health-related complications of diabetes mellitus are encountered by different citizens who have varying profile characteristics. The application of DM can allow the extraction of tacit information related to the complications faced by diabetic citizens in Saudi Arabia. The tacit information can then be converted to explicit knowledge to support not only health professionals in the provision of care to their diabetic individuals but also allow diabetic citizens themselves to self-manage their illness and improve their lifestyle and daily routines. This can be achieved if the tacit knowledge extracted by DM is integrated into a KM framework.

A DM methodology is required for the extraction of tacit knowledge associated with the non-health-related complications of diabetes mellitus. It should specify the algorithms and software tools suitable to a given purpose (i.e. descriptive or predictive approach) (Kurgan and Musilek, 2006). As the focus of this thesis is to apply DM to analyse diabetic data from Saudi Arabia, the following sections review the relevant current methodologies, modelling approaches and algorithms of DM. These aspects should guide our investigation of the problem associated with Saudi Arabian citizens suffering from diabetes mellitus. To this end, a questionnaire is designed to elicit these complications and is discussed in Chapter Six.

3.3.1. DM methodologies

A methodology is the process of identifying all tasks, inputs and outputs as well as specifying how to perform those tasks which are perceived to be accomplished by using relevant techniques (Pressman, 2005). According to Marbán et al. (2009) the most widely used DM methodologies nowadays are sample, explore, modify, model and assessment (SEMMA), knowledge discovery in databases (KDD) and the cross-industry standard process for DM (CRISP-DM). Each methodology has different steps in its life cycle to the others (see Table *3.2*) (Azevedo and Santos, 2008). These three methodologies are discussed in the following sections to describe their processes, advantages and drawbacks in relation to their application in the healthcare domain.

Table 3.2. Steps of KDD, SEMMA and CRISP-DM

<table>
<tr><th>KDD</th><th>SEMMA</th><th>CRISP-DM</th></tr>
<tr><td>Pre-KDD</td><td>----------</td><td>Business Understanding</td></tr>
<tr><td>Data Selection</td><td>Sample</td><td rowspan="2">Data Understanding</td></tr>
<tr><td>Data Pre-processing</td><td>Explore</td></tr>
<tr><td>Data Transformation</td><td>Modify</td><td>Data Preparation</td></tr>
<tr><td>Finding DM Technique</td><td rowspan="2">Model</td><td rowspan="2">Modelling</td></tr>
<tr><td>Model Selection</td></tr>
</table>

KDD	SEMMA	CRISP-DM
Data Mining		
Interpretation and Evaluation	Assessment	Evaluation
Post KDD	----------	Deployment

Source: (Azevedo and Santos, 2008)

3.3.1.1. SEMMA

The methodology of SEMMA (sample, explore, modify, model and assess) was proposed by the SAS institution, which develops statistical software called Enterprise Miner. The process of this methodology has five steps:

1. Sample: in this first step, the process begins by selecting a small sample of the data for analysis.
2. Explore: exploration of the data to gain more information about the sample. This step involves identifying trends and anomalies in the sampled data.
3. Modify: modifying the data by transforming the variables for the modelling step.
4. Model: investigating trends and patterns in the data by using a DM model provided by a given software tool.
5. Assess: evaluating the findings and determining their accuracy.

The SEMMA methodology implements some of the essential elements of DM projects. However, some criticisms have been documented about its performance. SEMMA only takes into consideration the statistical, the modelling and the data manipulation aspects of the DM process (Rohanizadeh and Moghadam, 2009). In other words, the performance of this methodology is based on the technical part of the DM project only. In addition, SEMMA is lacking in the analysis, design, and implementation phases of the information systems projects. Another drawback of SEMMA is the fact that it lacks consideration regarding the organisations' and stakeholders' roles in projects, because SEMMA was designed to work with the Enterprise Miner software and cannot be useful outside this scope.

3.3.1.2. Knowledge Discovery in Databases

The phrase knowledge discovery in databases (KDD) was coined at the first KDD workshop in 1989 to emphasise that knowledge is the end-product of data-driven discovery (Fayyad, Piatetsky-Shapiro and Smyth, 1996). KDD is the field concerned with the development of methods and techniques for making sense of data. According to Fayyad, Piatetsky-Shapiro and Smyth (1996), however, KDD refers to the overall process of discovering useful knowledge from data, and DM refers to a particular step in this process. Hence, the DM step is the application of specific algorithms for extracting patterns from data.

In general, the KDD involves multiple major steps. Those steps begin with a database, and involve selecting, pre-processing, sub-sampling and transforming of the selected dataset. The steps after include applying a data-mining algorithm to extract a pattern of knowledge from the data, evaluating that knowledge and identification of its subsets. These steps are illustrated below (see Figure *3.3*):

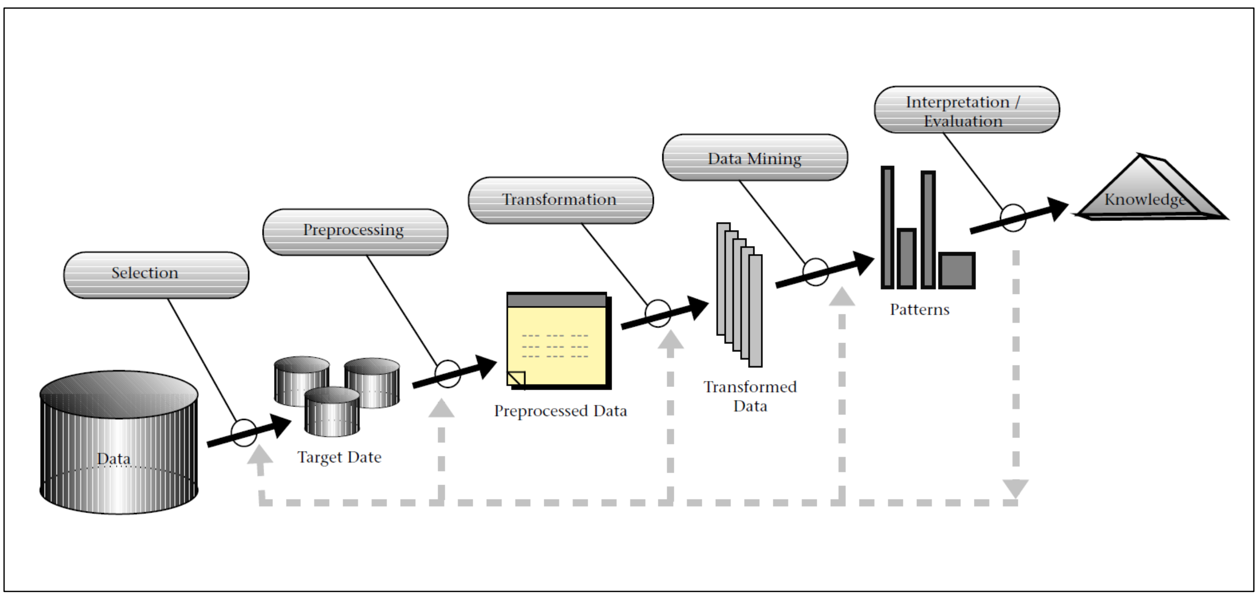

Figure 3.3. KDD general steps

Source: (Fayyad, Piatetsky-Shapiro and Smyth, 1996)

1. Learning the application domain: developing an understanding of the application domain and the relevant prior knowledge and identifying the goal of the KDD process from the customer's viewpoint.

2. Creating a target dataset: selecting a dataset, or focusing on a subset of variables or data samples, on which discovery is to be performed
3. Clean and transform the data: basic operations include removing noise if appropriate, collecting the necessary information to model or account for noise, deciding on strategies for handling missing data fields, and accounting for time-sequence information and known changes.
4. Data reduction and projection: finding useful features to represent the data depending on the goal of the task. With dimensionality reduction or transformation methods, the effective number of variables under consideration can be reduced, or invariant representations for the data can be found.
5. Matching the goals of the KDD process to a particular DM technique: matching step number 1 with the appropriate data-mining technique. Techniques of data mining include: summarisation, classification, regression, clustering and association.
6. Exploratory analyses and model selection: choosing the data-mining algorithm(s) and selecting technique(s) to be used for searching for data patterns. This process includes deciding which models and parameters might be appropriate and matching a particular data-mining method with the overall criteria of the KDD process (for example, the end user might be more interested in understanding the model than its predictive capabilities).
7. Data mining: searching for patterns of interest in a particular representational form or a set of such representations, including classification rules or trees, regression, and clustering. The user can significantly aid the data-mining method by correctly performing the preceding steps.
8. Interpretation of the mined patterns: possibly returning to any of steps of 1 through to 7 for further iteration. This step can also involve visualisation of the extracted patterns and models or visualisation of the data given the extracted models.
9. Acting on the discovered knowledge: using the knowledge directly, incorporating the knowledge into another system for further action, or simply documenting it and reporting it to interested parties. This process also includes checking for and resolving potential conflicts with previously believed (or extracted) knowledge.

KDD has become the most cited DM methodology in the literature. In fact, it is now considered as a cornerstone for other DM methodologies. It is the first methodology for DM projects and many other DM methodologies developed after were influenced by its leverage (Kurgan and Musilek, 2006). It is more suitable for projects requiring extensive data pre-processing than other DM methodologies. It best fits in the academic domain features and can be utilised in many other domains, such as medicine, engineering, production, e-business and software.

Nevertheless, KDD has some drawbacks. High dimensionality is one limitation of KDD: that is, it produces large records, attributes and variables in the database, which will increase the search space and can result in invalid patterns. Another limitation of KDD is overfitting: it can model the noise of the dataset and then result in poor performance of the technique on the data. KDD, in addition, may require unnecessary iterations back to previous steps because the prepared data may not be suitable for the chosen tool. Furthermore, it lacks the provision of user manuals and documented guidelines of its steps. No website and no books are available to support new KDD users. KDD may not be convenient for beginners as details of each step are not provided anywhere except in some research papers. Consequently, KDD is more suitable for users with sufficient DM skills and knowledge.

3.3.1.3. The Cross-Industry Standard Process for DM

The Cross-Industry Standard Process for DM (CRISP-DM) was proposed for the first time in 1996 by the four companies SPSS, the database provider NCR, Daimler Chrysler and the insurance company OHRA. The methodology was then released, with version 1.0, officially in 2000 (Shearer, 2000). CRISP-DM is an industry oriented methodology and, therefore, is seen as meeting industrial needs (Kurgan and Musilek, 2006). SPSS Inc has produced a manual to describe the CRISP-DM methodology and its steps (Chapman et al., 2000) (see Figure *3.4*). The steps are summarised below.

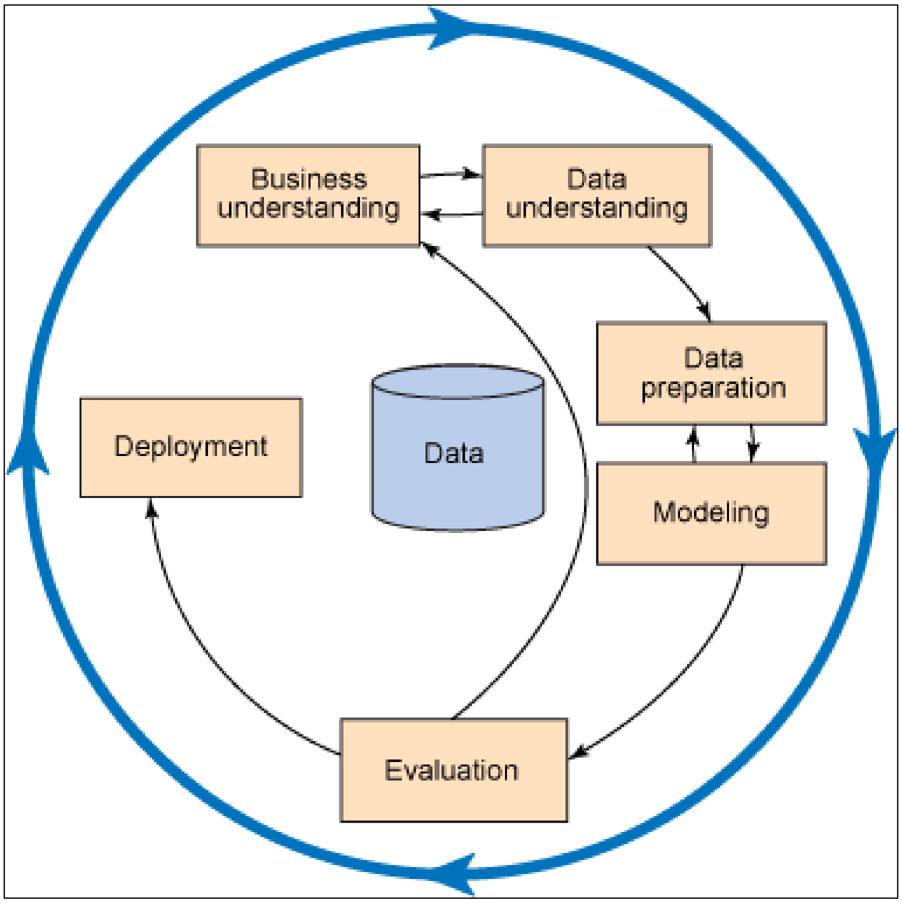

Figure 3.4. CRISP-DM

Source: (Chapman et al., 2000)

1. Business understanding: this stage concentrates on understanding the business objectives and the requirements of the DM project. It also focusses on defining DM to support the business needs. The user in this stage can select the problem types suitable to the business objectives and set results assessment criteria.
2. Data understanding: collection of the data and perform some formalisation on it. The users can become familiarised with the collected datasets and identify its attributes and any interesting patterns. The user can, in addition, determine the needed data quality and discover any raised data issues.
3. Data preparation: in this stage the dataset is selected for the modelling stage. The users should deal with data quality issues by ignoring noise data and integrate attributes. In addition, users may need to change the format of the dataset to fit the software tools perceived to be utilised in the DM project.

4. Modelling: in this stage the user selects the modelling technique that fits the objectives of the DM project. The user can also produce a test design to train and assess the chosen technique. Moreover, the user in this stage performs the modelling technique and understand its results.
5. Evaluation: understanding the results of the DM project. The results can be evaluated and ranked according to the assessment criteria specified in the first stage. The user may also evaluate and document the previous process to identify any skipped task or if any iteration is needed. In addition, users in this stage document the previous undertaken processes and decide how to deploy the resulted patterns.
6. Deployment: the final stage of this methodology, which identifies how to deploy the results. In this stage, the user can produce a deployment plan and monitor this deployment to determine whether the DM task needs to be undertaking periodically of after a specific period of time. It is also important in this stage to produce a report describing the project from its first stage.

The distinction of CRISP-DM from other methodologies is that it provides a more general, research-oriented description of its six steps, explicit feedback approaches and the ability to modify the description of the final step, which facilitates the application of the discovered knowledge in other domains (Kurgan and Musilek, 2006). In addition, CRISP-DM uses well-documented guidelines with understandable vocabulary and has a website that describes the methodology and its stages, in addition to research and white papers. In these sources, the stages of this methodology is divided into detailed sub-steps that provide all the information that might be needed by users who have limited DM experience and wish to utilise a methodology that provides guidelines to its steps. Another important advantage of CRISP-DM among other methodologies is the fact that it is a vendor-independent methodology. Therefore, CRISP-DM can be incorporated with any DM software and it can be utilised to solve any DM problem (Marbán et al., 2009b).

CRISP-DM is the most widely utilised DM methodology according to several polls (KDnuggets, 2004, 2007; Piatetsky, 2014). Another reason to utilise CRISP-DM is its ability to be utilised in different application domains, including medicine, engineering, marketing and environment, in addition to several research and industrial projects (Kurgan and Musilek, 2006).

The literature concerning CRISP-DM has revealed some drawbacks and disadvantages. One drawback, according to Solarte (2002), is the delay of the selection of the DM technique until the modelling stage. This delay may cause an iteration to any of the first stages if they were not performed with respect to the chosen technique. For example, a user may need to go back to the data preparation stage if the data cleaning process was not appropriate to the technique. Another negative side of CRISP-DM is that the selection of DM tools and techniques are combined in the same category. This may result in choosing a technique only because it is supported by a particular software tool and not because that technique is really suitable for the DM project. In addition, the CRISP-DM methodology lacks some important steps in some types of projects.

In spite of the drawbacks, the methodology of CRISP-DM is the most suitable approach to our analysis of diabetes non-health-related complications of citizens in Saudi Arabia. The steps of CRISP-DM are sufficiently clarified and documented through well-presented documentation produced by SPSS. Moreover, CRISP-DM methodology facilitates the utilisation of the discovered knowledge in a more convenient way than SEMMA and KDD and can be easily integrated with KM.

3.3.2. DM modelling approaches

One of the most significant components of KD is the modelling approach that need to be utilised in any DM project. DM modelling approaches can help by extracting hidden and interesting patterns within the large amount of data. It has many modelling approaches in which each one has one or more algorithms that help to achieve the goals of the DM project. Therefore, approaches of DM modelling are powerful as they have the ability to discover previously undiscovered relationships among data items to facilitate decision-making for the holders of the mined data. In addition, different DM modelling approaches are able to detect any factors responsible for a particular case or phenomenon (Tomar and Agarwal, 2013).

There is more than one way to classify DM modelling approaches. The methods used for modelling can be classified by the database type (rational, spatial), the level of discovered knowledge (primitive-level, high-level, multi-level) or by the modelling approach to be utilised (generalisation-based mining, statistical-based mining) (Jun Lee and Siau, 2001). In this research, we apply CRISP-DM as the methodology to be used to conduct our DM experiment due to its popularity, clarity and relevance to KM research. CRISP-DM 1.0 classified modelling approaches of DM according to the problem types described below:

1. Data description and summarisation.
2. Segmentation.
3. Concept descriptions.
4. Classification.
5. Prediction.
6. Dependency analysis.

3.3.2.1. Data description and summarisation

The goal of data description and summarisation is to describe and summarise the data characteristics (Chapman et al., 2000). Simple descriptive statistical and visualisation techniques provide first insights into the data and generate automated reports about the interactive exploratory data analysis (Fayyad et al., 1996a). Summarisation would be calculating the mean and standard deviations of some entities. Exploration can involve informing instances, such as the distribution of customers by shop, age and residence for further marketing decisions.
It is useful to understand the nature of the data to be analysed in the early stages of the DM project (Chapman et al., 2000). This description favour can help the user to set the hypotheses of potential hidden patterns. In addition, data description and summarisation postulate interesting segments in the data, which then can be summarised and described in a more useful way, particularly in the presentation of the final results (Fayyad et al., 1996a)

Data description and summarisation also have some documented drawbacks, one of which is the fact that this type of DM project is not a stand-alone problem type (Chapman et al., 2000). That is, data description and summarisation commonly occur in combination with other problem types. In fact, it is recommended to utilise data description and summarisation with other problem types, such as classification and clustering in its early stages before starting to perform the main objective of the project. Another negative side of data description and summarisation is the fact that there is no specific technique to be applied to achieve the goal of this problem type (Chapman et al., 2000). Many DM techniques can perform the same objectives of data description and summarisation. Techniques such as concept discerption and regression can also produce a summary and description of the utilised data. Nevertheless, if the objective of the DM experiment is to describe and summarise the data, this problem type becomes a stand-alone problem type, as no more DM analysis is required.

3.3.2.2. Segmentation

Segmentation is the creation of classes, so we can, afterwards, separate the data into meaningful sub-groups (Chapman et al., 2000). For instance, in shopping basket analysis, one could group shopping baskets depending on the items they contain. Therefore, it differs from classification as there are no predefined classes or target attributes. Segmentation can be used as a step prior to performing classification.

By utilising segmentation as a prior stage before performing other problem types, the data size is minimised and becomes more manageable to find homogeneous data subsets, which can be analysed in easier ways. Typically, in large datasets, different influences can overlay each other and conceal interesting patterns, unless appropriate segmentation is applied. For example, it is very challenging to analyse dependencies between items in millions of shopping baskets. It is much easier to identify dependencies in interesting segments of shopping baskets, such as clustering the baskets based on their values, the type of goods or the time of purchase (Chapman et al., 2000). However, it is documented that many DM users confuse clustering, which is one segmentation technique, with classification. While clustering aims to group data items into sub-groups or segments, classification aims to classify data items into predefined groups and classes. The following sub-section illustrates the clustering technique of segmentation.

Clustering

Clustering is a popular segmentation technique that seeks to identify a finite set of categories or clusters to describe the data where all objects in each sub-group have shared characteristics (Chapman et al., 2000; Jain and Dubes, 1988; Titterington, Smith and Makov, 1985). In clustering, there are no predefined classes to group data items into. Nevertheless, data items within one cluster have extreme similarity and differ significantly from other data items from another cluster.

Clustering have been utilised in the medical domain for different purposes. Engreitz, Daigle, Marshall and Altman (2010) utilised a supervised fuzzy clustering technique to screen individuals with a high risk of bladder cancer. Clustering technique were also utilised in the diagnosis of mental illness (Diederich et al., 2007), the treatment and prognosis of breast cancer (Liao and Tsai, 2007) (Delen et al., 2005), monitor patients in emergency departments (Lin et al., 2010), and the management of diabetes mellitus treatment (Antonelli et al., 2013).

3.3.2.3. Concept description

Concept description helps to gain a general understanding of the concepts associated with the datasets. For example, a store-owner might be interested to learn more about loyal and disloyal customers to his store. A concept description can assist the owner to understand the concepts of loyal and disloyal customers and, therefore, deduce what needs to be undertaken to keep customers' loyalty. According to Chapman et al. (2000), concept description is strongly connected to segmentation and classification. Concept description can be performed after performing segmentation to understand the segmented data and provide general insights into the DM project. In classification, on the other hand, some techniques are already considered to be of the concept description problem type, as the classification technique produces understandable classification models (Chapman et al., 2000). The distinction between concept description and classification is that in the earlier problem type, only important classes or concepts are described, whereas classification describes all classes in its classification model.

3.3.2.4. Classification

Classification maps new data to a particular predefined class (Weiss and Kulikowski, 1991; Hand, 1981). It assumes that each data item has features by which the data items can be assigned into a particular category, or class. In this problem type, the class labels are defined in advance by the user. For example, a bank may classify new customers into two classes, bad or good customers, based on the credit behaviour of current and previous customers, along with their geographical information (Chapman et al., 2000).

Classification rules are applied in many domains, including marketing, banking and healthcare (Tomar and Agarwal, 2013). In the medical domain, classification was utilised for the screening and detection of breast cancer (Luo and Cheng, 2012) and dengue disease (Bakar et al., 2011a), the diagnoses of cerebrovascular (Yeh et al., 2011) and heart diseases (Das et al., 2009), the treatment of diabetes mellitus and brain injuries (Lee et al.,, 2013 ; Marcano-Cedeño et al., 2013). In addition, classification algorithms have been used for the prognosis of heart malformation in children (Kusiak et al, 2001), the monitoring heart rates deterioration (Pecchia et al., 2011). The classification modelling approaches have also been utilised for management purposes, such as improving the quality of hospital services (Chae et al., 2003). Another example of utilising classification in healthcare is the detection of fraud in health insurance by using the classification algorithm Support Victor Machine (Kirlidog and Asuk, 2012).

3.3.2.5. Prediction

Prediction problem types focus on discovering a numerical value of the class attribute for unseen objects (Chapman et al., 2000). Prediction is similar to classification but the class attribute is continuous and is not a discrete qualitative value, like in classification problem types. Prediction is sometimes named regression or forecasting in the literature review. Nevertheless, regression is a commonly used technique in prediction and it is widely used in healthcare, especially for detecting diseases in patients (Tomar and Agarwal, 2013).

Regression

Regression is a function used to predict real value variables, such as price, age, height and weight (Fayyad et al., 1996). It maps the data items and finds any correlation among them (Tomar and Agarwal, 2013). Regression utilises a training model to predict new values based on the observation of predicting previous values for a period of time. In addition, regression uses one or more independent variables and one dependent variable to achieve its prediction correctly.

A simple example of regression is estimating the price of an estate, based on its size and location. The regression model can determine this price by a training regression model, which has predicted previous prices based on several criteria for a period of time. Afterwards, those criteria are used to determine the price for the new and unknown estate. Another example is the estimation of the probabilities that a patient will survive based on several diagnostic tests (Fayyad et al., 1996).

Based on the number of independent variables, there are two main types of regression. The first and simplest type is linear regression, which identifies the relations of a dependent variable and one or more independent variables. In liner regression, the goal is to spot a line that correlates between dependent and independent variables. Linear regression predicts only numeric variables and cannot be effective with categorical data. An example of linear regression is the prediction of consumer demand for new merchandise as a function of advertising expenditure (Fayyad et al., 1996a). Logistic regression is one type of non-linear regression and it accepts categorical data. Logistic regression can be in one of two forms: one is binomial regression, where the dependent variable can be one of two possible categories, for example, a student can be passed or failed. Multinomial regression, on the other hand, is another form of logistic regression where the dependent variable has three or more possibilities, such as categorising a patient into low risk, medium risk or high risk (Tomar and Agarwal, 2013).

Regression modelling has also been utilised in the healthcare domain to support different medical activities. For screening and prediction activities, regression was utilised to analyse risk factors for hypertension and hyperlipidemia (Chang et al., 2011) and Alzheimer's disease (Briones and Dinu, 2012). In addition, regression has been utilised in the diagnosis of head injuries (Sut and Simsek, 2011), the treatment of hypertension (Almazyad et al., 2010), the prognostic of lung cancer (Chen et al., 2007) and the monitoring of diabetic individuals (Gregori et al., 2011). Furthermore, regression technique was adopted to support remote monitoring of patients' activities in order to provide them with a healthcare services when necessary (Divya and Agarwal, 2011). Finally, regression techniques were also used for management purposes, as a liner regression algorithm was utilised to estimate surgery time (Devi et al., 2012).

3.3.2.6. Dependency analysis

Dependency analysis finds a model that describes important associations, or dependencies, between data variables or events (Chapman et al., 2000). Dependency analysis is used for predicting and understanding of data. Dependencies can be used to predict the value of data given information on different data items. For data understanding, on the other hand, they are mostly used for describing the data.

Dependency models can take two different forms. First, it can be in structural form that specifies the variables that are dependent on each other. Second, it exists in the quantitative form to describe the dependencies' strengths among data items (Fayyad et al., 1996)

In terms of its functionality, dependency analysis interferes with other problem types such as classification, concept description and segmentation. For the first problem type, dependency analysis serves the prediction goal with classification. In the second problem type, dependencies are used to help to highlight and understand relationships between data items. Dependency analysis is also recommended in segmentation, especially with large datasets to reveal dependencies among data items, which can be overplayed by many influences (Chapman et al., 2000).

Association rules are one of the techniques used in dependency analysis. It is considered as one of the most powerful approaches of DM that it is used to find out frequent patterns and interesting relationships between data items (Tomar and Agarwal, 2013). The following sub-section illustrates the association rules technique and its characteristics.

Association rules

Association rules is a technique that finds significant associations and relationships among data items. It is also known as basket-market analysis because of its ability to detect association patterns among purchased items (Tomar and Agarwal, 2013). For example, peanuts and bread are purchased in 40 percent of all purchases in a particular supermarket this month. This ability helps stores owners or employees to identify the behaviour of their customers in relation to buying products from their store. Eventually, identifying such a pattern enables stores and markets to make decisions to increase their sales and revenues.

Association rules takes the following expression form:

$$X \rightarrow Y$$

where both A, the antecedent of the rule, and C, the consequence of the rule, are sets of data in a data repository of a transaction. The expression $X \rightarrow Y$ implies that when A appears in a transaction, C appears.

Association rules can produce large number of rules from any dataset, regardless of its size. Therefore, users might be interested in limiting the number of rules to a minimal number that meet two thresholds, named support and confidence rules (Witten et al., 2011). Support threshold is the value of instances where the association rule appeared in the dataset. It can be calculated by the following formula:

Equation 3.1. Support calculation formula

$$support = \frac{freq\ (x,y)}{n}$$

Freq (x,y) denotes the number of times the variables x and y have appeared together and n denotes the number of rules generated by the association rule algorithm.
The confidence threshold is expressed as the value of all instances to which the association rule applies and it is used to express the strength of the extracted association. It can be calculated through the following formula:

Equation 3.2. Confidence calculation formula

$$confidence = \frac{freq\ (x,y)}{freq\ (x)}$$

Freq (x,y) is the number of times the variables x and y have appeared together and freq (x) denotes the number of frequencies of the antecedent x.
For example, from the following weather table (see Table *3.3*), the following association rule is extracted:

Table 3.3 Weather Table

Temperature	Humidity
Hot	Normal
Cool	High
Hot	Normal
Hot	Normal
Hot	Normal

If the temperature = hot then humidity = normal.

The support value in this rule is calculated as the following:

Equation 3.3. Support calculation for the Weather table

$$support = \frac{4}{5} = 0.8$$

Therefore, 0.8 or 80% is the support level of the rule. That is, 80% of the generated rules consist of *temperature = hot* and *humidity = normal*.

The confidence value, on the other hand, is calculated as the following:

Equation 3.4 Confidence calculation for the Weather table

$$confidence = \frac{4}{4} = 1$$

Therefore, 1 or 100% is the confidence of the rule. It implies that in 100% rules, where the antecedence *temperature=hot* appears, the consequence *humidity = normal* also appears.

It is recommended, therefore, to specify support value, which also can be as a percentage, and a confidence percentage to ensure that the rules discovered meet a minimal coverage and accuracy level.

Besides support and confidence, researches highlighted a third metric that can evaluate the reliability of the extracted association rules named lift (Ordonez, 2006 ; Tan et al., 2005). According to Tan et al. (2005), confidence value can sometimes be misleading as its calculation only takes into consideration the support of X and overlooks the support of Y.

Lift metric addresses this issue as its calculation takes into consideration the support of Y. Lift of association rules can be calculated by the following formula:

Equation 3.5. Lift calculation formula

$$lift = \frac{confidence\ (x \rightarrow y)}{freq\ (y)}$$

Lift metric can determine the relationship between X and Y. Specifically, lift can determine whether X and Y appear in dependence or independence of each other. In addition, the value of lift can indicate that one two variables of X and Y presents in the absence of the other variable. According to Ordonez (2006), a lift value greater than one indicates that X and Y are dependent on each other whereas a lift value close to one indicates that the two values are independent. A lift value below one, furthermore, indicates that X or Y depends on the absence of the other variable (see Section 6.2.5).

Association rules have several advantages that make them the right solution to adopt in DM projects. This technique can "predict" any attribute, not just the class attribute as in other techniques, such as classification (Witten et al., 2011). In addition, association rules can predict more than one attribute's value at a time and can produce more association rules than other DM techniques. Another advantage of this technique is the fact that with association rules the user can specify the strengths of the dependencies by using some numeric scale. That is, values such as support and confidence ensure the strength of the association rules resulting from the DM project and, therefore, end up with accurate rules that are reliable to deploy.

Despite the advantages of the association rules technique, some disadvantages have been remarked in the literature. One main problem with this method is the generation of large number of candidate item-sets which require large number of database scans in the memory (Sun et al., 2012). Another issue is that the resultant association rules have to be examined manually to determine their meaningfulness (Witten et al., 2011). Moreover, this technique deals with non-numeric attributes only (Witten et al., 2011), which implies that when we need to mine nominal data, for instance, through association rules, those data need to be transformed into numbers, which requires more time in the data preparation stage in the DM experiment.

Similar to previous DM techniques, association rules have been utilised in healthcare to support different medical activities. The literature shows that association algorithms were utilised to support the detection of different diseases, such as screening myocardial infarction (Lee et al., 2014) and breast masses (Mohanty, Senapati, and Lenka, 2013). In addition, association rules were involved in the diagnosis activities in healthcare organisations to diagnose Alzheimer's disease (Chaves et al., 2012), heart diseases (Nahar et al., 2013) and lung cancer (Yang and Chen, 2015). For treatment activities, association rules mining has succeeded in achieving this goal in different types of cancers, including breast, lung and skin cancers in a previous study (Nahar et al., 2013). Association rules were also utilised for the prognoses of some chronic diseases. For example, Simon et al. (2013), utilised association rules to assess the risks of type 2 diabetics. The association rules technique was also utilised in healthcare to support monitoring activities for patients. Hu et al. (2012), for example, used this technique to monitor individuals with risk of cardiac arrest. For e management purposes in healthcare organisations, association rules have been implemented widely as well. Example of such an implementation is the identification of suitable donors for organ transplants in hospitals with respect to time constraints (Koyuncugil and Ozgulbas, 2010).

There are number of useful algorithms that can be used in association rules mining, two of which are the Apriori algorithm and the Frequent Pattern growth (FP-growth) algorithm. These two algorithms are described in the next section, with highlights of their advantages and limitations. This information helps us to determine which algorithm is suitable for our DM experiment.

3.3.3. DM algorithms

In DM, there are many algorithms that can perform different kinds of problem type to discover useful knowledge from vast amounts of data. In this section, we illustrate different kinds of DM algorithms and to which technique they relate. The literature shows that there are ten algorithms that can be seen as the main algorithms in the DM area (Wu et al., 2008). The list of the top ten DM algorithms was conducted during the IEEE International Conference on Data Mining by a set of award winners in DM research. Those algorithms are C4.5, *k*-Means, SVM, Apriori, Expectation-Maximisation (EM), PageRank, AdaBoost, *k*NN, Naïve Bayes, and Classification and Regression Tree (CART).

3.3.3.1. C4.5

C4.5 is one of many algorithms that are used to build classifiers and perform classification DM. the algorithm was first introduced by Quilan in 1993 to construct a decision tree, which is a very popular technique in DM and KD. According to Wu et al. (2008), C4.5 at first builds an initial tree by performing the following two steps for a set S of cases:

1. If each case S belongs to the same class or S is small, the tree is a leaf labelled with the most frequent class in S.
2. If not, C4.5 chooses a test according to a single attribute with at least two outcomes. Makes this test the root of the tree with one branch for each outcome of the test, partitions S into corresponding subsets $S1$, $S2$, . . . based on the outcome for each case then performs the same procedure repeatedly to all subsets.

C4.5 has improved many disadvantages of previous classification algorithms, such as ID3 (Hssina et al., 2014). In this context, C4.5 is able to utilise continuous data, missing values, attributes with different weights and pruning the tree after being created. In addition, C4.5 is easy to implement and to interpret its outcomes (Dey and Rautaray, 2014). To improve its efficiency, C4.5 was superseded by a commercial system See5/C5.0, which added more capabilities to the performance of the algorithm. Nevertheless, some drawbacks have been noticed on C4.5. Decision trees utilise the divide and conquer method. Therefore, the C4.5 algorithm requires that the target attributes have discrete values only for the target attributes. The performance, in addition, is low with complex attribute interactions (Jothi et al., 2015).

The literature review lacks information regarding the utilisation of C4.5 in healthcare. Only one publication concluded that classification algorithms, such as C4.5 and others were adopted to build a decision support utility for heart diseases (Dey and Rautaray, 2014). Other studies for implementing C4.5 to perform medical activities would be needed in this context.

3.3.3.2. *k*-Means

k-Means is a simple clustering algorithm that helps to partition a set of data into a number of known clusters. In this algorithm, a set of ‘n’ data points is clustered into ‘k’ clusters (Tomar and Agarwal, 2013). The algorithm begins by randomly selecting a k-centroid. Then it assigns the data points to the k-centroid based on some measures related to the data similarities. The algorithm performs many iterations to hand data points to other clusters that have a similar mean.

k-Means clustering is one of the most popular algorithms in DM (Fayyad et al., 1996b). In addition, it is a very simple approach and less complex than other methods. *K*-Means is also seen to be very efficient for detecting useful knowledge from large amounts of data. However, the algorithm has some disadvantages. *k*-Means requires a number of clusters in advance and has problems when handling categorical attributes (Tomar and Agarwal, 2013). Moreover, the algorithm is unable to discover clusters with non-convex shapes and is very sensitive to the presence of outliers (Wu et al., 2008).

k-Means has been utilised in healthcare to support different medical activities. Soliman et al. (2010) utilised the algorithm, along with other statistical analyses, to analyse cancer conditions based on informative genes. In another study, the *k*-Means algorithm was utilised to find individuals who are affected by drinking underground water that have a high level of fluoride (Balasubramanian and Umarani, 2012). In an older study, *k*-Means was utilised to partition individuals with depression into different health states and studied how they have been changed over a period of time (Lenert et al., 1999). *k*-Means also was implemented for detecting Alzheimer’s disease in a group of infected individuals into pathologic and non-pathologic clusters (Escudero et al., 2011).

3.3.3.3. Support Vector Machine

The Support Vector Machine (SVM) is a classification algorithm introduced by Vapnik (1998a, 1998b). The SVM separates the data by constructing a hyper-plane in original input space. The algorithm utilises mathematical programming and kernel function to perform its operation (Jothi et al., 2015). SVM classifies data points with a hyper-plane, constructed with support vectors, to maximise the separation among data points.

SVM is considered as the most accurate algorithm in the DM field (Wu et al., 2008). It can provide very accurate results and can be extended to deal with problems with multiclass despite the fact that it was developed for binary classification (Cristianini and Shawe-Taylor, 2000b, 2000a). In addition, SVM can handle non-linear data points and reduce the issue of overfitting. It is effective in high-dimensional spaces and powerful even when the dimensions’ number is greater than the samples. Moreover, SVM is memory efficient as it only uses the subsets of training points (Jothi et al., 2015; Tomar and Agarwal, 2013). Nevertheless, disadvantages of SVM have been documented. However, SVM is expensive to compute and to perform large datasets (Yu et al., 2003). That is the probability that estimates can be calculated through five-fold cross-validation. In addition, SVM may produce different results when utilising different kernel functions. Finally, the training stage in SVM can consume more time than other algorithms when dealing with large datasets (Awad et al., 2004).

SVM have also been utilised in healthcare. For example, SVM was applied to diagnose breast cancer based on significant risk factors (Huang et al., 2008). In another study, Avci (2009) utilised SVM to analyse diseases related to heart valves. In another example, SVM and another algorithm, namely AdaBoost, were utilised for predicting the post-operative life expectancy of individuals who suffer from lung cancer (Zięba et al., 2014).

3.3.3.4. Apriori

Apriori is the algorithm that is commonly utilised to find associations and relationships among sets of data. The algorithm was first introduced back in 1994 by Agrawal and Srikant (1994) and it utilises an iterative approach and makes various passes to the database to detect frequent item-sets. The algorithm, in addition, utilises the two thresholds described above, support and confidence, in order to generate desired rules. This algorithm generates all possible rules and counts the support and confidence for them in order to generate only rules that meet these two constraints to produce powerful results (Lai and Cerpa, 2001). The Apriori algorithm separates the association rule mining into two main stages (Vishwakarma, 2013). First, it generates frequent item-sets that meet the minimum predefined support value; second, it extracts only the association rules that meet the minimum confidence value specified before. It utilises a level-wise approach to detect frequent item-sets. In this approach, the algorithm scans the database for candidate item-sets with the size of one. Any of the found candidates that has less than the minimum support value is rejected. Other item-sets that exceed the minimum support are added to frequent item-sets with the size of one. The algorithm continues searching for other frequent item-sets but with bigger size. It generates new candidate item-sets, with the size of previous frequent item-sets + one, and scans the database again to check the support value of each candidate. Similar to the previous step, only candidates that exceed the minimum support value are added to the new frequent item-sets, which is larger by one item. The scan of the database continues until no more frequent item-sets are generated.

The Apriori algorithm has been frequently applied in healthcare. An example of such a utilisation is documented by Nahar et al. (2013) who used this algorithm to discover factors that contribute to heart conditions in males and females. In another example, Ilayaraja (2013) utilised the Apriori algorithm to find frequently occurring diseases in multiple locations and times to facilitate medical decision-making for healthcare staff.

Advantages and limitations have investigated the Apriori algorithm in the literature. On the positive side, Apriori is considered as the most popular algorithm in centralised databases (Manoj and Rajni, 2016). In addition, it has influenced most proposed algorithms for generating association rules. It is a simple approach, which can be incorporated in many DM software tools. Moreover, it reduces the time of scanning of the database and uses improved efficiency methods, such as hash table, partitioning, transaction reduction etc., (Agrawal and Srikant, 1994; Ji et al., 2011). For the negative side, Apriori produces a very large number of candidate item-sets in situations where the item-sets are large or where if the minimum support value is very low (Vishwakarma, 2013; Wu et al., 2008). As the algorithm requires multiple scans to the database for support counting of each candidate, this process is seen to be tedious and consumes more processing time and memory space (Vishwakarma, 2013; Kumar and Rukmani, 2010). According to Witten et al. (2011), this process is costly, especially with a large amount of data. Improvement have been suggested and proposed to overcome the issues of the Apriori algorithm. Han et al. (2000) proposed a new algorithm, FP-Growth, which avoids the cost of mining large frequent patterns. The FP-Growth algorithm works in two simple stages. Firstly, it constructs a compressed database, called FP-Tree, which represents its frequent item-sets; secondly, it extracts the association rules directly from the previously constructed tree. FP-Growth scans the database only twice and requires less searching time and space, as it does not generate a large number of candidate item-sets. However, large space is required when dealing with large databases (Vishwakarma, 2013).

3.3.3.5. Expectation-Maximisation

The Expectation-Maximisation (EM) algorithm is a simple mathematical approach to cluster continuous data through normal mixture models. EM also provides a flexible way to estimate the underlying density functions. The algorithm is a hierarchical approach, which aims to provide finite mixture distributions to cluster observed data in a random phenomenon (Wu et al., 2008). This approach to modelling has been used widely to cluster datasets on different occasions (McLachlan and Peel, 2004). The EM algorithm is one of the preferred approaches for maximum likelihood estimation, which is commonly used for many areas, such as system identification, image processing, pattern recognition and other statistical applications (Couvreur, 1997). The EM algorithm has many advantages. The algorithm is simple and its implementation is easy. In general, the algorithm produces the best performance when the dimensionality of data is not too large. However, it requires many iterations and some of its steps may perform slowly because of high dimensionality (Singh, 2005). Roy et al. (2014) stated that the EM algorithm is limited, in that it only clusters convex data and it needs to know the number of clusters in order to perform well.

Healthcare is one of the domains that has utilised the EM algorithm. For example, the EM algorithm was utilised to infer the emergency department throughput model (Wang et al., 2013). In this study, the algorithm helped to estimate the parameters of the model and the system noise in the emergency department with the utilisation of real-world time-series data.

3.3.3.6. PageRank

The PageRank algorithm is a statistical method utilised to rank web pages. The algorithm was introduced by Brin and Page in 1998. The algorithm interprets a hyperlink and its pages as votes for every page. PageRank is a useful modelling approach that can make web pages more significant by receiving votes from more important web pages. It scores a web page by considering the number of hyperlinks that point to that particular web page from other web pages. In addition, PageRank considers the importance of each web page, pointing to that particular web page. That is the web page which is pointed to by other important web pages receives a higher score, and therefore becomes more important than web pages that are pointed to by less important web pages (Wasserman and Faust, 1994).

PageRank remains a simple approach for ranking web pages. However, it has some limitations especially when compared with other algorithms. Its relevance is less as it ranks web pages according to the indexing time (Sharma and Sharma, 2010). The results of PageRank come out based on the time of indexing of the web pages and not based on the time of the query. Moreover, the algorithm is medium quality and many other web ranking algorithms have higher quality. In relation to the algorithm's utilisation in healthcare, PageRank seems to be more involved in ranking web pages and its implementation in the medical domain is deficient in the literature.

3.3.3.7. AdaBoost

The AdaBoost algorithm is an important ensemble learning method proposed by Freund and Schapire in 1995. The algorithm is useful to construct a classifier as a linear combination. It combines different weak hypotheses into one strong hypothesis that has a very low level of errors (Mukherjee et al., 2011). AdaBoost is the first algorithm for practical boosting and has been utilised in many domains (Schapire, 2013). One successful example is the application of AdaBoost with a cascade process for face detection (Viola and Jones, 2004).

The algorithm was implemented in the healthcare domain in many studies. An example of such a utilisation is the study by Madabhushi et al. (2006), who utilised AdaBoost to combine images' features to distinguish between lesion and shadowing. The experiment helps to improve breast ultrasounds for breast diseases effectively.

3.3.3.8. *K*- Nearest Neighbour

k-Nearest Neighbour (*k*NN) is a classification algorithm that discovers a group of objects in the training set that is closest to the test object (Wu et al., 2008). The algorithm discover new objects based on other objects known previously and classifies them by a voting system (Silver et al., 2001).

Besides its vast utilisation, *k*NN is also easy to implement. The algorithm utilises a training set of data to perform correctly. Nevertheless, this initial process is seen to be completed in a very fast way (Tomar and Agarwal, 2013). However, some limitations of *k*NN's performance have been remarked upon. Firstly, the algorithm requires considerable storage space. Secondly, *k*NN is very sensitive to noise data. In addition, the testing process of this algorithm performs slowly.

In healthcare, *k*NN has been utilised by many scholars and for different medical purposes. The algorithm was implemented to diagnose skin disease and heart disease (Cataloluk and Kesler, 2012; Shouman et al., 2012) In addition, the algorithm was utilised to classify chronic diseases to help build an early warning system. *k*NN helped to analyse the association between cardiovascular disease and hypertension and many other diseases' risk factors (Jen et al., 2012).

3.3.3.9. Naïve Bayes

Naïve Bayes is a classification algorithm that helps to classify new objects into a class (Wu et al., 2008). The algorithm mainly sets a rule for classifying those new objects based on a classification task done before for previous objects. Therefore, Naïve Bayes is a supervised classification method that classifies new objects based on the vector variables of previously classified data.

Naïve Bayes has several advantages. It is a very simple and easy classification model. According to Jothi et al. (2015), Naïve Bayes makes the computation process very easy. Moreover, the algorithm does not need an iterative parameter estimation scheme (Wu et al., 2008). Another important advantage is the fact that Naïve Bayes performs quickly and accurately, even with large datasets. On the other hand, Naïve Bayes has a limitation, as it assumes that all attributes are independent from each other (Tomar and Agarwal, 2013). This limitation can cause huge deficiencies especially if the algorithm is utilised in the healthcare domain.

Naïve Bayes has been utilised in healthcare as well as its implementation in other domains. For example, Bakar et al. (2011) utilised the Naïve Bayes algorithm to detect dengue disease. The experiment utilised other classifiers, including the decision tree and rough set classifier, and helps in early and better detection of the disease.

3.3.3.10. Classification and Regression Tree

The Classification and Regression Tree (CART) is a decision tree algorithm produced in 1984 by Breiman et al., the algorithm has been utilised in various areas including Artificial

Intelligence, Machine Learning and DM. The algorithm helps process continuous and nominal attributes. The algorithm is utilised to build a decision tree. The constructed decision tree can then be used to classify data objects. CART operates by implementing three operations (Timofeev, 2005). It constructs a maximum tree, choose the right size of the tree and classifies new data objects by using the constructed tree. The CART algorithms produce multiple trees and each one is evaluated in a pruning order to determine the right size tree (Wu et al., 2008).

According to Timofeev (2005), there are some advantages and disadvantages of the CART algorithm. The first advantage is that the algorithm is non-parametric, which means that it does not require a specific function form. In addition, CART does not require prior selection of variables as it will identify and only select important variables. Moreover, the structure of the constructed tree is stable even if the variables are changed. Finally, this algorithm is simple, fixable, fast and convenient as it handles outliers. However, CART's disadvantages are the instability of the decision tree and the fact that the algorithm can split through one variable only.

Sathyadevi (2011) applied CART to classify disease in order to build an intelligent decision support system for disease diagnoses. The study concluded that the CART algorithm offered an accurate classification model.

3.4 Conclusion

KD and KM are promising fields that can strongly support many healthcare applications as described in the above sections. KD, on one hand, provides the ability to extract useful knowledge via a non-trivial process. KM, on the other hand, enables the dissemination of the discovered knowledge and provides useful ways for successful utilisation of that knowledge. To the best of our knowledge, the integration of KM and KD is needed to maximise knowledge extraction from people and data and its dissemination of e-health, which is the focus of our study.

DM, a particular KD field, has been successfully utilised to extract knowledge from a large amount of data in many healthcare and medical domains. For our study, we aim to integrate KD and KM to support diabetic citizens in Saudi Arabia as this disease is affecting a large part of the population. This study will demonstrate how DM can extract valuable tacit knowledge related to diabetes mellitus in particular. This implicit knowledge can facilitate decision-making in relation to diabetes prediction, diagnoses and treatment for both healthcare professionals and diabetic individuals.

CRISP-DM methodology is chosen to be utilised in the pilot study of DM in this research due to its popularity, well-documented guidelines and its relevance to the KM field. The association rules that the DM problem type is chosen for this study because of its relevance to the study's objective in extracting useful associations between various diabetic non-health-related complications and the profile information of individuals who struggle with this health condition in Saudi Arabia. Moreover, the Apriori algorithm is one of the most applied algorithms that will be carried to discover association rules among our set of diabetes data, which was collected via a questionnaire from Saudi Arabian diabetic citizens. The integration of KD and KM can improve the healthcare of Saudi Arabian diabetic citizens and provide effective care and support to self-management and education of diabetes mellitus within the acceptable norms of the Saudi Arabian culture.

This study aims at proposing a framework that can integrate KD and KM to support e-health in Saudi Arabia. Having reviewed these two fields in this chapter, Chapter Four presents the developed framework.

Chapter Four: Integrated Framework of Knowledge Discovery and Knowledge Management

4.1 Introduction

The current research proposes an integrated framework of KM and KD to assist Saudi Arabian diabetic citizens to overcome the diabetes non-health-related complications. In this chapter, the framework is discussed and the three main layers of the framework are illustrated. The first layer of our integrated framework contains the e-health barriers, list of prevalent diseases and diabetes non-health-related complications in Saudi Arabia. In the second layer, KD is applied to extract useful trends in relation to non-health-related complications of diabetes mellitus. The third layer utilises KM where the socialisation, externalisation, combination and internalisation (SECI) model is applied to disseminate useful diabetes self-management solutions to citizens and healthcare professionals of diabetes mellitus in the kingdom. In each layer, utilisation descriptions are outlined with respect to the perceived domain of application. In addition to the framework's dedication to support diabetic citizens, the barriers of e-health in the kingdom are also taken into consideration in the utilisation of the framework. This aims to facilitate the adoption of the proposed framework, as well as other e-health initiatives, by the provision of relevant guidelines to different e-health barriers.

4.2 Knowledge Management and Knowledge Discovery Framework

4.2.1. Overview of the framework

The term framework is defined as a skeleton of connected items that follow a particular approach in order to achieve an objective (Business Dictionary, 20012). A framework acts as a guide which can be modified by adding or deleting any of its items. According to Mnkandla (2009) a framework provides multiple steps and phases that are followed without going into details of what is being done in order to solve a specific problem. A collection of methods, models and tools are contained in frameworks where some, or even all of them, are utilised to solve a problem (Suzi, 2012).

In this study, we propose an integrated framework of KM and KD. Our framework is primarily designed to address complications encountered by citizens in Saudi Arabia who may have one or more diseases. The framework utilises KD to extract useful trends related to those complications through DM. The framework is inspired by Nonaka's SECI model, which implements knowledge conversion between tacit and explicit. Such an integration of KD and KM enables identifying, extracting and organising tacit and explicit knowledge related to different diseases and solutions. Although the framework is designed to overcome complications of different diseases, the implementation in this study focuses in on a specific disease to ensure the applicability and validity of our proposed framework. Therefore, diabetes mellitus is chosen to be the domain of application of our proposed solution, due to its high prevalence in Saudi Arabia (Aguiree et al., 2013). In addition, the diseases is considered as one of the most common causes of death in the kingdom (Centers for Disease Control and Prevention, 2016).

Although a domain of application is chosen to apply to the framework, it is important to note that the framework was initially proposed to overcome several e-health barriers, which are related to four perspectives: business, human, technological and financial (see Chapter Two). The framework aimed to utilise KD to identify trends in relation to e-health barriers in Saudi Arabia. The KM based on the SECI model, on the other hand, can facilitate sharing of useful guidelines and best practices of diabetes as a typical application to enhance successful use of e-health initiatives in Saudi Arabia. The initial framework for e-health barriers is shown in Figure *4.1*.

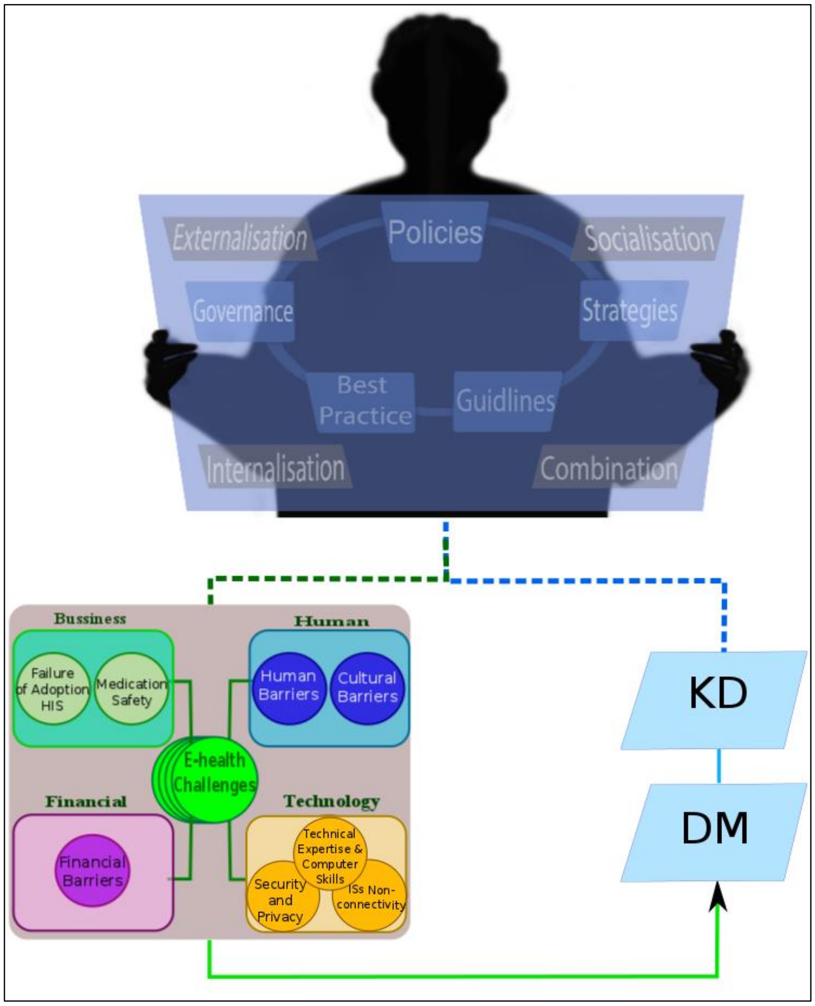

Figure 4.1. Initial framework designed to overcome e-health barriers

Source: (Almuayqil et al., 2015)

The aim of our framework in this thesis is to integrate KM and KD to support e-health in Saudi Arabia. Our proposed solution has to meet the following objectives in order to accomplish this aim:

1. to determine e-health barriers in Saudi Arabia
2. to determine a domain of application from the healthcare sector in Saudi Arabia; the chosen domain is diabetes mellitus
3. to select a DM technique
4. to choose a KM model to provide self-management and education solutions

5. to build a web portal using the SECI model to embody the provision of self-management and education solutions.

4.3 Framework components and issues

It is important before building the intended integrated framework to discuss its main theoretical bases along with the concerns related to each component. These concerns are associated with e-health and the domain of application, KD and DM, KM and the SECI model. In addition, the current status of KD and KM integration is discussed in the following sub-sections.

4.3.1. E-health barriers as layer 1

E-health is the provision of healthcare services through electronic means. E-health can connect different stakeholders, such as patients, medical staffs, service providers and governmental agencies, through information and communication technologies (Ouhbi et al., 2017). The utilisation of e-health can bring significant advantages to many healthcare sectors. According to several studies, e-health can increase scalability, time efficiency and the capacity to accept more individuals. Moreover, e-health facilitates the provision of healthcare services to individuals with reasonably lower costs (Senor et al., 2012 ; Fernández-Alemán et al., 2013).

Many e-health initiatives have been applied in healthcare. These initiatives involve different technologies, such as electronic records, disease monitoring and cloud computing (Ram, 2014). However, the implementation of such technologies faced different barriers that hinder successful e-health implementation. These barriers are investigated in Chapter Five in a statistical study. As the results from the analyses can benefit different e-health solutions, the resultant barriers are shared using a web portal which we have built to support users managing their illness.

The area of e-health covers a wide domain that includes different aspects related to different diseases, along with its preventions and treatments. That is, due to its effectiveness, e-health solutions can be implemented to overcome different chronic diseases. Examples of such diseases include heart diseases (Wong et al., 2016), cancer (Anderson et al., 2016), Alzheimer’s disease (Chiu et al., 2009) and diabetes mellitus (Jha et al., 2016). Consequently, there is a need to apply our integrated framework in a specific domain in order to facilitate its application and measure its effectiveness. Therefore, we aimed our study to focus on particular diseases that serve the second objective of our proposed solution. We set two conditions that diseases should meet in order for them to be our chosen domain of application in Saudi Arabia, and these conditions are as follows:

1. the disease should be prevalent in Saudi Arabia
2. the disease should be self-manageable.

The two conditions outlined above ensure that the application of our integrated framework will be useful to support e-health in Saudi Arabia. In the first condition, many diseases are seen to be prevalent in Saudi Arabia, based on different official and trusted resources. According to the Saudi Arabian Ministry of Health, the top outpatient visits made to PHCs are associated with upper respiratory tract infections, musculoskeletal disorders and diabetes mellitus (Ministry of Health, 2011). The term ‘upper respiratory tract infection’ is used to describe infections that can affect the nose, paranasal sinuses, pharynx and trachea, which can be caused by different viruses and patristics (Sherif B, 2013; Masavkar and Naikwadi, 2016). Musculoskeletal disorders are common health conditions in many countries and include different syndromes, such as tendon inflammations, nerve compression disorders, osteoarthritis, myalgia and lower back pain (Punnett and Wegman, 2004). Diabetes mellitus is a metabolic disorder resulting from the lack of insulin secretion, insulin action or both (American Diabetes Association, 2013). Of the three diseases, diabetes mellitus was considered the highest cause of death in Saudi Arabia in 2013, according to the Institute of Health Metrics and Evaluation (Centers for Disease Control and Prevention, 2016). In addition, Saudi Arabia is considered to be one of the top ten countries in term of the prevalence of diabetes mellitus according to the International Diabetes Federation, with a prevalence of 23.9% (Aguiree et al., 2013).

The term self-management in the medical domain is used to emphasise the patients’ role in controlling their diseases. The term has been used to enable individuals to deal with their chronic illnesses, and its resulted complications, by increasing their knowledge, skills and confidence (Lorig et al., 2000). Self-management also empowers people with different diseases to manage their negative emotions and maintain life roles. It has been applied globally and has proved its usefulness to a number of diseases, including different chronic conditions.

All the three diseases, upper respiratory tract infection, musculoskeletal disorders and diabetes mellitus, are proved to be self-manageable. According to Masavkar and Naikwadi (2016), the degree to which individuals are educated and literate about respiratory tract infections plays a significant role in the prevention and control of the disease. For musculoskeletal disorders, a study conducted by Kroenke et al. (2009) showed that self-management and education programmes have shown significant improvement in individuals with this condition. Diabetes mellitus, similarly, has been witnessed to be self-manageable in different studies. In one study, a diabetes self-management strategy was found effective in controlling different aspects of the disease, including fasting blood glucose level, glycated haemoglobin, diabetes knowledge, reducing systolic blood pressure levels and body weight (Deakin et al., 2005).

Even though all diseases mentioned previously meet the two conditions, diabetes mellitus was chosen to be the domain of application in our current study. Diabetes mellitus is chosen, over the other two diseases, because it constitutes more life-threatening health conditions than the other two diseases (Centers for Disease Control and Prevention, 2016). In addition, diabetes mellitus has wider attention in the area of self-management and education from a variety of studies which have demonstrated such programmes in different countries. However, the implementation of diabetes self-management and education in Saudi Arabia is still deficient, especially when considering the vast prevalence of the disease in the kingdom. Consequently, the other two diseases, upper respiratory tract infections and musculoskeletal disorders, can be undertaken in future research.

Nevertheless, the e-health barriers represented in the first layer of our integrated framework still have a major role in our study. These barriers are investigated in Chapter Five to reveal the factors affecting the success of different e-health initiatives in Saudi Arabia. The e-health issues resulted from the questionnaire help when designing the web portal, which is dedicated to incorporating the SECI model into the framework. E-health barriers are incorporated in our web portal which we have built to support users managing their illness.

4.3.2. Knowledge management

The framework primarily relies on KM as an effective tool to achieve sufficient education and knowledge acquisition. KM is defined as a dynamic process that aims to capture, store, disseminate and create knowledge (Ni et al., 2010). KM can be used in organisations to increase knowledge via communication, the provision of learning opportunities and the dissemination of different knowledge among organisations' members (McInerney and Koenig, 2011). The created and disseminated knowledge enables organisations and individuals to gain competitive advantages. This constitutes the importance of KM utilisation in different organisations, and many organisations acknowledge its value.

The practice of KM has proved its feasibility in different domains (El Morr and Subercaze, 2010; Petrides, 2003; Yeh, 2011). The general insights to KM's advantages and success factors are discussed in Chapter Three. In this chapter, however, the focus is on investigating the application of knowledge and KM within the Saudi Arabian healthcare sector.

The utilisation of KM in healthcare is associated with a number of advantages. According to El Morr and Subercaze (2010), KM in healthcare can benefit medical staffs in hospitals in reducing medical prescriptions. Other studies have indicated that KM has a reported error reduction in healthcare of 55% (Computerworld, 2002). The error reduction in healthcare results in a cost reduction as well. In addition, KM systems can increase the practice of corporations in healthcare organisations, which will reduce medical mistakes. Another advantage of KM in healthcare is the enhancement of quality of care. KM can contribute to this objective by developing, cooperation and sharing of medical knowledge within the hospital (El Morr and Subercaze, 2010). Cost reduction is another advantage of KM implementation in the healthcare and medical domains. In fact, the reduction of medical errors and the increased cooperation facilitated by KM in healthcare have the consequence of improved cost efficiency. The practice of cooperation can encourage the sharing of information among different healthcare providers, whereas KM can reduce adverse drug effects and then reduce medical expenses caused by medical errors.

Patients' knowledge about their diseases, and their associated aspects, such as diagnoses and drugs, is the first step in their treatment journey (Alshammari, 2016). The knowledge patients have about their diseases can affect their lives, as it can determine their activities and lifestyles. This can contribute to their control and treatment of their diseases. In addition, knowledge enriches patients' medical knowledge in the treatment and drugs they require for different diseases.

Many factors, described in Chapter Three, that are seen to be affecting KM utilisation. These factors are related to national culture, such as high power distance in Arabic communities, and organisational culture, such as lack of communication and team-work in Saudi Arabian organisations. These factors can also be related to healthcare, such as absence of KM strategy and the degree of professionalisation in healthcare organisations. Beside these factors, the utilisation of KM has additional issue when utilised in Saudi Arabia. The major obstacle of KM in this context is the lack of KM utilisation in the Saudi Arabian healthcare sector. The area of KM in the Saudi Arabia is still relatively new and focusses on domains other than healthcare including economy, oil production investment and military (ALHussain, 2011). Few studies show limited utilisation of KM in the Saudi Arabian healthcare domain. For example, AlSanad and Zemirli, 2015 utilised KM to increase efficiency of telemedicine in Saudi Arabia. In another study conducted by Ahmad et al. (2016), KM was used to increase commitment of employees and total quality management in healthcare in Saudi Arabia. Nabutete (2013), in addition, reviewed KM practice in Saudi Arabian hospitals. However, his review focused on increasing performance in hospitals among staffs and employees.

The education influence, offered to patients and other stakeholders, is well documented in developed countries, which plays significant role in empowering patients and enriching their knowledge about the illnesses they have. However, such an influence is still deficient in Saudi Arabian healthcare sector (Alshammari, 2016). This issue is discussed in Chapter Two to show that small number of large healthcare organisations in the kingdom have documented education efforts to enrich their patients about their diseases and drugs. Nevertheless, the majority of healthcare organisations lacks an effort in relations to educate their patients about the different diseases they suffer from. Therefore, the current study aims to apply KM to increase the knowledge of citizens who struggle from particular diseases in Saudi Arabia. This will also fill the gap of deficient KM utilisation in the Saudi Arabian healthcare sector.

4.3.3. SECI model layer

As described in Chapter Three, Nonaka and Takeuchi (1995) proposed the knowledge creation model that facilitates interaction of tacit and explicit knowledge by applying the four conversion modes SECI. The SECI model is a well-known theory in the area of KM, and has been successfully applied to manage knowledge in a variety of domains. More insights about the SECI model, its modes, and barrier of non-validity in different cultures, were discussed in Chapter Three. In this chapter, however, we focus on the application of the model in the healthcare domain and type of knowledge of the SECI model.

The SECI model has been utilised in different domains for the purpose of knowledge creation and dissemination. Several studies have shown successful applications of the knowledge creation model. For example, the SECI model was proposed to be applied in a library to build a system for KS (Cao et al., 2010). In another study, the SECI model was utilised in the field of software development in order to assist stakeholders in the process of elicitation, specification and validation of software requirements (Chikh, 2011). Moreover, Easa (2012) utilised the SECI model in a banking sector successfully. Additionally, Li et al. (2009) examined the SECI model's utilisation in the manufacturing sector and proved its successful utilisation.

The healthcare domain utilises tacit and explicit knowledge in different ways. Researchers have demonstrated the importance of the two types of knowledge in different studies. Tacit knowledge is valuable for many healthcare practitioners in addressing a medical problem (Herbig et al., 2001). Tacit knowledge is also beneficial in clinical care as it is the basis for decision-making, even though these decision guidelines are made available in an explicit form (Thornton, 2006). According to Kothari et al. (2012), the value of tacit knowledge in this context is that capturing such a form of knowledge can contribute to the performance and training of practice, which is typically based on experience. More precisely, utilisation of tacit knowledge in healthcare has more connotations for healthcare delivery by promotion or rejection of explicit medical expertise (Boateng, 2008). Moreover, the capture of tacit knowledge, and its transformation into explicit knowledge, seems to benefit the performance, not only for clinicians but also for hospital leadership and other individuals in the various departments of the hospital (Hovlid et al., 2012).

Explicit knowledge, on the other hand, is also useful in the healthcare sector. The explicit knowledge can address several issues which exist in the healthcare sector. According to Wickramasinghe and Davison (2004), knowledge is the driving force for enhanced practice management. Therefore, making this knowledge explicit can make healthcare organisations better equipped to deal with complications, such as increased cost and the pressure for delivering high-quality and effective care. In addition, explicit knowledge is valuable for the practice of evidence-based medicine, which is based on research evidence, clinical expertise and patients' preferences and values for the purpose of performing medical decision-making (Wickramasinghe and Davison, 2004).

The advantages of tacit and explicit knowledge, as well as the case for evidence-based medicine, raises the importance of utilising a conversion mechanism for the two types of knowledge in healthcare. Evidence-based medicine is primarily based on the explicit evidence from research. However, it is important to consider the tacit knowledge that represents both the clinical expertise of medical staff and the patients' preferences. According to Wickramasinghe and Davison (2004), the tacit knowledge of medical expertise and patients' preferences are not utilised sufficiently. More importantly, it is almost impossible for healthcare professionals to rely only on tacit knowledge in supporting their medical decisions and practices. Wickramasinghe and Davison (2004) also stated that ignoring the tacit knowledge of healthcare professionals, which is gained from daily practices, might not be the solution, as that tacit knowledge can provide great significance to the healthcare system. Therefore, the best solution in tackling this problem is to adopt a knowledge-conversion theory that can convert tacit and explicit knowledge to support different activities in the healthcare domain.

Despite the importance of the existence of knowledge creation models and methods, the literature indicated that there is a deficiency of such models in the KM area. The SECI model seems to be the only highly utilised model for KM and knowledge creation in different domains (Li et al., 2009 ; Cao et al., 2010). According to Snowden (2002), the knowledge conversion model of Nonaka and Takeuchi (1995) contributes to the deficiency of other KM models and tools because the focus on this model has dominated the KM area. Therefore, the model is adopted in this study for four main reasons. Firstly, the SECI model explores the interrelationship between the two different types of knowledge, tacit and explicit, which have been outlined above and which are highly utilised in healthcare. Secondly, the SECI model facilitates the conversion between tacit and explicit knowledge, which is a necessary process to benefit from knowledge availability in the healthcare domain (Dalkir & Liebowitz, 2011). Thirdly, the model does not only concentrate on the dissemination of knowledge. It also takes into consideration the process of knowledge creation, which is also a valuable process in the area of KM. Finally, the SECI model is widely utilised in different domains, such as organisational learning, product development and IT. Its successful implementation in different domains requires similar applications within the healthcare sector in Saudi Arabia, which is seen to have slower KM practice than other healthcare sectors in developed countries (Szulanski, 2001; Scott, 1998).

4.3.4. Knowledge discovery layer

Knowledge discovery (KD) is another field whose focus is on analysing knowledge embedded in data, texts and images in order to extract valid, novel, understandable and useful patterns via non-trivial processes (Feng, 2010). KD uses statistical and machine-learning techniques to analyse and process large numbers of datasets (Delen et al., 2005). The process of KD can be carried out without, or at least less, human intervention (Grobelnik and Mladenic, 2005). KD has multiple different sub-domains. Mostly known domains are text mining, web mining, link mining and data mining (DM). DM is the primary focus of illustration.

Text mining is defined as the process of analysing text in order to find useful patterns in text to serve a particular objective (Witten et al., 2011). Text mining deals with text, which is unstructured, and therefore difficult to handle. However, in the western world, text is the most utilised force for knowledge exchange. Web mining is the process of searching for knowledge from the World Wide Web and it is similar to text mining. However, it takes advantage of the extra information available on the web, such as document format and hypertexts. Web mining also improves its results by capitalising on topic directories available on the web. Link mining is another area in knowledge discovery that has special emphasis in order to extract useful knowledge (Getoor and Diehl, 2005). It has several tasks, namely link-based object ranking, link-based object classification, link prediction as well as others. DM is defined as a subfield of KD which concentrates on using learning techniques on databases and spreadsheets (Grobelnik and Mladenic, 2005). According to Silwattananusarn and Tuamsuk (2012), DM has a number of techniques that are separated based on its objectives. Predictive techniques include classification and regression and descriptive techniques include clustering, association rules and summarisation. Details of DM and its techniques and algorithms are discussed in details in Chapter Three. Here we discuss DM in the context of our integrated framework and domain of application.

DM has been widely used to support different major activities in the healthcare domain. Mining medical data has important advantages related to improving accuracy, time and cost efficiency and decision support systems (Esfandiari et al., 2014). Therefore, different DM techniques have been applied in healthcare to support different activities, including screening, diagnosis, treatment, monitoring and management. Esfandiari et al. (2014) have reviewed the utilisation of DM to support these activities in healthcare. They found that screening, for example, is performed by utilising classification and association rules for diseases such as diabetes mellitus and cancer. For diagnosis, regression is utilised to diagnose liver diseases. Treatment is another activity in healthcare where classification is used to treat diabetes mellitus. Monitoring has also been performed with the utilisation of different DM techniques, such as association rules for monitoring infections and classification and regression for monitoring diabetes mellitus. For management, association rules are utilised to schedule operations in hospitals.

The application of DM to support diabetes mellitus in Saudi Arabia is well documented in the literature. This application was performed by Aljumah et al. (2013), for example, who utilised DM to compare the effectiveness of six different treatment plans which are based on drug, diet, weight reduction, smoking cessation, exercise and insulin on young and old diabetic individuals. Aljumah et al. (2013) concluded that treatment associated with diet is best suited for young and elderly diabetic individuals, but the order of the other treatment attributes varies between the two groups. However, the application of DM for the purpose of extracting non-health-related complications related to diabetes mellitus is still deficient in Saudi Arabia. Non-health-related complications of diabetes mellitus are the related difficulties in controlling eating habits, doubt in using medication, deficient adherence to lifestyle measures and other factors, which are described in Chapter Two. Moreover, DM utilisation for diabetes non-health complications extraction is also deficient in other countries as well, as most DM utilisation concentrates on the provision of diabetes self-management and education solutions. Consequently, the current thesis aims to fill this gap by applying DM to diabetes data to extract non-health-related complications.

One concern that should be taken into consideration when utilising DM is the fact that DM has many techniques. The area of DM has a number of problem types and techniques that can solve a number of different problems. Choosing the right technique to solve a particular problem is still seen as a difficult task. According to Swayne et al. (2010), appropriate selection of the best technique requires sufficient expertise in the area of DM (Swayne et al., 2010). In addition, the number of DM techniques is growing rapidly, which means users of DM need to keep updated about the development of new aspects in this area. Swayne et al. (2010) proposed an automated system to overcome this issue. His system chooses the right DM technique based on case-based reasoning (CBR) which chooses the right technique based on past experience of other DM users to avoid repetition of choosing an inappropriate DM method. The idea of CBR is that projects can be accomplished by reusing techniques used on similar projects that have been solved in the past. In this study, CBR is chosen over a knowledge-based approach, which requires continuous upgrades in the newly developed technologies. Swayne et al. (2010) believe that the selection of DM techniques in the majority of DM applications depends on two main parameters. These two parameters are the goal of the project to be solved and the structure of the available data to be mined. These two parameters have guided this thesis in selecting an appropriate DM technique, which is presented in Chapter Six, with justification for the selected technique.

4.4 Knowledge Discovery and Knowledge Management Integration

DM and the SECI model also have provided valuable ways to extract and create knowledge in different domains. In healthcare, the integration of DM and the SECI model can provide increased value to the two interdisciplinary areas. Moreover, the application of KD and KM in the healthcare domain fills several gaps in applying these two concepts in the Saudi Arabian healthcare sector, especially in the domain of diabetes mellitus.

While KD can be used by healthcare organisations to analyse their datasets to discover valuable new knowledge about their patients to provide better healthcare services, KM can be employed to extract and disseminate the best practices of healthcare professionals in order to provide efficiency and effectiveness in their healthcare services. Such an integration can be a powerful tool for making effective decisions (Li et al., 2010). As Wang and Wang (2008) explain, the usefulness of DM emerges in two main manners, to share common knowledge among individuals who perform DM tasks, and to extend human knowledge. Many organisations are realising the merits of KM and DM to derive the best practices and improve their strategic decision-making based on the new knowledge extracted from their datasets. However, KM and KD seem to be employed separately. KM technologies and business intelligence technologies can now be combined to derive more values from the explosion of company data and textual information systems. For example, their integration can improve the company's marketing knowledge management framework as explained by Shaw et al. (2001). To the best of our knowledge, no such integration is carried out by the healthcare sector in Saudi Arabia.

The current study proposes an integrated framework of KM and KD. Diabetes mellitus is the domain of application where our integrated framework is applied. The KD part of our framework is responsible for extracting useful trends related to diabetes complications encountered by diabetic citizens in Saudi Arabia. Four KD methods can be applied in this part of the framework: DM, text mining, web mining and link mining. The current study, however, focuses on DM to extract implicit knowledge related to diabetes mellitus.

The KM part of our framework applies the SECI model to disseminate useful knowledge related to diabetes self-management and education in order to resolve the complications revealed from the KD part. Beside the contribution of applying this integration in the Saudi Arabian healthcare sector, the framework applies the SECI model to disseminate valuable knowledge extracted from databases. The SECI model is a useful theory that converts human knowledge and expertise between tacit and explicit. In this study, the four modes of the SECI model are applied to disseminate knowledge associated with diabetes mellitus.

The application of the SECI model in this study is performed through technological means instead of social interactions, as suggested by Nonaka and Takeuchi (1995). A web portal is an essential part of our study, which is designed to demonstrate our integrated framework. The web portal is dedicated to diabetic citizens and healthcare professionals in Saudi Arabia. In addition, the web portal applies the KD and DM parts of our framework by generating a dataset that can be mined for future studies. Moreover, the four modes of the SECI model are applied in order to disseminate useful diabetes self-management and educational guidelines and best practice.

Finally, the web portal includes the e-health barriers in Saudi Arabia. The framework and the web portal form an e-health contribution to support e-health for diabetic citizens and healthcare professionals in Saudi Arabia. Therefore, e-health barriers in Saudi Arabia that relate to the four quadrants – business, human, technology and financial – are taken into consideration to ensure successful utilisation of our framework as well as ensuring that our web portal is successful. Figure *4.2* shows the diabetes mellitus, KD, the SECI model e-health barriers in Saudi Arabia and the web portal in our framework.

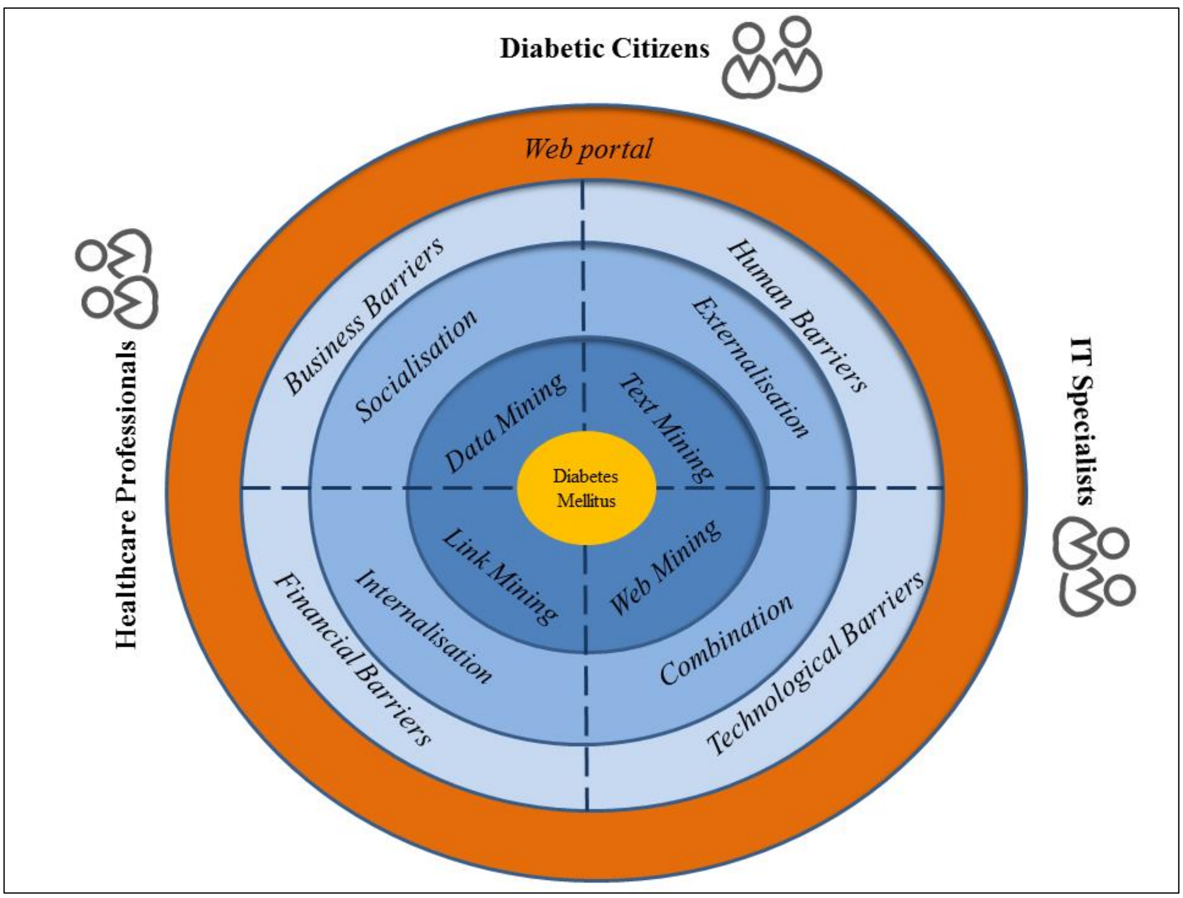

Figure 4.2. Inclusion of diabetes mellitus, KD, the SECI model, e-health barriers and the web portal in our framework

4.5 Framework Structure

The framework is designed in three layers (see Figure *4.3*). The first layer focuses on the barriers related to e-health in Saudi Arabia and the complications that can be related to different diseases. As mentioned in section 4.3.1, the framework is applied to the domain of diabetes mellitus in Saudi Arabia. Therefore, the non-health-related complications related to diabetes mellitus are investigated in this research. The second layer is related to KD and DM in particular, where the diabetes mellitus non-health-related complications obtained from the first layer are data mined. The third layer is the KM layer, where the SECI model is applied to capture these complications and disseminate useful diabetes self-management and provide education guidelines and best practices to diabetic citizens in Saudi Arabia.

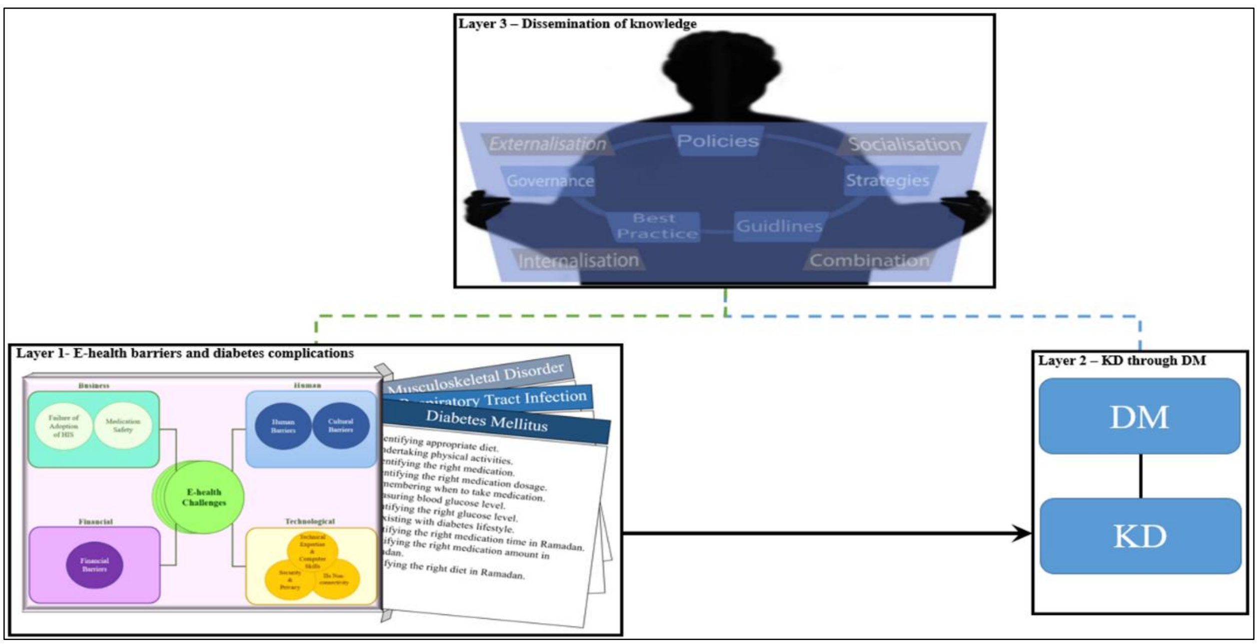

Figure 4.3 Integrated framework of KD and KM for diabetes mellitus in Saudi Arabia

4.5.1. The first layer: issues and complications

In this layer, there are two categories of issues: firstly the e-health barriers and secondly the complications related to a particular disease in Saudi Arabia.

- **E-health barriers**

The literature review has identified eight e-health barriers hindering successful e-health initiatives in Saudi Arabia. These are discussed in details in Chapter Two and summarised as follows:

- 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.
- 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 citizens towards the use of virtual contact and interaction with technological devices. The role of citizens in the process of knowledge production, and the computing skills of both the healthcare professionals and citizens, are critical to the success of our framework.
- 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.
- 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.

A questionnaire was undertaken in this study to investigate and rank these barriers from the perspectives of three stakeholders: citizens, healthcare professionals and IT specialists. The results from the questionnaire are used to ensure the success of any e-health solution being developed in Saudi Arabia. To facilitate effective sharing of guidelines and best practices to diabetic citizens in the kingdom, a web portal was designed. Details about the e-health barriers questionnaire are discussed in Chapter Five.

- **Diabetes non-health-related complications**

As mentioned previously, diabetes non-health-related complications relate to difficulties encountered by Saudi Arabian diabetes mellitus sufferers in their daily life. A survey was undertaken in this study to investigate these complications related to lifestyle issues and the medication aspects and profile attributes of diabetic citizens (e.g. age, gender, educational level, etc.). In this survey, we focused on 11 complications, namely diet, physical activities, medication (i.e. dosage intake), blood glucose level, identifying the right glucose level, lifestyle, identifying the right medication time, amount and the appropriate diet in Ramadan (see Figure *4.4*).

Diabetes Mellitus

- Identifying appropriate diet.
- Undertaking physical activities.
- Identifying the right medication.
- Identifying the right medication dosage.
- Remembering when to take medication.
- Measuring blood glucose level.
- Identifying the right glucose level.
- Coexisting with diabetes lifestyle.
- Identifying the right medication time in Ramadan.
- Identifying the right medication amount in Ramadan.
- Identifying the right diet in Ramadan.

Figure 4.4. Diabetes non-health-related complications

4.5.2. The second layer: knowledge discovery and data mining

The aim of this layer is to mine the data acquired from the survey and elicit new knowledge that can link the non-health-related complications encountered by diabetic citizens in Saudi Arabia with the their profile characteristics. Consequently, the DM method employed is association rule mining, which is appropriate to the structure of our survey which contains nominal attributes and instances. The DM of our survey is discussed in Chapter Six.

4.5.3. The third layer: knowledge management layer

The third layer in the framework is designed to enable effective provision of useful strategies, guidelines and best practices to citizens who may encounter many complications related to different diseases. In addition, the KM layer facilitates the exchange and conversion of tacit and explicit knowledge between citizens and healthcare professionals in order to provide useful recommendations that can empower citizens to control their diseases. Therefore, the SECI model is applied in this stage of the framework. As the domain of application in this study is diabetes mellitus, the knowledge to be disseminated in the third layer is related to diabetes self-management and education (see Figure *4.5*).

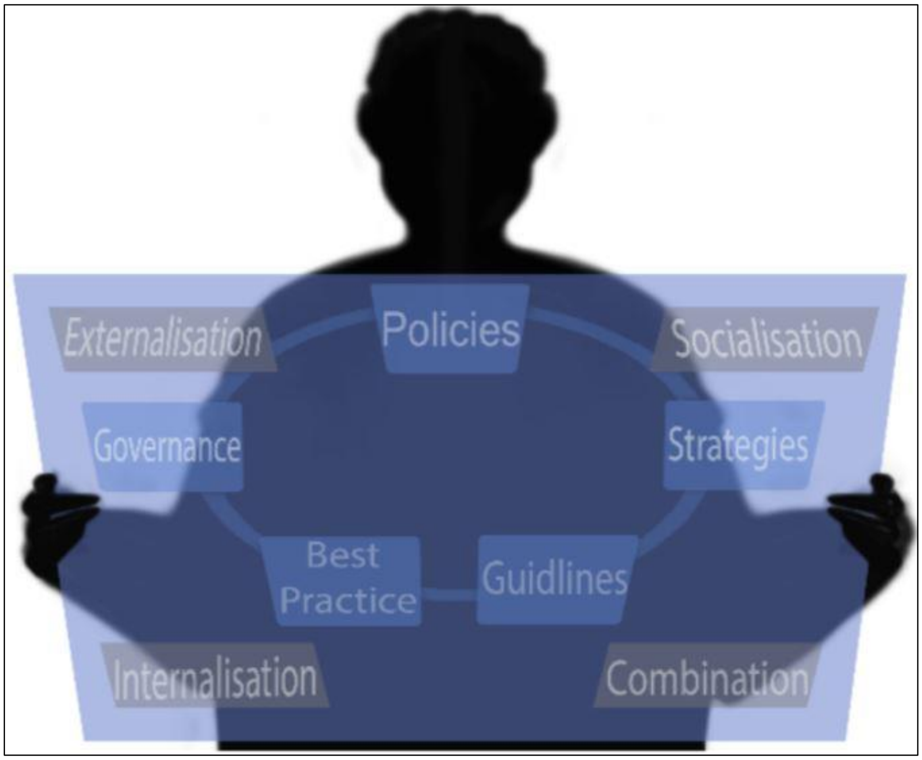

Figure 4.5. The KM layer

Policies, strategies, guidelines, best practice and governance are the forms of diabetes self-management and education to be shared between stakeholders: citizens and healthcare professionals. These aspects provide promising solutions to overcome every non-health-related complication of diabetes mellitus. Some of these solutions, such as medication intake guidelines, might be in the explicit form of knowledge, while others, such as physical activities and best practices, can be tacit. The SECI model enables knowledge creation as the solution presented in one form of knowledge (tacit or explicit) to be transformed to another, in order to facilitate effective diabetes self-management for every diabetic citizen in Saudi Arabia and successful e-health utilisation in the Saudi Arabian healthcare sector.

The four modes of the SECI model can play a significant rule in the control of diabetes non-health-related complications. The socialisation mode can play a significant role in overcoming these complications by enabling diabetic individuals to socialise with each other via the portal. The outcomes from such an action result in engaging diabetic individuals in group discussions about their complications and best practices. Diabetic citizens can also socialise and interact with healthcare professionals. In terms of externalisation, healthcare professionals can help patients to overcome their complications through converting useful guidelines, best practices and recommendations to comprehensible and appropriate media. The externalised recommendations can empower diabetic individuals to deal with different types of non-health-related complications of diabetes mellitus, such as identifying appropriate time and/or dosage of medication. Moreover, the externalisation mode can disseminate our tacit DM findings and make them explicit. This can benefit the community which has diabetes mellitus by providing data in explicit form and making them available for further research and studies related to diabetes mellitus. The combination mode provides a flexible way to integrate different aspects of guidelines and strategies for appropriate diabetic citizens, taking into consideration their specific lifestyle, diet, medication issues and Ramadan requirements. In the internalisation mode, Community of Practices (CoPs) can be created, where diabetic citizens are learning by doing and following different guidelines related to dealing with several barriers such as identifying the right physical activity and coexistence with the life style of diabetes mellitus.

4.6 Potential Benefits

Diabetes mellitus is the medical domain where our framework is validated in order to evaluate its usefulness and performance. To bridge the two concepts of e-health and diabetes mellitus, financial barriers are one of the major obstacles for utilising e-health in Saudi Arabia. Diabetes mellitus contributes to this barrier as it is extremely prevalent in the kingdom. Furthermore, diabetes mellitus requires everyday monitoring and intense care and utilising e-health initiatives can support this concept. Several studies have shown the positive influence of technology in providing better care for diabetics (Balas et al., 2004; Ko, 1990). Nevertheless, many e-health barriers hinder successful utilisation of e-health initiatives. Healthcare organisations in Saudi Arabia made high expenditure to benefit from e-health solutions. However, the implementation has become problematic, which results in wasting time, money and apparently having patients not benefiting from new technologies being used in healthcare sectors elsewhere. This framework is ambitious in seeking to provide a solution tailored to diabetics' needs as well as the barriers outlined in the literature. This will help to provide successful implementation and utilisation for future e-health initiatives.

The SECI model is utilised to provide diabetes self-management and education initiatives to diabetic citizens in the kingdom. Initiatives such as guidelines, recommendations, tips and best practices are transformed from one form of knowledge to another in order to reach perceived diabetic individuals to enable them to overcome diabetic non-health-related complications. While the third layer facilitates effective sharing of useful solutions to diabetic citizens, the complications of diabetes mellitus can be extracted from the DM associating analyses for the different characteristics of diabetics with a variety of complications. The complications to be analysed through DM show the need for efficient implementation of socialisation, externalisation, combination and internalisation in order to be addressed. That is, these complications are not related to health issues, such as heart disease, foot injury or strokes; instead, the complications considered here are non-health-related issues, such as the difficulties of identifying appropriate diet, the difficulties in identifying the right physical activities and the difficulties in identifying the right medication dosage. The aim of the SECI model utilisation in our framework is to provide knowledge not only to healthcare professionals who may be seeking or sharing best practices, guidelines, policies and recommendations, but also to diabetic citizens in Saudi Arabia who may need to contact specific healthcare service, healthcare professional or other diabetic citizens to seek advice and assistance regarding the non-health-related complications they encounter.

The integrated framework can also be applied to overcome the obstacles associated with different e-health initiatives in Saudi Arabia. The socialisation mode in the SECI model enables the transfer of best practices from one individual to another in its tacit form through imitation and observation. Hence, the barrier related to poor interface design faced by citizens and healthcare professionals can be overcome. In addition, sharing best practices regarding diabetes care helps citizens and healthcare professionals to overcome human and cultural barriers, such as negative beliefs, lack of trust, resistance to change and preference of physical interaction. Externalisation helps share and convert strategies and governance from tacit to explicit. Such a conversion helps IT specialists to cope with the absence of a national healthcare system and financial barriers. Externalisation can also convert guidelines from tacit to explicit, which will overcome the lack of guidelines issue and enable citizens to benefit from e-health initiatives properly. The combination mode will be used in our framework to provide policies, strategies and governance in explicit form to overcome the absence of a national healthcare system obstacle identified by citizens and healthcare professionals. Furthermore, policies can be shared with healthcare professionals to govern and regulate access to patients' medical records. The sub-barrier deficient technical support can also be overcome through combination by adding strategies. Internalisation can assist citizens and healthcare professionals to overcome the obstacles related to technical expertise and computer skills. Best practice will be facilitated in such a case through training and "learning by doing" to enable citizens and healthcare professionals to overcome the barriers of lack of guidelines and poor maintenance.

4.7 Diabetes Web Portal

One of the important tasks in designing our framework is the design of a web portal that supports the framework’s objectives and features. The internet is increasingly used for different purposes. In healthcare, internet technology is utilised as an e-health tool. According to Gurjit and Neena (2006), the internet has the infrastructure, the scope and the acceptance to achieve widespread change and to drive the development and implementation of e-health applications. In this thesis, a web portal is designed to support diabetic citizens and healthcare professionals in Saudi Arabia. The web portal is dedicated to providing diabetes self-management and education guidelines and best practices to stakeholders through the application of the SECI model utilised in the third layer in our integrated framework. Several web tools and technologies are implemented to support the four modes of Nonaka and Takeuchi (1995) in the internet environment and the design of our web portal and its conceptual bases are described in more details in Chapter Seven.

4.8 Validation of the Framework

In order to ensure the framework's accuracy and reliability, the framework will be validated through a panel of experts of diabetic citizens, healthcare professionals and IT specialists at a healthcare organisation in Saudi Arabia. Validation is defined as the process of determining whether a model accurately represents the real world from the perspective of the intended uses of the model (Sommerville and Prechelt, 2008). The designed web portal will also be evaluated to ensure that it fulfils the requirements for the utilisation of our proposed framework. According to Kahan (2008), evaluation differs from validation as the former aims to review processes, activities and strategies through the generation of a set of questions to determine whether the objectives of the project has been achieved. Similar to the previous task, web portal evaluation will be accomplished via focus groups of diabetes social groups, healthcare professionals and IT specialists at a local hospital in Saudi Arabia. The framework validation and web portal evaluation process are described in more detail in Chapter Eight.

4.9 Conclusion

KM and KD are two well-developed disciplines. However, to the best of our knowledge, there has been no methodical attempt at integrating them within the SECI model and addressing non-related healthcare issues in Saudi Arabia. The aim of this research project is to bridge this gap and consequently to improve the healthcare services and provide a forum for both, for healthcare professionals to deliver the best healthcare to their patients, for diabetic citizens to overcome their problems and difficulties in managing their medical condition. In this chapter, a framework that integrates KD and KM is proposed. The three layers of the framework are described, focusing on e-health barriers and relations to the domain of diabetes mellitus in Saudi Arabia. The proposed framework is implemented in a web portal system to provide a tailored KM approach to help diabetic citizens to self-manage their health condition and support healthcare providers and citizens to share their recommendations and best practices. There are a number of contributions associated with our integrated framework; these are listed below.

1. The framework is the first to integrate DM and KM in the healthcare domain in Saudi Arabia. In particular, the integration of the SECI model with a DM approach has not

yet been investigated in the literature in the domain of diabetes mellitus in Saudi Arabia.

2. The utilisation of DM for the purpose of extracting useful knowledge in relation to diabetes non-health-related complications.
3. The utilisation of KM and the SECI model in the healthcare domain in Saudi Arabia.
4. The application of the SECI model to encourage the practice of diabetes self-management and education.

Having demonstrated our proposed framework in this chapter, Chapter Five investigates the e-health barriers in Saudi Arabia.

Chapter Five: A Study of E-health Barriers in Saudi Arabia

5.1 Introduction

E-health provides useful initiatives to enhance healthcare services all over the globe. It is an ideal forum to show how DM and KM can be integrated to realise the SECI model. In Chapter Two we discussed several factors that are seen to be hindering successful e-health utilisation in Saudi Arabia. In this chapter, these factors are investigated. These factors were elicited using a questionnaire designed to survey different stakeholders of e-health, namely citizens, healthcare professionals and IT specialists. The questionnaire is then analysed, constituting a quantitative study revealing the number of current barriers associated with different e-health initiatives.

5.2 Investigation of E-health Barriers in Saudi Arabia

The first task is to investigate the barriers associated with e-health and Electronic Health Records (EHR) in Saudi Arabia among the potential users of our proposed framework. EHRs are identified as a key e-health technology that is increasingly utilised in different hospitals, globally and in the kingdom of Saudi Arabia (Aldosari, 2014; Hasanain and Cooper, 2014; Alsanea, 2012). In the literature review, we have indicated eight barriers that are related to four components: business, human, technological and financial factors. Our questionnaire surveys and ranks the issues and attitudes of the three stakeholders (i.e. Saudi citizens, healthcare professionals and IT specialists) with respect to four stated components; the findings published by Almuayqil et al. (2016) are further described in the following sections.

5.2.1. Questionnaire design

A questionnaire was utilised to fulfil the three research objectives. The perceived participants included citizens who may use healthcare services, healthcare professionals who work in the healthcare sector, and specialists in IT who support healthcare organisations. The questionnaire investigates two barriers related to the business components, failure of adoption of HISs and medication safety, and another two barriers related to the human components, human barriers and cultural barriers. The third component, technology, is associated with three barriers to be investigated which are technical expertise and computer skills, non-connectivity of ISs and security and privacy. The fourth component, financial, has the financial barrier as the only barrier to be investigated in this category.

The questionnaire was carried out from 21 January to 20 April 2015. It was sent to 288 individuals, ensuring that the sample is higher than the size recommended by Gorsuch (1983) and Kline (1979) as cited in (MacCallum et al., 1999). Snowball sampling was adopted to reach participants (Saunders et al., 2009); whereby initial participants, who are citizens, healthcare professionals and IT specialists, were reached through personal contacts and social media such as Twitter.com, WhatsApp Messenger Application and email services. These communication media were chosen for this study to disseminate the questionnaire due to their high prevalence among people in Saudi Arabia. For instance, Twitter is used by 41% of the online population in Saudi Arabia, which is higher than any other country (Smith, 2013).

Each group of participants was asked to complete two sections of the questionnaire. The first section consists of five questions to gather demographical information about each participant. The second stage includes two types of multiple choice questions, where each participant is asked to read statements related to barriers to e-healthcare. Participants were given the opportunity to add their own comments. The first type of multiple choice questions have the options ‘yes’, ‘no’ and ‘I don’t know’, whereas the other type of options have the options of ‘strongly agree’, ‘moderately agree’, ‘neutral’, ‘moderately disagree’, ‘strongly disagree’ and ‘I don’t know’ (see Appendix A.5), the option of ‘I don’t know’ is provided to avoid forcing respondents to answer (Wang, 1997). Options for all questions were coded. However, some were presented as positive statements and others negative. Consequently, reverse recoding is used with some scales to ensure consistency in coding (Sims, 2000). The questionnaire was presented in two languages, Arabic and English, for participants’ convenience and to ensure understanding of each item (see Appendix A.6).

Table 5.1. E-health barriers

Barriers components	Areas of study	Sub-factors	Citizens	Healthcare professionals	IT specialists
Business	Failure of adoption of HIS	Planning, technical support and running over time and cost		√	√
	Medication safety	Limited use of technology and communication gap		√	√
Human	Human barriers	Negative beliefs, lack of trust and resistance to change	√	√	
	Cultural barriers	Human interaction	√	√	
Technological	Non-connectivity of ISs	Lack of national healthcare system	√	√	√
	Technical expertise and computer skills	Interface design, guidelines, experience in computing applications, access and maintenance	√	√	√
	Security and privacy	Easy access to patients' medical records	√	√	√
Financial	Financial barriers	Financial barrier	√	√	√

The areas of study are summarised in Table *5.1* above. Cronbach's alpha was calculated to measure internal consistency between every set of items (Tavakol and Dennick, 2011). Nkhoma et al. (2013) suggested that Cronbach's alpha value of greater than 0.7 is optimum whereas the value over 0.5 is acceptable. For our study, Cronbach's Alpha values varied from 0.624 to 0.980, which shows good consistency among items. The overall eight investigated factors of the questionnaire are described below:

- **Failure of adoption of health information services (HIS)** covers planning, technical support and running over time and cost. Healthcare professionals were asked to answer 17 items related to the first two sub-factors (i.e. planning and technical support); whereas IT specialists were asked to answer 21 items belonging to the all three sub-factors (i.e. planning, technical support and running over time and cost). Scales used for the items in this instrument were strongly agree, moderately agree, neutral, moderately disagree, strongly disagree, and I don't know.
- **Medication safety** addresses two sub-factors: limited use of technology and the communication gap. Healthcare professionals were provided with seven items while IT

specialists were provided with nine. The scale used for all the items was strongly agree, moderately agree, neutral, moderately disagree, strongly disagree, and I don't know.

- **Human barriers** focuses on negative beliefs, lack of trust and resistance to change. Sixteen items related to negative beliefs, lack of trust and resistance to change were provided to citizens, while healthcare professionals were provided with 22 items, namely, negative beliefs, lack of trust and resistance to change. All items had the scale with the options strongly agree, moderately agree, neutral, moderately disagree, strongly disagree, and I don't know.
- **Cultural barriers** investigates human interaction. Citizens and healthcare professionals were asked to fill up three items related to the human interaction sub-barrier. All items used one scale, which is the strongly agree, moderately agree, neutral, moderately disagree, strongly disagree, and I don't know scale.
- **Non-connectivity of information systems** investigates whether the lack of a national healthcare system is an important factor to investigate. Citizens are provided with three items with the scale yes, no and I'm not sure, whereas healthcare professionals are provided with an additional two factors and IT specialists with 18 items to examine their opinion regarding this factor. Healthcare professionals and IT specialists use two scales for answering the questions: 1) yes, no and I'm not sure and; 2) strongly agree, moderately agree, neutral, moderately disagree, strongly disagree, and I don't know.
- **Technical expertise and computer skills** focuses on interface design, guidelines, experience in computer applications, access and maintenance. Citizens and healthcare professionals are asked to answer 17 items whereas IT specialists are asked to answer 14 items. All participants use the scale strongly agree, moderately agree, neutral, moderately disagree, strongly disagree, and I don't know for all the items.
- **Security and privacy** investigate how easy it is to access patients' medical records. The three groups of respondents participated in this instrument which contained ten items. All items used the scale strongly agree, moderately agree, neutral, moderately disagree, strongly disagree, and I don't know.
- **Financial barriers:** Two items were presented for the three groups of respondents: citizens, healthcare professionals and IT specialists. This instrument is constituted by one sub-factor, the cost of adopting IT in healthcare. The scale strongly agree,

moderately agree, neutral, moderately disagree, strongly disagree, and I don't know was used for all items in this instrument.

5.2.2. Ethical considerations

We gained ethical approval prior to generating our questionnaire. A fast-track ethical form was approved by the university ethics committee (see Appendix A.3). The participants included adult citizens, healthcare professionals and IT specialists in Saudi Arabia; the questionnaire was anonymous and participants were allowed to withdraw their participation at any stage. Our study did not seek any participation from children, people with communication or learning difficulties, patients, people in custody, people who can be considered vulnerable or people engaged in illegal activities.

5.2.3. Pilot study

Before disseminating the questionnaire to the 288 participants, a pilot study based on participants from Saudi Arabia was conducted in order to ensure the formalisation of the questions and to identify any ambiguous or unclear questions or issues. Some modifications were carried out related to the phrasing of questions, grammar and spelling mistakes.

5.3 Data Analysis

For the purpose of ranking e-health barriers from different perspectives, we compared the mean scores for each factor and sub-factor within each group of respondents. The highest possible score for the mean was 5.00 and the lowest was 0.00 where the higher the mean score is, the more the barrier constitutes an obstacle. Based on the paper by Haener and Adamowicz (1998) the responses of 'I don't know were eliminated from the analysis (Haener and Adamowicz, 1998). Simple proportional transformation was used to enable comparison between the two types of scales we utilised in this study, as advocated by Colman et al. (1997) and Sambandam (2006).

5.3.1. Respondents' profile

Out of 288 targeted participants, 201 completed the questionnaire. The response rate of 69.7% was higher than the reasonable response rate documented by Saunders et al. (2009). Out of 201 respondents, the questionnaire was completed by 117 citizens (58.2%), 43 healthcare professionals (21.4%) and 41 IT specialists (20.4%) (see Table 5.2). There is a great variation in the age of participants as shown in Table 5.2; it differs significantly as 98 participants (48.8%) belong to the age category 31 to 40, and 64 (31.8%) participants belong to the ages between 18 and 30, 15.4% belonging to the ages between 41 and 50, 3.5% belong to ages 51 to 60 and 0.5% of participants are over 60 years old. The levels of education also differ significantly among the participants, as bachelor degree holders constituted most respondents (54.7%), followed by masters degree holders (32.3%) and doctoral degree holders (8.0%) and high school diplomas (5%). In terms of computer skills, 63.2% of participants have a good level, 29.4% have a high level and 7.6% have low level skills (see Figure *5.1*).

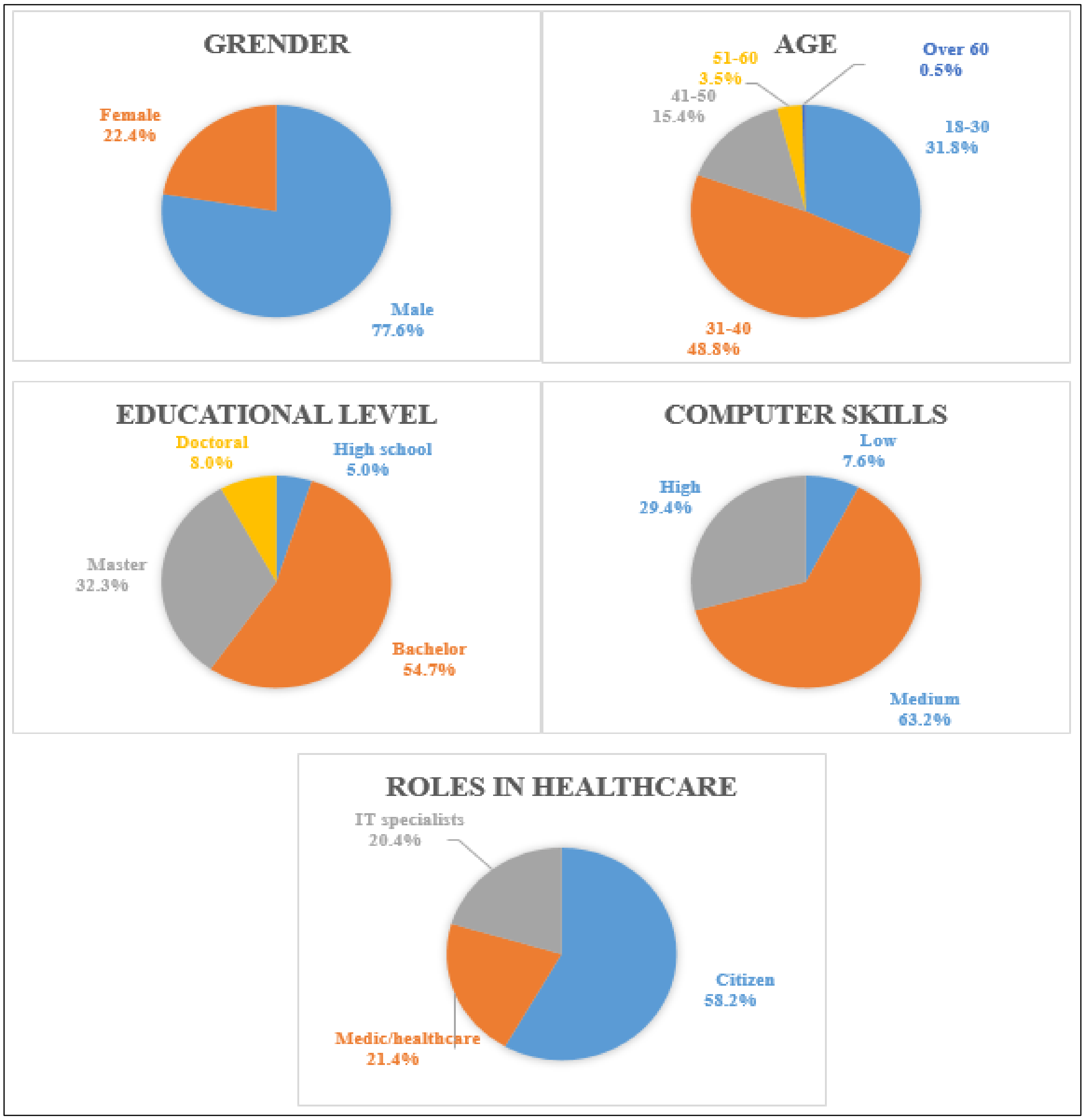

Figure 5.1. Profile of respondents to the questionnaire

Table 5.2 Profile of respondents to the questionnaire

Items	N	%	Total
Please specify your gender			
Male	156	77.6	201
Female	45	22.4	
Please specify your age			
18-30	64	31.8	
31-40	98	48.8	
41-50	31	15.4	201
51-60	7	3.5	
Over 60	1	0.5	
Please specify your educational level			
High school	10	5.0	
Bachelor	110	54.7	201
Master	65	32.3	
Doctoral	16	8.0	
Please specify your computer skills			
Low	15	7.6	
Medium	127	63.2	201
High	59	29.4	
Please specify your role in the healthcare sector			
Citizen	117	58.2	
Medic/healthcare	43	21.4	201
IT specialists	41	20.4	

5.3.2. Results of business component

The business component focused on two groups of stakeholders: health professionals and IT specialists. The questionnaire associated with this component elicited two main issues: failure of health information services and medication safety.

5.3.2.1. Failure of adoption of health information services (HIS)

Healthcare professionals indicated issues associated with technical support. Most healthcare professionals complained about the lack of availability of technical support (n=9, 52.9%), slow responses of EHRs (n=11, 64.7%) and inability to view their patients' progress (n=11, 64.7%).

The majority of IT specialists complained that EHRs were adopted without patients' engagement (n=14, 34.1%), and indicated that the time needed for adoption of EHRs was not clearly identified (n= 11, 26.8%). Technical support and running over time and cost were positively highlighted as critical issues in considering the adoption of e-healthcare.

Healthcare professionals reported a higher mean regarding the failure of adoption HIS (mean= 2.8) than IT specialists (mean= 2.7). Other issues identified by the healthcare professionals were lack of technical support (mean= 3.4) and planning (mean= 2.7). IT specialists' mean scores for the sub-factors were running over time/cost (mean= 2.8), lack of technical support (mean= 2.7) and lack of planning (mean= 2.2).

5.3.2.2. Medication safety

Both the healthcare professionals and IT specialist stakeholders have not identified any issues in relation to medication safety. The mean for the IT specialists is slightly higher (mean= 3.7) than the healthcare professionals (mean= 2.5). Regarding the limited use of the technology sub-factor, IT specialists scoring is higher (mean= 4.2) than the sub-factor related to the communication gap (mean= 3.4). Healthcare professionals reported lower mean scores for limited use of technology (mean= 2.7) and the communication gap (mean= 2.5).

5.3.3. Results of human component

The findings of this questionnaire are based on the responses of the two major stakeholders: citizens and healthcare professionals. The questionnaire associated with the human component elicits two main factors: human barriers and cultural barriers.

5.3.3.1. Human barriers

Regarding the human barriers, citizens have indicated critical issues throughout this component. In the negative beliefs sub-factor, almost half of the citizens believe that EHRs can involve technical problems (n= 56, 47.9%), legal problems (n= 58, 49.6%) and administrative problems (n= 50, 42.7%). Furthermore, the majority of citizens believe that EHRs are beneficial for healthcare professionals but not for themselves (n= 54, 45.8%). They also believe that implementation of EHRs can decrease productivity of healthcare professionals (n= 45, 46.2%). The results from the lack of trust sub-factor were similar: the majority of citizens think their EHRs may be out of date (n= 66, 56.4%), using EHRs can be complicated (n= 55, 47.0%), EHRs can give incorrect information regarding their medication (n= 59, 50.4%), medication dates (n= 55, 47.0%) and laboratory test results (n= 53, 45.3%). They also think that EHRs can allow unauthorised people to access their information (n= 66, 56.4%). In relation to the resistance to change, most citizens believe that changing to e-health requires a long period before being accepted (n= 70, 59.8%) and such a change must include training of patients in how to use e-health solutions (n= 89, 76.1%). Citizens also believe that implementation of HIS will reduce job opportunities (n= 64, 54.7%) and using EHRs will affect their relationship with their doctors (n= 55, 47.0%).

Healthcare professionals indicated that there are issues with respect to the lack of trust sub-factor, as most of them believe that their patients' records can be out of date (n= 21, 48.8%). Furthermore, they believe that moving to e-health can requires a period of adjustment (n= 26, 60.5%), will reduce job opportunities (n= 16, 37.2%) and need special training in how to use e-health solutions (n= 36, 83.7%).

Citizens scored the highest mean score in relation to this human factor (mean= 3.9). Resistance to change reported a mean score (mean= 4.0) higher than other sub-factors, such as lack of trust (mean= 3.7) and negative beliefs (mean= 3.6). Healthcare professionals, on the other hand, had lower mean scores for human barriers than citizens (mean= 2.6) with the sub-factors ranking resistance to change (mean= 2.8), lack of trust (mean= 2.7) and negative beliefs (mean= 2.4).

5.3.3.2. Cultural barriers

Most of the citizens indicated their preference for human interaction in relation to healthcare services. Citizens prefer to meet with their doctors to get information about their medications (n= 76, 65.0%). In addition, they prefer paper-based records as their medical records (n= 43, 36.8%) and believe that EHRs can be less detailed than the traditional records (n= 54, 46.2%).

Similarly, most healthcare professionals prefer meeting with their patients so as to provide them with the appropriate medical information (n= 30, 69.8%). No other cultural barriers were identified from the healthcare professionals' perspectives.

Both citizens and healthcare professionals shared the same mean score for the preference of human interaction sub-factor (mean= 3.1).

5.3.4. Results of technological component

The technology component focused on the stakeholders' views: citizens, healthcare professionals and IT specialists. The questionnaire associated with this component elicited three main issues: connectivity of information systems, technical expertise and computer skills, and security and privacy.

5.3.4.1. Connectivity of information systems

More than half of the citizens do not currently use EHRs (n= 60, 51.3%). The majority of citizens are not sure if they can access and use their EHRs in more than one hospital in Saudi Arabia (n= 29, 50.9%). The healthcare professionals share similar concerns as most of them do not have access to EHRs (n= 22, 51.2%). Healthcare professionals who use EHRs can access them in more than one hospital (n= 11, 64.7%). However, they indicated their inability to view patients' EHRs, update laboratory test results for patients who are visiting from other hospitals and disseminate patients' records electronically to other hospitals in the country.

More than half of IT specialists claimed that EHRs are used in more than one hospital in Saudi Arabia (n= 23, 56.1%). In addition, 23 IT specialists expressed serious concerns regarding not only the inability to share patients' information electronically, to access patients' records in other hospitals electronically, to electronically update exchanged patients' EHRs, but also the lack of integration among EHRs and of structure standards. However, they perceived some benefits, such as the utilisation of vocabulary standards, the ability of other EHR systems to understand and process exchanged information and the support of EHRs for national healthcare strategies.

However, IT specialists also indicated that the IT infrastructure in the healthcare sector in the kingdom is not ready to have a national EHR system (n= 20, 49.0%). The majority of IT specialists complained about out-of-date computer networks (n= 8, 40.0%), insufficient storage capacity (n= 10, 50.0%), old servers (n= 8, 40.0%), old routers (n= 7, 35.0%) and lack of development of the national healthcare system (n= 17, 85.0%).

The mean score for this factor varies among citizens, healthcare professionals and IT specialists. Citizens scores the highest mean in this aspect (mean= 4.0) whereas the IT specialists had the lowest score (mean= 3.1). The score for the healthcare professionals were in the middle (mean= 3.5).

5.3.4.2. Technical expertise and computer skills

Citizens indicated difficulties in using EHRs (n= 44, 77.2%); some of these are related to difficult terminologies (n= 46, 80.7%), inaccurate information (n= 40, 70.2%) and others to an inability to modify personal information (n= 45, 78.9%). Most of the respondents from the citizens complained about the absence of guidelines (n= 44, 77.2%) and training (n= 53, 93.0%) for using their EHRs. Inadequacy of internet speed was also indicated (n= 61, 52.1) as well as deficiency in maintenance of computers (n= 62, 53.0%) and internet connections (n= 74, 63.2%). These factors are related to the lack of experience in using computer applications as the majority of citizens use computers at work and are able to browse the internet, check their emails, accomplish tasks at work and download applications skilfully. Similarly, most citizens have access to a computer to check their emails and browse the internet.

Similar to citizens, healthcare professionals stressed the difficulty of EHRs (n= 7, 41.2%) and inaccuracy of their information (n= 9, 52.9%). Not surprisingly, most healthcare professionals disagreed that EHRs use difficult terminologies (n= 10, 58.8%) as most of the healthcare professional respondents have been trained in how to use EHRs (n= 12, 70.6%) and the majority of them were provided with guidelines on how to use EHRs (n= 7, 46.7%). Even though no major issues were raised by healthcare professionals in relation to computers' speed, internet connection speed and computers' maintenance, the majority complained about deficiencies in maintaining an internet connection (n= 20, 46.5%). Similarly, no issues were expressed related to their computing experience and insufficient access to computers.

IT specialists did not indicate any issues in relation to their technical expertise and computer skills. However, two-third of them indicated that working with EHRs requires skills in IT and computer applications (n=30, 75%).

Citizens scored a higher mean than other groups of participants in relation to technical expertise and computer skills (mean= 3.2). The lack of guidelines sub-factor constituted the overall mean of this factor (mean= 4.7) and then the poor interface design sub-factor (mean= 4.5). Other sub-factors were poor maintenance (mean= 3.34), insufficient access (mean= 2.7) and lack of experience in computer applications (mean= 2.1).
IT specialists scored the second highest mean (mean= 2.6) with the lack of experience in computer application as the highest sub-factor (mean= 3.9). The remaining sub-factors were poor maintenance (mean= 2.4), insufficient access and no guidelines (mean= 2.4) and the lowest constituent of this barrier was poor interface design (mean= 2.2). Healthcare professionals had the lowest mean score in the technical expertise and computer skills factor (mean= 2.2). Poor interface design was a major obstacle (mean= 2.9). Other sub-factors were poor maintenance (mean= 2.8), lack of guidelines (mean= 2.7), insufficient access (mean= 1.9) and the lowest hurdle was the lack of experience in computer applications (mean= 1.5).

5.3.4.3. Security and privacy

Citizens reported a number of issues associated with security and privacy. More than half of the citizens complained that their EHRs are accessed without their permission (n= 11, 64.7%). The same citizens complained that their EHRs are disseminated without their permission (n= 11, 55.0%). Almost two-thirds of citizens indicated that their electronic records are updated without their permission (n= 15, 71.4%). Most citizens indicated that they are not able to control access of others to their EHRs (n= 23, 85.2%). They also complained about their inability to determine who should see their EHRs (n= 29, 90.6%). In addition, they are not informed of people who accessed their records (n= 24, 88.9%). Almost all citizens complained about their inability to access their EHRs from other countries (n=24, 92.3%).

The majority of healthcare professionals expressed concerns regarding security and privacy issues in relation to the ease of accessing records of the patients. Most healthcare professionals identified the issue of accessing their patients' EHRs without their permission (n= 9, 52.9%). More than one-third complained that their patients' EHRs were disseminated and updated without their permission (n= 7, 41.2%). Almost half of the healthcare professionals indicated that they are not able to control the access of others to their patients' EHRs (n= 8, 47.1%) and the same number of respondents had access to other patients' EHRs they are not authorised to see. More than half of healthcare professionals are not able to determine who should see their patients' EHRs (n= 9, 52.9%). The majority of healthcare professionals also complained that they are not informed of people who had access to their patients' EHRs (n= 11, 64.7%). A high number of healthcare professionals also expressed that they had the ability to control other patients' health records (n= 6, 37.5%). IT specialists, however, did not report any issues in relation to security and privacy factors.

The mean score from the citizens were higher than the other two groups of respondents (mean= 3.5). Healthcare professionals reported the second highest mean in this factor (mean= 3.2), whereas the lowest mean score resulted from the IT specialists (mean= 2.2).

5.3.5. Results of financial component

The financial component focused on the citizens, healthcare professionals and IT specialist stakeholders. The questionnaire associated with this component consisted of questions eliciting one main issue: financial barriers.

Over half of citizens stated that the expenditure spent on IT in healthcare should be spent to build other hospitals (n= 51, 53.1%) and to provide employment opportunities (n= 60, 60.6%). More than half of the IT specialists think that adoption of e-health needs high expenditure (n=25, 61.0%). Consequently, most respondents expressed funding difficulties for the adoption of EHRs (n= 18, 43.9%). Healthcare professionals, on the other hand, did not raise any issues in relation to financial barriers.

Citizens reported their concerns with this issue more than the other two groups of respondents (mean= 3.7). The mean score from IT specialists were lower than citizens' (mean= 3.5). Healthcare professionals highlighted this issue least frequently compared to other participants as the mean score they reported were the lowest (mean= 2.7).

5.4 Discussion

This section analyses the findings of our study with respect to those described in the literature review.

5.4.1. Citizens' views

The findings from our study confirmed the existence of the six barriers which were identified in the literature. Our findings from the factor related to the connectivity of information systems showed that this barrier is the first reason that hinders successful implementation of e-health in Saudi Arabia. The citizens' point of view is consistent with Altuwaijri (2008) in terms of no communication among information systems in the Saudi Arabian healthcare sector. The second most important barrier for e-health identified from citizens' data is the human barriers factor. Sub-factors, such as negative beliefs, lack of trust, and resistance to change, were also identified in the literature as the main causes of failure for adoption of HIS (Altuwaijri, 2011). Citizens ranked the financial barriers in the third place. The fourth barrier, related to security and privacy, is an important concern for the citizens, though most citizens responded neutrally. Technical expertise and computer skill were also identified as a critical barrier to e-health in the kingdom. The findings from the citizens indicated consistency with the literature in terms of lack of providence of guidelines for handling EHRs, low internet speeds, deficient maintenance of computers and internet connections (Khalifa, 2013). Cultural barriers have the lowest impact factor which can hinder e-health in Saudi Arabia.

Citizens' results were similar to Aldraehim and Edwards (2013) findings where the need for human interaction is preferable by Saudi Arabian people. Figure 5.2 summarises the ranking of the e-health barriers from citizens' point of view.

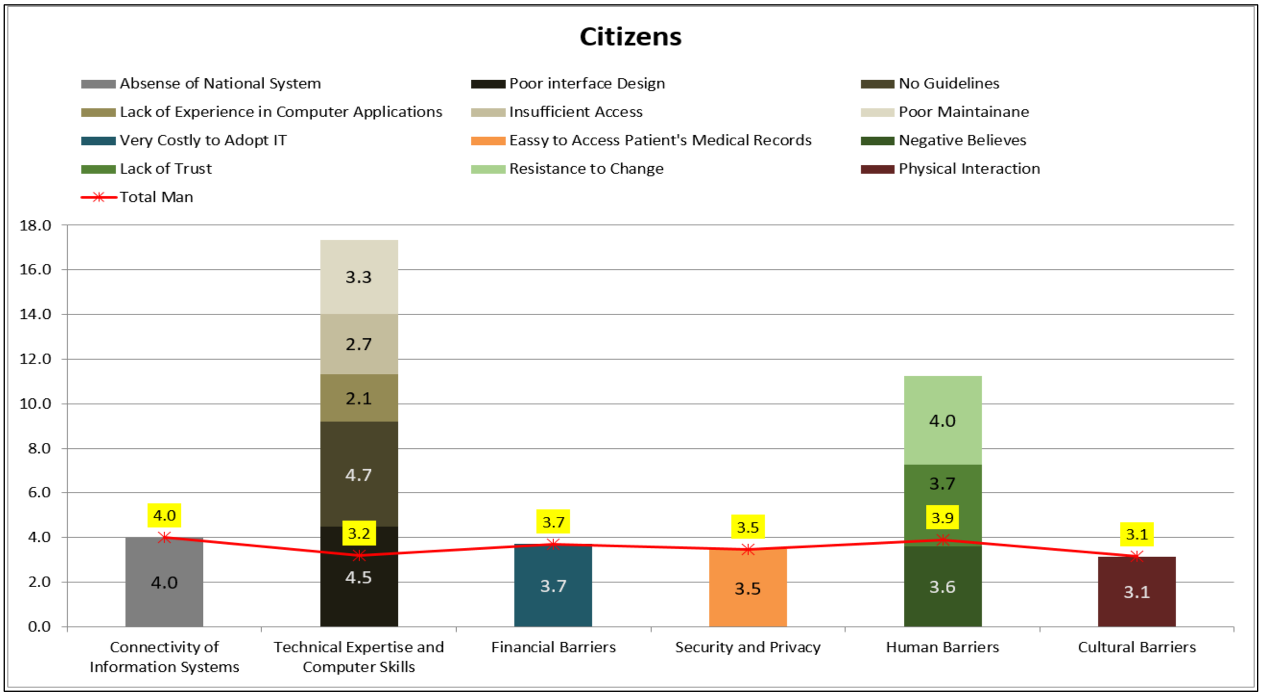

Figure 5.2. Ranking of e-health barriers in Saudi Arabia from citizens' perspective

5.4.2. Healthcare professionals' views

Even though the ranking of e-health barriers from the healthcare professionals' perspective starts with the connectivity of information systems, their responses show inconsistency with the literature as most of them who use EHRs are able to use these records in more than one hospital in Saudi Arabia (Altuwaijri, 2008). Based on our findings, this is due to the fact that most healthcare professionals do not use EHRs for their patients and, therefore, were not able to answer questions related to EHR connectivity in the kingdom. In addition, many healthcare professionals expressed their inability to perform viewing, updating and disseminating of EHRs and laboratory test results of patients who are visiting from other hospitals.

Cultural barriers were ranked second by the majority of healthcare professionals, confirming that human interaction is most preferred by Saudi people (Aldraehim and Edwards, 2013). The findings in our study are consistent with the literature, as many healthcare professionals prefer meeting their patients face-to-face to provide them with tailored medical information.

The third ranked e-health barrier from the healthcare professionals' point of view was security and privacy. Our findings are consistent with Khalifa (2013) who documented the dissemination of patients’ medical records without permission from the patient or his/her doctor. Their second greatest concern was the ability of unauthorised people to access their patients’ records, and the inability to be informed of such access.

Healthcare professionals ranked failure of adoption of HIS as the fourth e-health barrier in Saudi Arabia, as they complained about their inability to view their patients’ progress. They also indicated slow responses of EHRs and lack of availability of technical support, which is similar to the poor technical support reported by Altuwaijri (2011) and Khalifa (2013).

Although our findings did not identify critical financial issues among healthcare professionals, the ranking of this factor is held in fifth place. Our findings show that lack of trust of EHRs and resistance to change to e-health from traditional health approaches are dominant concerns. These issues are also raised by Altuwaijri (2011), who considered them as the biggest indication of failing to adopt HISs.

The two barriers of medication safety and technical expertise and computer skills are the lowest ranked e-health barriers by healthcare professionals. Our findings do not show issues related to the medication safety factor. However, the technical expertise and computer skills factor was raised by many healthcare professionals, especially regarding the deficient internet maintenance, difficulty of using EHRs and inaccuracy of its information. These issues were documented by Khalifa (2013) along with other factors related to technical expertise and computer skills. Figure 5.3 summarises the ranking of the barriers from the perspective of healthcare professionals.

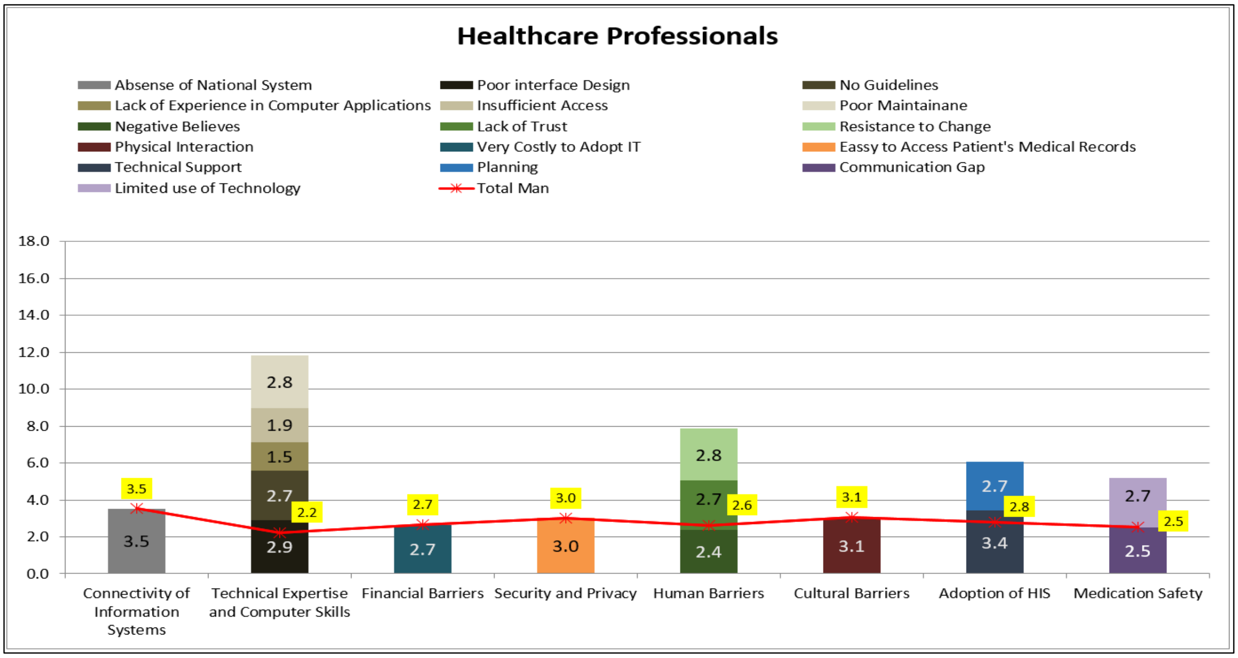

Figure 5.3. Ranking of E-health barriers in Saudi Arabia from the healthcare professionals' perspective

5.4.3. IT specialists' views

The findings from IT specialists indicated that medication safety has the highest ranked mean score among other barriers. The second ranked barrier relates to the financial barriers. As Amatayakul (2010) described, IT specialists stressed the importance of investment involved in providing e-health services.

IT specialists ranked connectivity of information systems as the third barrier that hinders e-health adoption in Saudi. As Altuwaijri (2008) has explained in his paper, our findings confirmed the issues raised in relation to the inability to access, update, share and integrate EHRs of patients. IT specialists stressed that technical expertise and computer skills are required to work with EHRs. They ranked this factor as the fourth barrier in their scale. Furthermore, most IT specialists support the adoption of the HIS factor, if the partnership issue with patients is addressed. This finding is also identified as one important reason for failing to adopt HISs (Altuwaijri, 2011 and Khalifa, 2013).

Security and privacy are ranked sixth, impeding the adoption of e-health in Saudi. The literature has identified many factors that can affect the privacy of patients' information, such as ease of access to such information without permission (Khalifa, 2013). On the contrary, respondents from the IT specialists group stressed the use of various security and privacy mechanisms to ensure confidentiality of patients' information. IT specialists' ranking of e-health barriers is shown in Figure 5.4.

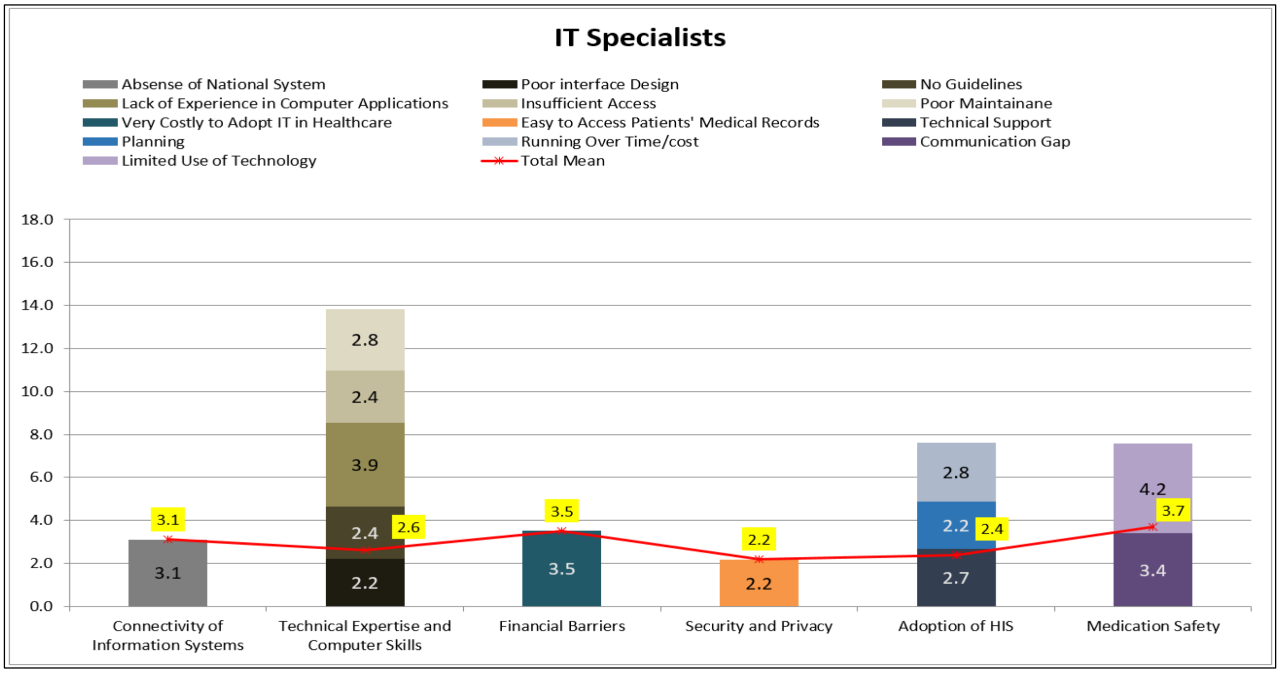

Figure 5.4. Ranking of e-health barriers in Saudi Arabia from IT specialists' perspective

Besides the ranking of e-health barriers, the analyses from the questionnaire show various e-health barriers in Saudi Arabia. Each group of respondents identified a number of factors that hinder successful utilisation and implementation of e-health (see Figure 5.5). According to the citizens, the questionnaire identified eight sub-barriers, such as negative beliefs, lack of trust, resistance to change, preference of physical interaction, absence of a national healthcare system, poor interface design, no guidelines and poor maintenance. Healthcare professionals indicated eight sub-barriers. Most respondents from this group of participants indicated the sub-barriers as deficient technical support, lack of trust, resistance to change, preference of physical interaction, absence of a national healthcare system, poor interface design, poor maintenance, and easy in accessing patients' medical records. IT specialists complained about the three sub-barriers of planning, IT infrastructure in Saudi Arabia, which contributes to the absence of a national healthcare system sub-barrier, and the very costly to adopt IT in health, which was identified by the concerns of high cost for adoption HISs and funding difficulties.

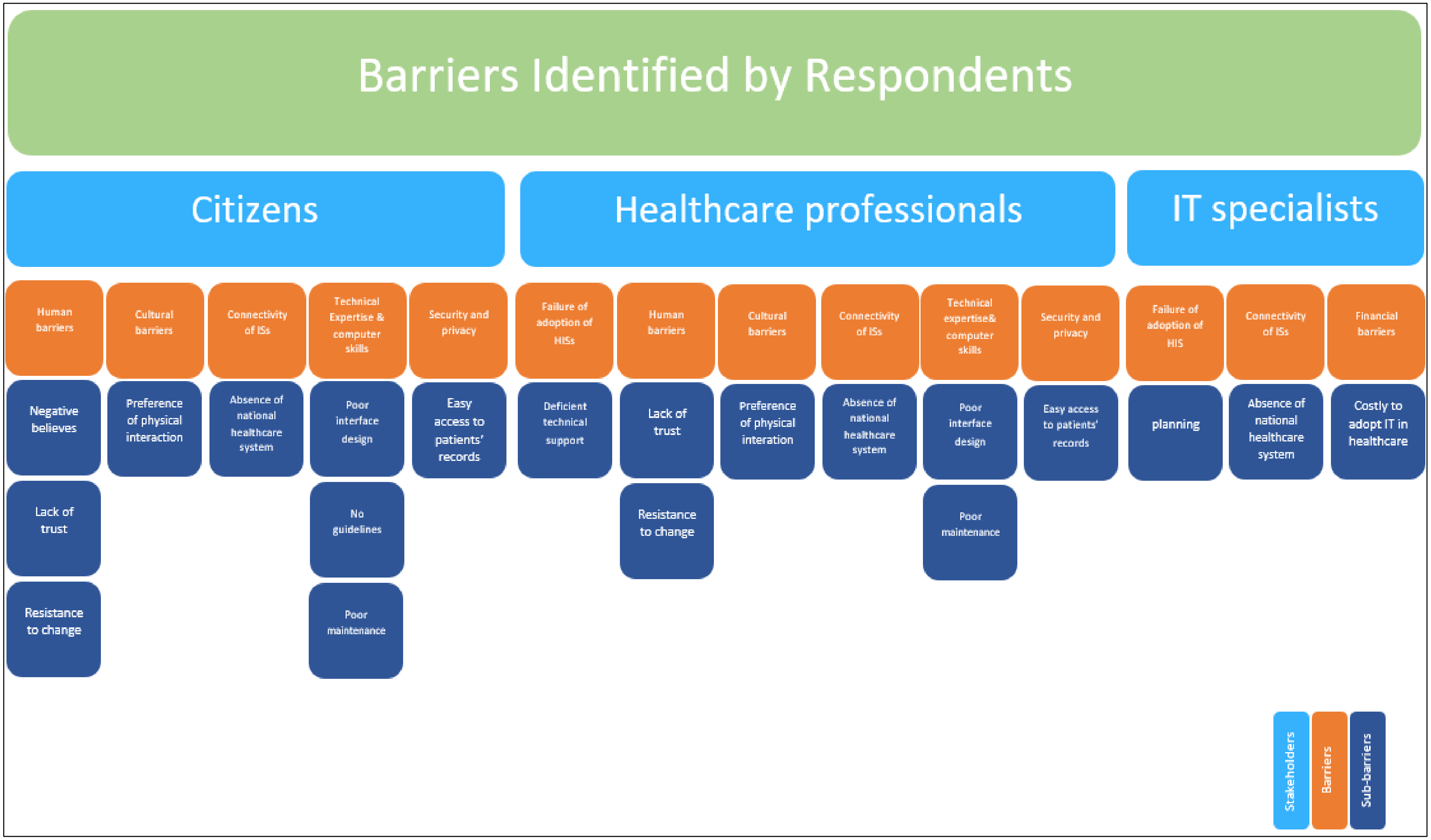

Figure 5.5. E-health barriers encountered by citizens, healthcare professionals and IT specialists in Saudi Arabia

5.5 Conclusion

E-health solutions provide promising tools and techniques that can enhance the healthcare services in Saudi Arabia. The current research proposes to develop a framework to integrate KM and KD to support the provision of e-health services to citizens in the kingdom. However, it was important to investigate first the current e-health barriers met not only by citizens but also healthcare professionals and IT specialists. These barriers will strengthen the proposed integrated framework.

Ranking e-health barriers in Saudi Arabia from the perspectives of Saudi Arabian citizens, healthcare professionals and IT specialists will enable the provision of e-health solutions for each stakeholder. Eight factors identified from the literature were perceived to be hindering e-health utilisation in Saudi Arabia. In this research, we investigated the eight barriers and ranked them from the point of view of each group of respondents. The analysis of the questionnaires shows that citizens and healthcare professionals perceive the lack of connectivity of HISs in Saudi Arabia to be the main reason for the failure of e-health, whereas IT specialists believe that the lack of medication safety is the biggest obstacle factor leading to such a failure. The results will assist us in developing a knowledge management system to assist healthcare and IT professionals to provide the best support to diabetic citizens in Saudi Arabia by considering these barriers. Beside the aim of the proposed framework to overcome such complications, the framework can be effectively utilised to overcome the e-health barriers identified in the current chapter to satisfy the needs of e-health users in the kingdom. Additionally, the findings of this study can contribute to successful utilisation of different e-health initiatives in the kingdom by increasing the awareness to these issues.

This research has focused on the diabetes mellitus domain application to illustrate the ability of our proposed framework, taking into consideration the identified barriers associated with e-health provision. Chapter Six seeks to investigate the specific issues faced by citizens suffering from diabetes mellitus in order to provide them with an effective e-health support.

Chapter Six: Data Mining Pilot Study for Diabetic Citizens in Saudi Arabia

6.1 Introduction

This chapter presents the DM pilot study. The aim of DM is to discover knowledge which is hidden in databases, surveys and spreadsheets. The hidden knowledge, which is tacit, can provide useful insights to decision- and policy-makers. Its elicitation can contribute significantly to the externalisation, and strengthen the internalisation, socialisation and combination knowledge dimensions, of the SECI model.

To illustrate this integration of DM and KM, we focus in this study on a specific area of healthcare related to diabetes mellitus, as this illness is of great concern in Saudi Arabia, as discussed in Chapter Two. This chapter implements the CRISP-DM methodology adopted to collect and mine the data using the association rule algorithm described in Chapter Three.

As the proposed framework contains a KD layer to support Saudi Arabian diabetic citizens, the DM pilot study is performed to extract associations of non-health-related complications of diabetes mellitus and profile information of citizens of diabetes mellitus in Saudi Arabia. The SECI model, which constitutes the third layer in the proposed framework, is also deployed in the final step of this pilot study. This integration of the DM and SECI models forms a useful tool for delivering self-management and education solutions to empower diabetic citizens in Saudi Arabia to successfully control their disease.

6.2 Data Mining Pilot Study

The focus of the DM pilot study is to investigate the issues and difficulties of diabetic citizens in Saudi Arabia, in order to discover tacit knowledge about the citizens' profiles, which could help healthcare professionals, as well as citizens, provide effective e-health support. Typical areas of study include medication, diet, physical activities, diabetes lifestyle and management of diabetes during the holy month of Ramadan in particular. These areas are elicited using a questionnaire discussed in Section 6.2.2. The CRISP-DM methodology adopted in this study is described in the following sections and summarised in Figure *6.1*.

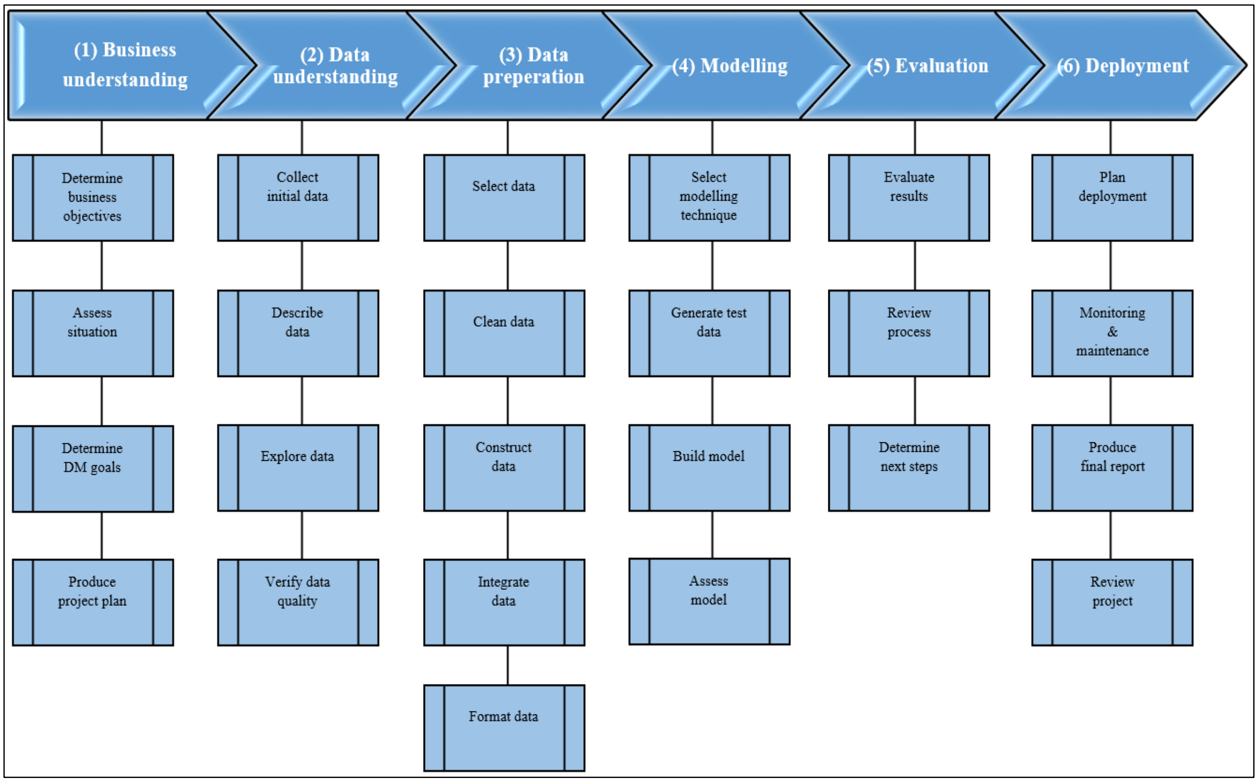

Figure 6.1. CRISP- DM steps
Source: (Chapman et al., 2000)

6.2.1. Business understanding

Saudi Arabia has a high number of diabetic citizens who live in different parts of the country. Many of them have encountered different complications that are related to their lifestyles and diabetes education. In order to overcome the non-health-related complications of diabetic citizens in Saudi Arabia, diabetes self-management and education initiatives are proposed to assist individuals to increase their awareness of the disease and empower them to cope with their health conditions. The objective of the current DM study is to detect interesting associations among citizens' profile information and the non-health-related complications they encounter. The resultant association rules can then help overcome, through diabetes self-management and education recommendations, guidelines, best practices and strategies with respect to diabetics' characteristics and diabetes types. The study can benefit different diabetic citizens and healthcare professionals in the kingdom by reducing their medication usage and visits to healthcare organisations. This part of the study attempts to investigate whether diabetes non-health-related complications of diabetic citizens in Saudi Arabia are related to their profile characteristics.

The focus in the current analyses is to find frequent item-sets that contain profile information of individuals and any indicated complications. That is, only resultant associations of profile information of Saudi Arabian citizen with an encountered non-health-related complication, faced by the same individual, are considered valuable association rules, which need to be overcome through relevant diabetes self-management and education initiatives. The resultant frequent item-sets that do not indicate non-health-related complications encountered by citizens, are not considered as a desired association rule and are therefore filtered out. As association rules mining is utilised in this study, two measures, support and confidence, are considered to ensure the level of interest and accuracy of the results. Minimum support of 20% and minimum confidence of 90% in valuable association rules are set to be the success criteria of the item-sets resulting from the analyses. In addition, K-fold cross-validation is utilised to validate the associations.

This study requires a dataset of diabetic citizens in Saudi Arabia in order to be performed completely. The dataset should contain records of diabetic citizens in the kingdom with different attributes. The attributes required are the citizens' profile information, such as age, gender, place of birth, marital status, education level, employment status and the type of diabetes they have. Furthermore, other attributes are required to specify the non-health-related complications encountered by the citizens. Each attribute should list one complication related to diabetes education and the lifestyle of diabetic citizens, and an indication of whether or not these complications are encountered by each citizen.

Obtaining a dataset that contains all the required attributes constituted a major constraint in completion of this part of the study. Some researchers refrained from cooperating and did not share their datasets. Although some other open source data were available to utilise, they do not include attributes required for this analysis, such as the non-health-related complications of diabetes mellitus encountered by diabetic citizens in Saudi Arabia (see Figure *6.2*). Consequently, a survey was conducted in order to gather appropriate data for this study. The survey is described in the next step, Section 6.2.2, and contains questions related to participants' profile information, their diabetes types and all non-health-related complications they might have faced.

(Table 1 - 22) Health Centers Visits MOH , by Common Diseases and Age group, 1432H

Age group (years) 60 +	60 - 45	44 - 15	14 - 5	4 - 1	< 1 (فئة العمر (بالسنوات))	عدد الزيارات No. of visits	Disease
6135	17570	41405	34073	20011	6972	126166	Infectious and parasitic diseases
6045	18689	44103	49143	30333	3767	152080	Intestinal helminthiasis
463026	865486	515672	37576	8043	1962	1891765	Diabetes mellitus
19679	72742	139799	52177	20176	3377	307950	Diseases of blood and immunity

Table 16.3: Emergency cases at the MOH hospitals by type of disease/injury, nationality and gender, 2012

Disease or injury	Cases	Nationality		Gender	
		Saudi	Non-Saudi	Male	Female
Infectious & parasitic diseases	202,563	176,642	25,921	117,174	85,389
Diabetes Mellitus	736,843	661,733	75,110	403,596	333,247
Blood diseases	261,692	244,498	17,194	141,653	120,039
Nervous system	212,099	189,406	22,693	118,675	93,424

Table 16.3: Emergency cases at the MOH hospitals by type of disease/injury, nationality and gender, 2013

Disease or injury	Cases	Nationality		Gender	
		Saudi	Non-Saudi	Male	Female
Infectious & parasitic diseases	191479	162942	28537	114294	77185
Diabetes Mellitus	759982	681779	78203	418631	341351
Blood diseases	273897	249796	24101	149576	124321
Nervous system	218272	194719	23553	119626	98646

Figure 6.2. Examples of irrelevant open source datasets
Source: (Ministry of Health, 2011, 2012, 2013)

The DM pilot study undertook the stages advocated by CRISP-DM. The data understanding stage, which focuses on extracting relevant data and exploring it before the modelling stage, follows the business understanding step. The evaluation stage is performed in order to examine association rules and to ensure that the objectives of this study are met. Finally, a deployment plan is produced to ensure efficient application of the new knowledge.

6.2.2. Data understanding

A survey was carried out to gather relevant data from diabetes citizens in Saudi Arabia for mining. The survey contains 19 statements belonging to two different categories. The first category is related to the participants' profile information. This category has seven statements to gather information related to participants' age group, gender, region of birth, marital status, education level, employment status and diabetes type. In these statements, participants chose the best answer among multiple options. The second category has 11 statements related to 11 different non-health-related complications. The statements in this part of the survey are as follows:

1. Do you have difficulties identifying the diet appropriate to your health condition?
2. Do you have difficulties undertaking any physical activity?
3. Do you have difficulties identifying the right medication?
4. Do you have difficulties identifying the right dosage for your medication type?
5. Do you have difficulties remembering when to take your medication?
6. Do you have difficulties in how to measure your blood glucose?
7. Do you have difficulties in identifying the appropriate glucose level?
8. Do you have difficulties to coexist with the aspects of diabetes lifestyle?
9. In Ramadan, I have difficulties in identifying the right medication time.
10. In Ramadan, I have difficulties in identifying the right medication amount.
11. In Ramadan, I have difficulties in identifying the right diet for my health condition.

Participants read each statement and indicated whether they encounter the complication with a response of ‘Yes’ or ‘No’. One open-ended statement is presented to allow participants to add any additional relevant and associated complications.

Since the study aims to gather information related to diabetic citizens in Saudi Arabia, the survey was translated into the Arabic language and sent to participants through a well-known diabetes forum (www.dmeducation.com). The forum constitutes the largest online community of diabetic individuals in Saudi Arabia and has over 96,000 members. The survey asked only members who have diabetes mellitus to participate in the survey. In addition, the aim of the survey was described to participants and it was explained that their participation was optional and confidential and that they had the right to withdraw at any time. A proportional ethical form was signed and approved by the university research ethics committee member prior to the publication of the survey (see Appendix B.1).

The survey was undertaken in the period from 25 May to 25 July 2016. The number of participants who started the survey is 278. Only one participant did not complete the survey and therefore was removed from the analysis, as proposed by the list-wise exclusion technique (Peugh and Enders, 2004). Table *6.1* summarises participants’ profiles and Table *6.2* outlines their diabetes non-health-related complications.

Table 6.1. Profile information of participants

Items	N	%	Total
Age			
18-19	28	10.1	277
20-29	64	23.1	
30-39	63	22.7	
40-49	70	25.3	
50-59	39	14.1	
60-69	8	2.9	
Over 69	5	1.8	
Gender			
Male	175	63.2	277
Female	102	36.8	
Region of birth			
Central region	88	31.8	277
Northern region	63	22.7	
Southern region	38	13.7	
Eastern region	19	6.9	
Western region	50	18.1	
Outside Saudi Arabia	19	6.9	
Marital status			
Married	192	69.3	277
Single	85	30.7	
Education level			
High school or below	98	35.4	277
Bachelor degree	152	54.9	
Higher education	27	9.7	
Employment status			
Employed	159	57.4	277
Unemployed	118	42.6	
Retired	0	0	
Diabetes type			
Type 1	149	53.8	277
Type 2	125	45.1	
Gestational diabetes	3	1.1	

Table 6.2. Participants' non-health-related complications of diabetes mellitus

Items	N	%	Total
Do you have difficulties identifying the diet appropriate to your health condition?			
Yes	170	61.4	277
No	107	38.6	
Do you have difficulties undertaking any physical activity?			
Yes	154	55.6	277
No	123	44.4	
Do you have difficulties identifying the right medication?			
Yes	120	43.3	277
No	157	56.7	
Do you have difficulties identifying the right dosage for your medication type?			
Yes	132	47.7	277
No	145	52.3	
Do you have difficulties remembering when to take your medication?			
Yes	99	35.7	277
No	178	64.3	
Do you have difficulties in how to measure your blood glucose?			
Yes	31	11.2	277
No	246	88.8	
Do you have difficulties in identifying the appropriate glucose level?			
Yes	51	18.4	277
No	226	81.6	
Do you have difficulties to coexist with the aspects of diabetes lifestyle?			
Yes	155	56.0	277
No	122	44.0	
In Ramadan, I have difficulties in identifying the right medication time.			
Yes	143	51.6	277
No	134	48.4	
In Ramadan, I have difficulties in identifying the right medication amount.			
Yes	165	59.6	277
No	112	40.4	
In Ramadan, I have difficulties in identifying the right diet for my health condition.			
Yes	191	69.0	277
No	86	31.0	

Initial exploration of the responses indicates that attributes are filled completely, except for the open-ended statement where no comments were provided by participants. The profile information table shows that participants are predominately male (63.2%) (See Figure *6.3*). To prevent bias in the results, the dataset was separated into two datasets; females' and males' responses are referred to as D_{Female} and D_{Male} in this thesis. Therefore, the modelling stage is performed for each dataset.

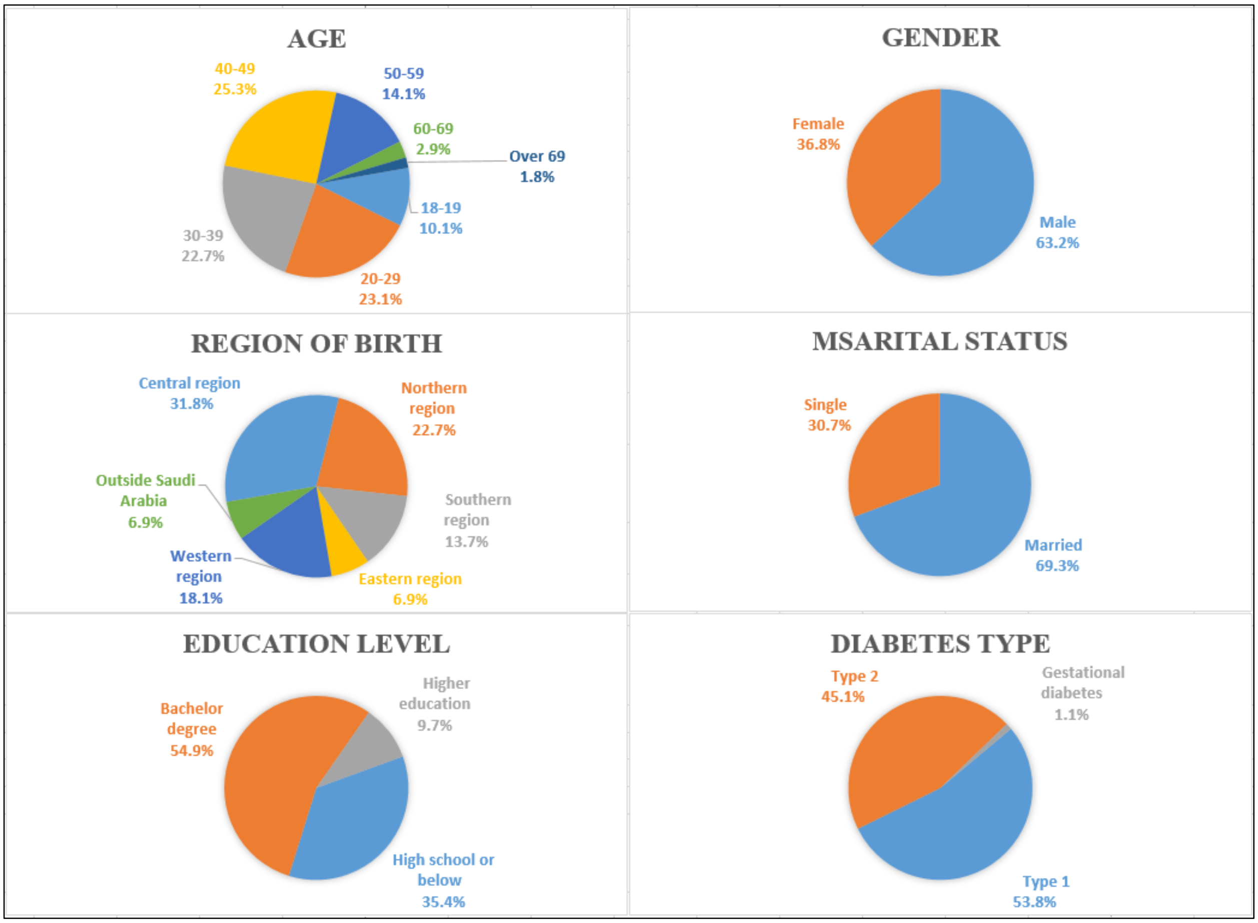

Figure 6.3. Participants' profile information

The data preparation, which includes data transformation, is necessary in order to extract accurate association rules among different non-health-related complications with the profile information of diabetic citizens in Saudi Arabia.

6.2.3. Data preparation

The dataset obtained for the analysis includes 18 attributes and 277 instances. All attributes and instances are involved in the modelling process, which computes the frequent item-sets. The first task in this stage is to transform categorical data into nominal form. The survey has only one attribute presented in categorical form, which is the age attribute and its associated options, described in Table *6.3* below:

Table 6.3. Transformation process of the age attribute

Categorical age groups	**Nominal age groups**
18-19	One
20-29	Two
30-39	Three
40-49	Four
50-59	Five
60-69	Six
Over 69	Seven

The second task is to translate the entire dataset from Arabic into English, and store it into a Microsoft Excel Worksheet (xlsx). WEKA is an open source DM program produced by the University of Waikato in 1992. The package supports a variety of DM problem types and has different capabilities in relation to pre-processing, modelling algorithms and graphical interfaces (Hall et al., 2009). As WEKA is used for the modelling stage, the dataset is expressed into Attribute Relation File Format whose attribute types can be either nominal, string, date or relation-valued attributes (Witten et al., 2011). The two datasets, D_{Female} and D_{Male}, are saved in CSV format; as an example, Figure *6.4* describes the transformation for D_{Female}. (A) Shows the dataset in spreadsheet software with Excel format and (B) shows the dataset in a CSV format.

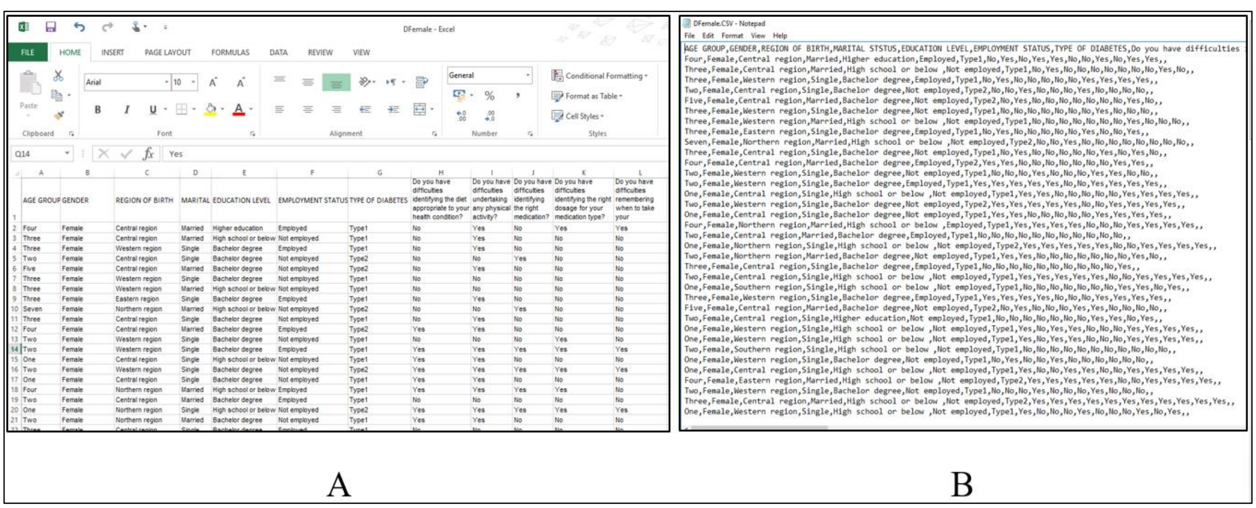

Figure 6.4. Data transformation of D_{Female} from Excel to CSV.

6.2.4. Modelling

The modelling stage is carried out on the two datasets: D_{Female} and D_{Male}. D_{Female} includes 102 records whereas D_{Male} contains 175 records related to their profile information and their diabetes non-health-related complications. Dependency Analyses, association rules in particular, and Apriori algorithm are selected to discover association rules between diabetes non-health-related complications and the profile information of our participants. The Apriori algorithm, which is adopted in this study, was developed by Agrawal and Srikant in 1994. Since then, Apriori has become the simplest and most utilised algorithm to find association rules and frequent item-sets in large amounts of data (Ilayaraja and Meyyappan, 2013).

It is important to ensure the relevancy of generated association rules. The current datasets can result in frequent item-sets with different complications encountered, with no clear associations to the profile information of participants. To overcome this, the modelling stage is carried out to discover any associations between the profile information of participants and only one complication. For example, the profile information of participants (i.e. age, region of birth, marital status, education level, employment status and diabetes type) is investigated with the first complication related to the difficulties of identifying the diet appropriate to your health condition. The modelling process continues until all remaining complications are tested for associations with the profile information of participants for both datasets, D_{Female} and D_{Male}. R_{Female} and R_{Male} are used to denote association rules extracted from D_{Female} and D_{Male} respectively.

In the initial modelling, we set the minimum support value at 0.4 (40%) and the minimum confidence value at 0.9 (90%) to ensure that only rules with a high accuracy are generated. However, these parameters generated few rules. Consequently, the minimum support value is modified gradually until desirable rules are extracted from D_{Female} and D_{Male} at 0.2 (20%). Some of the generated item-sets do not include the required attributes. For example, some frequent item-sets associate profile information of participants with a complication not encountered by the participant. In another example, a frequent item-set associates only different attributes of the participants' profile information (i.e. age, gender and education level). These frequent item-sets are filtered out and removed from the list of extracted association rules. Only frequent item-sets that extract associations among participants' encountered complications and their profile information are included in the final results. Table *6.4* shows association rules found in R_{Female} and Table *6.5* shows association rules extracted from R_{Male}. In both tables, rules are ordered according to the confidence level. Where two or more rules have the same confidence value, the rule that was extracted first is listed first.

In R_{Female}, a set of 11 rules is generated associating six non-health-related complications of diabetes mellitus with different characteristics of female diabetic citizens in Saudi Arabia. These are as follows:

- The rule related to the *difficulties in identifying the right medication amount in the holy month of Ramadan* is extracted more frequently than other rules. It is extracted in four rules (2, 6, 7, 9) showing its association to different female profiles. The highest confidence is attributed to the complication associated with single females who have type 1 diabetes mellitus. It is followed by the complication rule associated with females whose education level is high school or below, have type 1 diabetes mellitus and are unemployed. The next strongest rule relates to the complication associated with single females who have diabetes and are unemployed. The final rule, the difficulty in identifying the right medication amount in Ramadan, relates this complication with the education level of high school or below and unemployed status.
- *The difficulties in identifying the appropriate diet* is extracted in three rules (3, 4, 11) with associations to different attributes. The highest confidence rule associates this complication with females with high school or below education level, type 1 diabetes and unemployed employment status. It is followed by the association of this complication with high school or below education level and employment status. The next rule associates this complication with females whose marital status is single and who have type 1 diabetes.
- The *complication of remembering when to take medication* is extracted once (Rule 1) in female participants whose education level is high school or below and who are unemployed. However, this rule has the highest confidence (95%) among other rules.

- The *difficulties in coexisting with the aspects of diabetes lifestyle* (rule 5), is associated with the high school or below education level, type 1 diabetes mellitus and unemployed participants.
- *The difficulties in identifying the right medication time in Ramadan* rule is associated with females with high school or below education level, type 1 diabetes mellitus and unemployment, with a 91% confidence level (rule 8).
- The final complication, *difficulties in identifying the right diet in Ramadan*, is also associated with high school or below education level, type 1 diabetes mellitus and unemployed females (Rule 10).

Table 6.4. Best association rules extracted from D_{Female}

Rule No	Best rules (R_{Female})	Minimum Support	Confidence
1	EDUCATION LEVEL=High school or below Do you have difficulties remembering when to take your medication?=Yes 22 ==> EMPLOYMENT STATUS=Unemployed 21	0.2	0.95
2	MARITAL STATUS=Single In Ramadan, I have difficulties in identifying the right medication amount.=Yes 32 ==> TYPE OF DIABETES=Type1	0.2	0.94
3	EDUCATION LEVEL=High school or below TYPE OF DIABETES=Type1 Do you have difficulties identifying the diet appropriate to your health condition?=Yes 25 ==> EMPLOYMENT STATUS=Unemployed 23	0.2	0.92
4	EDUCATION LEVEL=High school or below Do you have difficulties identifying the diet appropriate to your health condition?=Yes 33 ==> EMPLOYMENT STATUS=Unemployed 3	0.2	0.92
5	EDUCATION LEVEL=High school or below TYPE OF DIABETES=Type1 Do you have difficulties to coexist with the aspects of diabetes lifestyle?=Yes 26 ==> EMPLOYMENT STATUS=Unemployed 24	0.2	0.92
6	EDUCATION LEVEL=High school or below TYPE OF DIABETES=Type1 In Ramadan, I have difficulties in identifying the right medication amount.=Yes 25 ==> EMPLOYMENT STATUS=Unemployed 23	0.2	0.92
7	MARITAL STATUS=Single EMPLOYMENT STATUS=Unemployed In Ramadan, I have difficulties in identifying the right medication amount.=Yes 24 ==> TYPE OF DIABETES=Type1 22	0.2	0.92
8	EDUCATION LEVEL=High school or below TYPE OF DIABETES=Type1 In Ramadan, I have difficulties in identifying the right medication time.=Yes 22 ==> EMPLOYMENT STATUS=Unemployed 20	0.2	0.91
9	EDUCATION LEVEL=High school or below In Ramadan, I have difficulties in identifying the right medication amount.=Yes 32 ==> EMPLOYMENT STATUS=Unemployed 2	0.2	0.91
10	EDUCATION LEVEL=High school or below TYPE OF DIABETES=Type1 In Ramadan, I have difficulties in identifying the right diet for my health condition. =Yes 22 ==> EMPLOYMENT STATUS=Unemployed 20	0.2	0.91
11	MARITAL STATUS=Single Do you have difficulties identifying the diet appropriate to your health condition?=Yes 31 ==> TYPE OF DIABETES=Type1 28	0.2	0.90

In R_{Male}, 20 association rules are discovered. These associations are as follows:

- The most extracted complication is *the difficulties identifying the right medication* (6, 7, 12, 18, 20). In the highest confidence rule (95%) which contains this complication, the difficulty in identifying the right medication is associated with males who are employed and married. The second rule that contains the complication of difficulty in identifying the right medication is associated with employed citizens who have type 2 diabetes mellitus and are married. In the third rule, the current complication is associated with participants whose education level is bachelor degree, who are employed and married. In the fourth rule, the complication is associated with type 2 diabetes mellitus and the married marital status. In the least confidence rule (90%), the complication is encountered by citizens whose education level is bachelor degree and who are married.

- *The difficulties in identifying the right medication dosage* is extracted in four rules (1, 4, 9, 10) as the second most extracted non-health-related complication among male diabetic citizens in Saudi Arabia. In the highest confidence rule (98%), this complication is associated with employed and married citizens, which constitutes the rule with the highest confidence value among all other rules in R_{Male}. In the second rule of the current complication, the associated profile characteristics are employed and married citizens. The third rule associated this complication with type 2 diabetes mellitus in married citizens. The final association rule that contains this complication associates it with citizens whose education level is bachelor degree, with employed and married marital status.
- Similar to previous complications, *difficulties in identifying the right medication amount in Ramadan* has been extracted in four rules (No 11, 13, 14, 19). The highest confidence rule in relation to this complication (94%) highlights its presence in citizens who have a bachelor degree, who are employed and married. In the second rule, the difficulties identifying the right medication amount in Ramadan is associated with employed citizens who have type 2 of diabetes mellitus and are married. The third rule in relation to the current complication is extracted with the same confidence level (93%). In this rule, the *difficulties in identifying the right medication amount in Ramadan* is associated with citizens who are employed and married. In the fourth rule, the current complication is associated with type 2 diabetes mellitus and married marital status.
- The complication of *difficulties in undertaking any physical activity* is extracted in three rules (2, 5, 17). In the rule with the highest confidence level (97%), the current complication is associated with employed employment status, type 2 diabetes mellitus and married marital status. In the second rule, the difficulties in undertaking any physical

activity are encountered by citizens who hold a bachelor degree and are married. In the last rule, the current complication is associated with type 2 diabetes mellitus and married marital status.

- The complication of *difficulties in remembering when to take medication* is extracted twice (3, 8). In the first rule, the current complication is associated with type 2 diabetes mellitus and married marital status. In the second rule, the current complication is associated with employed and married citizens.
- The last complication extracted from D_{Male} is related to the *difficulties in identifying the diet appropriate to diabetics' health condition*. This complication is extracted in two rules (15, 16). The first rule that indicates the current complication is associated with employed citizens who have type 2 diabetes mellitus and are married. In the second rule, the current complication is associated with both employed and married status.

Table 6.5. Best association rules extracted from D_{Male}

Rule No	Best rules (R_{Male})	Minimum Support	Confidence
1	EMPLOYMENT STATUS=Employed TYPE OF DIABETES=Type2 Do you have difficulties identifying the right dosage for your medication type?=Yes 45 ==> MARITAL STATUS=Married 44	0.2	0.98
2	EMPLOYMENT STATUS=Employed TYPE OF DIABETES=Type2 Do you have difficulties undertaking any physical activity?=Yes 37 ==> MARITAL STATUS=Married 36	0.2	0.97
3	TYPE OF DIABETES=Type2 Do you have difficulties remembering when to take your medication?=Yes 36 ==> MARITAL STATUS=Married 35	0.2	0.97
4	EMPLOYMENT STATUS=Employed Do you have difficulties identifying the right dosage for your medication type?=Yes 69 ==> MARITAL STATUS=Married 66	0.2	0.96
5	EDUCATION LEVEL=Bachelor degree EMPLOYMENT STATUS=Employed Do you have difficulties undertaking any physical activity?=Yes 39 ==> MARITAL STATUS=Married 37	0.2	0.95
6	EMPLOYMENT STATUS=Employed Do you have difficulties identifying the right medication?=Yes 65 ==> MARITAL STATUS=Married 62	0.2	0.95
7	EMPLOYMENT STATUS=Employed TYPE OF DIABETES=Type2 Do you have difficulties identifying the right medication?=Yes 41 ==> MARITAL STASTUS=Married 39	0.2	0.95
8	EMPLOYMENT STATUS=Employed Do you have difficulties remembering when to take your medication?=Yes 41 ==> MARITAL STATUS=Married 39	0.2	0.95
9	TYPE OF DIABETES=Type2 Do you have difficulties identifying the right dosage for your medication type?=Yes 53 ==> MARITAL STATUS=Married 50	0.2	0.94
10	EDUCATION LEVEL=Bachelor degree EMPLOYMENT STATUS=Employed Do you have difficulties identifying the right dosage for your medication type?=Yes 47 ==> MARITAL STATUS=Married 44	0.2	0.94
11	EDUCATION LEVEL=Bachelor degree EMPLOYMENT STATUS=Employed In Ramadan, I have difficulties in identifying the right medication amount.=Yes 49 ==> MARITAL STATUS=Married 46	0.2	0.94
12	EDUCATION LEVEL=Bachelor degree EMPLOYMENT STATUS=Employed Do you have difficulties identifying the right medication?=Yes 43 ==> MARITAL STATUS=Married 40	0.2	0.93

Rule No	Best rules (R_{Male})	Minimum Support	Confidence
13	EMPLOYMENT STATUS=Employed TYPE OF DIABETES=Type2 In Ramadan, I have difficulties in identifying the right medication amount.=Yes 44 ==> MARITAL STATUS=Married 41	0.2	0.93
14	EMPLOYMENT STATUS=Employed In Ramadan, I have difficulties in identifying the right medication amount.=Yes 72 ==> MARITAL STATUS=Married 67	0.2	0.93
15	EMPLOYMENT STATUS=Employed TYPE OF DIABETES=Type2 Do you have difficulties identifying the diet appropriate to your health condition?=Yes 49 ==> MARITAL STATUS=Married 45	0.2	0.92
16	EMPLOYMENT STATUS=Employed Do you have difficulties identifying the diet appropriate to your health condition?=Yes 84 ==> MARITAL STATUS=Married 77	0.2	0.92
17	TYPE OF DIABETES=Type2 Do you have difficulties undertaking any physical activity?=Yes 48 ==> MARITAL STATUS=Married 44	0.2	0.92
18	TYPE OF DIABETES=Type2 Do you have difficulties identifying the right medication?=Yes 49 ==> MARITAL STATUS=Married 45	0.2	0.92
19	TYPE OF DIABETES=Type2 In Ramadan, I have difficulties in identifying the right medication amount.=Yes 54 ==> MARITAL STATUS=Married 49	0.2	0.91
20	EDUCATION LEVEL=Bachelor degree Do you have difficulties identifying the right medication?=Yes 50 ==> MARITAL STATUS=Married 45	0.2	0.90

Lift metric was also used in the extraction of the association rules. However, the lift calculation indicated that the resulted rules do not differ significantly (see Section 3.3.2.6). Therefore, the current DM study used the two-metrics support and confidence as suggested by Witten et al. (2011).

6.2.5. Validation

Two common metrics are used to validate association rules resulting from each dataset; these are support and confidence, measuring the accuracy of the association rules. Support and confidence are calculated using the following two formulas:

Equation 6.1. Support calculation

$$Support\ (\mathrm{X} \rightarrow \mathrm{Y}) = \frac{number\ of\ records\ containing\ x\ and\ y}{total\ number\ of\ records}$$

Equation 6.2. Confidence calculation

$$Confidence\ (\mathrm{X} \rightarrow \mathrm{Y}) = \frac{number\ of\ records\ containing\ x\ and\ y}{total\ number\ of\ records\ containing\ x}$$

In addition, the association rules are evaluated using a k-fold cross-validation method, which utilises the idea of training and testing. In k-fold cross-validation, the dataset is equally partitioned into a K number of folds, where each fold is used once for testing and the remaining dataset is used for training. This process is performed K number of times, by setting the next fold for testing and the remaining dataset for training, until each fold is used for testing exactly once (Witten et al., 2011). This procedure ensures achieving reliable validation of the generated association rules. K-fold cross-validation is commonly used in DM to calculate the average error rate of each run of the training and testing process. However, each association rule mined is independent from other rules and, therefore, the training and testing procedures are performed differently. That is, association rules that do not appear in both training and testing datasets with the same support value are filtered out. Most DM projects utilise a 10-fold cross-validation method as a perfect way to estimate performance errors. Nevertheless, this method is more suitable with large datasets (Ordonez, 2006). During our experiment, two-fold cross-validation is implemented to evaluate association rules extracted from our two datasets (Tomovic and Stansic, 2011). The two-fold cross-validation used in this study is described below:

1. Each dataset, D_{Female} and D_{Male}, are equally portioned into two subsets: $D_{Female1}$ and $D_{Female2}$ for D_{Female} and D_{Male1} and D_{Male2} for D_{Male}, where $D_{Female} = D_{Female1} \cup D_{Female2}$ and $D_{Female1} \cap D_{Female2} = \emptyset$ and $D_{Male} = D_{Male1} \cup D_{Male2}$ and $D_{Male1} \cap D_{Male2} = \emptyset$. The number of transactions in each subset is given in Table *6.6*.

Table 6.6. Number of transactions in training and testing subsets

	$D_{Female1}$	$D_{Female2}$	D_{Male1}	D_{Male2}
Number of transactions	51	51	87	88

2. $D_{Female1}$ and D_{Male1} are used are used for training. Their respective association rules are extracted with respect to the minimum support and confidence values, 0.2 and 0.9 respectively. Extracted rules are denoted with $R_{Female1}$ and R_{Male1}.
3. Utilisation of $D_{Female2}$ and D_{Male2} for testing. Association rules in $R_{Female1}$ and R_{Male1} are validated with $D_{Female2}$ and D_{Male2} respectively. That is, any association rule in $R_{Female1}$ and R_{Male1} that do not satisfy the minimum metrics in R_{Female} and R_{Male} are filtered out.

4. $D_{Female2}$ and D_{Male2} are used for training. Their respective association rules are extracted with respect to the minimum support and confidence values. Extracted rules are denoted with $R_{Female2}$ and R_{Male2}.
5. Utilisation of $D_{Female1}$ and D_{Male1} for testing. Association rules in $R_{Female2}$ and R_{Male2} are validated with $D_{Female1}$ and D_{Male1} respectively. That is, any association rules in $R_{Female2}$ and R_{Male2} that do not satisfy minimum metrics in R_{Female} and R_{Male} are filtered out.
6. Valid rules in $R_{Female1}$ and $R_{Female2}$ and R_{Male1} and R_{Male2} are combined. In general, $R_{Female1} \cup R_{Female2} = R_{Female}$ and $R_{Male1} \cup R_{Male2} = R_{Male}$

The two-fold cross-validation is used to evaluate the extracted rules from R_{Female} and R_{Male}. The number of association rules that resulted in R_1 and R_2 do not satisfy the minimum metrics utilised in R. The association rules which do not satisfy specified metrics are removed from our final examination. Table *6.7* and Table *6.8* show the validation results of the filtered-out rules which are in **bold**.

With respect to R_{Female}, there are three rules (1, 4, 6) whose average confidence level from $R_{Female1}$ and $R_{Female2}$ do not satisfy the minimum confidence threshold in R_{Female}. These rules are eliminated as follows:

- The highest confidence rule in R_{Female} (1) relating to *the complication of remembering when to take medication* does not satisfy the confidence level in R_{Female} (0.95), and therefore, is filtered out from the list of complications encountered by female diabetic citizens in Saudi Arabia.
- The second eliminated rule associates *the difficulty of identifying the appropriate diet* to females whose education level is high school or below and who are unemployed (4) as its average confidence does not satisfy the confidence level in R_{Female} (0.92). However, this complication is still valid in the other two rules, where it is associated with the education level of high school or below, type 1 diabetes mellitus and unemployed female citizens (3); it is also associated with females who are single and have type 1 diabetes mellitus (11) as their confidence exceeded the confidence level in R_{Female} (0.93) and (0.92) accordingly.

- The third eliminated rule is related to *the difficulty identifying the right medication amount in the holy month of Ramadan* (6). In this rule, the complication is associated with the high school or below education level, type 1 diabetes mellitus and unemployed employment status, as the two-fold validation procedure did not extract the same rule, either in $R_{Female1}$ or in $R_{Female2}$. Similar to the previous complication, *the difficulty identifying the right medication amount in the holy month of Ramadan* is validly associated with different item-sets of profile information (2, 7, 9).

Table 6.7. Two-fold cross-validation results of R_{Female}

Rule No	Best rules (R_{Female})	Minimum support			Minimum confidence		
		$R_{Female1}$	$R_{Female2}$	Average	$R_{Female1}$	$R_{Female2}$	Average
1	**EDUCATION LEVEL=High school or below Do you have difficulties remembering when to take your medication?=Yes 22 ==> EMPLOYMENT STATUS=Unemployed 21**	**-**	**0.2**	**0.2**	**-**	**0.93**	**0.93**
2	MARITAL STATUS=Single In Ramadan, I have difficulties in identifying the right medication amount.=Yes 32 ==> TYPE OF DIABETES=Type1	-	0.2	0.2	-	1	1
3	EDUCATION LEVEL=High school or below TYPE OF DIABETES=Type1 Do you have difficulties identifying the diet appropriate to your health condition?=Yes 25 ==> EMPLOYMENT STATUS=Unemployed 23	-	0.2	0.2	-	0.93	0.93
4	**EDUCATION LEVEL=High school or below Do you have difficulties identifying the diet appropriate to your health condition?=Yes 33 ==> EMPLOYMENT STATUS=Unemployed 3**	**0.2**	**0.2**	**0.2**	**0.92**	**0.90**	**0.91**
5	EDUCATION LEVEL=High school or below TYPE OF DIABETES=Type1 Do you have difficulties to coexist with the aspects of diabetes lifestyle?=Yes 26 ==> EMPLOYMENT STATUS=Unemployed 24	-	0.2	0.2	-	0.94	0.94
6	**EDUCATION LEVEL=High school or below TYPE OF DIABETES=Type1 In Ramadan, I have difficulties in identifying the right medication amount.=Yes 25 ==> EMPLOYMENT STATUS=Unemployed 23**	-	-	-	-	-	-
7	MARITAL STATUS=Single EMPLOYMENT STATUS=Unemployed In Ramadan, I have difficulties in identifying the right medication amount.=Yes 24 ==> TYPE OF DIABETES=Type1 22	-	0.2	0.2	-	1	1
8	EDUCATION LEVEL=High school or below TYPE OF DIABETES=Type1 In Ramadan, I have difficulties in identifying the right medication time.=Yes 22 ==> EMPLOYMENT STATUS=Unemployed 20	-	0.2	0.2	-	0.92	0.92
9	EDUCATION LEVEL=High school or below In Ramadan, I have difficulties in identifying the right medication amount.=Yes 32 ==> EMPLOYMENT STATUS=Unemployed 2	0.2	-	0.2	0.92	-	0.92
10	EDUCATION LEVEL=High school or below TYPE OF DIABETES=Type1 In Ramadan, I have difficulties in identifying the right diet for my health condition. =Yes 22 ==> EMPLOYMENT STATUS=Unemployed 20	-	0.2	0.2	-	0.92	0.92
11	MARITAL STATUS=Single Do you have difficulties identifying the diet appropriate to your health condition?=Yes 31 ==> TYPE OF DIABETES=Type1 28	-	0.2	0.2	-	0.92	0.92

The validation of R_{Male} indicated that there are only two rules that are not valid and therefore filtered out from the final results of this study. The first rule to be filtered out associates *the difficulties in identifying the right medication dosage* with males who have a bachelor degree, are employed and married (10) as its average confidence level from R_{Male1} and R_{Male2} does not satisfy the confidence level in R_{Male} (0.94). However, the difficulties in identifying the right medication dosage is extracted in other rules showing strong validity (1, 4, 9). The second rule that is filtered out associates *difficulties in identifying the diet appropriate to diabetics' health condition* with males who are employed and married (16) as its average confidence level from R_{Male1} and R_{Male2} does not satisfy the confidence level in R_{Male} (0.92). Similar to previous complications, difficulties in identifying the diet appropriate to diabetics' health is extracted in another rule that shows strong validity but with a different combination of profile information (15).

Table 6.8. Two-fold cross-validation results of R_{Male}

Rule No	Best rules (R_{Male})	Minimum support			Minimum confidence		
		R_{Male1}	R_{Male2}	Average	R_{Male1}	R_{Male2}	Average
1	EMPLOYMENT STATUS=Employed TYPE OF DIABETES=Type2 Do you have difficulties identifying the right dosage for your medication type?=Yes 45 ==> MARITAL STATUS=Married 44	0.2	0.2	0.2	1	0.96	0.98
2	EMPLOYMENT STATUS=Employed TYPE OF DIABETES=Type2 Do you have difficulties undertaking any physical activity?=Yes 37 ==> MARITAL STATUS=Married 36	0.2	0.2	0.2	0.94	1	0.97
3	TYPE OF DIABETES=Type2 Do you have difficulties remembering when to take your medication?=Yes 36 ==> MARITAL STATUS=Married 35	0.2	0.2	0.2	1	0.95	0.97
4	EMPLOYMENT STATUS=Employed Do you have difficulties identifying the right dosage for your medication type?=Yes 69 ==> MARITAL STATUS=Married 66	0.2	0.2	0.2	0.97	0.95	0.96
5	EDUCATION LEVEL=Bachelor degree EMPLOYMENT STATUS=Employed Do you have difficulties undertaking any physical activity?=Yes 39 ==> MARITAL STATUS=Married 37	-	0.2	0.2	-	1	1
6	EMPLOYMENT STATUS=Employed Do you have difficulties identifying the right medication?=Yes 65 ==> MARITAL STATUS=Married 62	0.2	0.2	0.2	0.97	0.94	0.95
7	EMPLOYMENT STATUS=Employed TYPE OF DIABETES=Type2 Do you have difficulties identifying the right medication?=Yes 41 ==> MARITAL STATUS=Married 39	0.2	0.2	0.2	1	0.91	0.95
8	EMPLOYMENT STATUS=Employed Do you have difficulties remembering when to take your medication?=Yes 41 ==> MARITAL STATUS=Married 39	0.2	-	0.2	0.96	-	0.96
9	TYPE OF DIABETES=Type2 Do you have difficulties identifying the right dosage for your medication type?=Yes 53 ==> MARITAL STATUS=Married 50	0.2	0.2	0.2	1	0.91	0.95
10	**EDUCATION LEVEL=Bachelor degree EMPLOYMENT STATUS=Employed Do you have difficulties identifying the right dosage for your medication type?=Yes 47 ==> MARITAL STATUS=Married 44**	**0.2**	**0.2**	**0.2**	**0.95**	**0.92**	**0.93**
11	EDUCATION LEVEL=Bachelor degree EMPLOYMENT STATUS=Employed In Ramadan, I have difficulties in identifying the right medication amount.=Yes 49 ==> MARITAL STATUS=Married 46	0.2	0.2	0.2	0.95	0.93	0.94
12	EDUCATION LEVEL=Bachelor degree EMPLOYMENT STATUS=Employed Do you have difficulties identifying the right medication?=Yes 43 ==> MARITAL STATUS=Married 40	0.2	0.2	0.2	0.95	0.91	0.93
13	EMPLOYMENT STATUS=Employed TYPE OF DIABETES=Type2 In Ramadan, I have difficulties in identifying the right medication amount.=Yes 44 ==> MARITAL STATUS=Married 41	0.2	0.2	0.2	0.95	0.91	0.93
14	EMPLOYMENT STATUS=Employed In Ramadan, I have difficulties in identifying the right medication amount.=Yes 72 ==> MARITAL STATUS=Married 67	0.2	0.2	0.2	0.92	0.94	0.93

15	EMPLOYMENT STATUS=Employed TYPE OF DIABETES=Type2 Do you have difficulties identifying the diet appropriate to your health condition?=Yes 49 ==> MARITAL STATUS=Married 45	0.2	-	-	0.96	-	0.96
16	**EMPLOYMENT STATUS=Employed Do you have difficulties identifying the diet appropriate to your health condition?=Yes 84 ==> MARITAL STATUS=Married 77**	**0.2**	**0.2**	**0.2**	**0.93**	**0.90**	**0.91**
17	TYPE OF DIABETES=Type2 Do you have difficulties undertaking any physical activity?=Yes 48 ==> MARITAL STATUS=Married 44	0.2	-	0.2	0.95	-	0.95
18	TYPE OF DIABETES=Type2 Do you have difficulties identifying the right medication?=Yes 49 ==> MARITAL STATUS=Married 45	0.2	-	0.2	1	-	1
19	TYPE OF DIABETES=Type2 In Ramadan, I have difficulties in identifying the right medication amount.=Yes 54 ==> MARITAL STATUS=Married 49	0.2	-	0.2	0.96	-	0.96
20	EDUCATION LEVEL=Bachelor degree Do you have difficulties identifying the right medication?=Yes 50 ==> MARITAL STATUS=Married 45	0.2	-	0.2	0.92	-	0.92

6.2.6.Discussion

The results of our DM pilot study reveal interesting associations among different diabetes non-health-related complications and different profile information of female and male diabetic citizens in Saudi Arabia.

The results show common complications that are encountered by female and male diabetic citizens in Saudi Arabia. These complications are *the difficulties of identifying the right medication amount in Ramadan* and *the difficulties of identifying the diet appropriate to their health condition*. In relation to the profile information, complications encountered by female diabetics are associated with single marital status, type 1 diabetes mellitus, being unemployed and/or high school or below education level. On the other hand, the profile characteristics associated with complications encountered by male diabetics are employed, type 2 diabetes, married and/or bachelor degree education level. The results from both females and males do not indicate associations of complication to any age group, nor the region of birth of diabetic citizens.

The association rules from our DM study were intended to be compared with previous literature for further validation. However, a limited number of publications that discuss non-health-related complications of diabetes mellitus in Saudi Arabia were found. Only one study, conducted by Memon et al. (2017), revealed that individuals who have type 1 diabetes in Saudi Arabia follow physician's exercises more than those with type 2 diabetes. Our study shows consistency with this finding as *the complication of undertaking any physical activity* is only associated with type 2 diabetes mellitus. This is also confirmed by the work of Sharaf et al. (2013) who stated that failure to follow strict diet, exercise and medications are the leading causes of type 2 diabetes mellitus.

The newly discovered associations are to be utilised by providing useful diabetes self-management and education recommendations and guidelines to overcome extracted complications with respect to the associated profile information.

6.2.7.Deployment

The current DM study reveals 25 deployable association rules (see Table *6.9*).

Table 6.9. Summary of deployable new associations discovered from our survey

Rule No	Complications	Gender	Marital status	Education level	Employment status	Diabetes type
1	Identifying the right medication dosage.	Male	Married	-	Employed	Type2
2	Undertaking any physical activity.	Male	Married	-	Employed	Type2
3	Remembering when to take medication.	Male	Married	-	-	Type2
4	Identifying the right medication dosage.	Male	Married	-	Employed	-
5	Undertaking any physical activity.	Male	Married	Bachelor degree	Employed	-
6	Identifying the right medication.	Male	Married	-	Employed	-
7	Identifying the right medication.	Male	Married	-	Employed	Type2
8	Remembering when to take medication.	Male	Married	-	Employed	-
9	Identifying the right medication amount in Ramadan.	Male	Married	Bachelor degree	Employed	-
10	Identifying the right medication amount in Ramadan.	Female	Single	-	-	Type1

Rule No	Complications	Gender	Marital status	Education level	Employment status	Diabetes type
11	Identifying the right medication dosage.	Male	Married	-	-	Type2
12	Identifying the right medication.	Male	Married	Bachelor degree	Employed	-
13	Identifying the right medication amount in Ramadan.	Male	Married	-	Employed	Type2
14	Identifying the right medication amount in Ramadan.	Male	Married	-	Employed	-
15	Identifying the diet appropriate to the health condition.	Female	-	High school or below	Unemployed	Type1
16	Coexisting with aspects of diabetes lifestyle.	Female	-	High school or below	Unemployed	Type1
17	Identifying the right medication amount in Ramadan.	Female	Single	-	Unemployed	Type1
18	Identifying the diet appropriate to the health condition.	Male	Married	-	Employed	Type2
19	Undertaking any physical activity.	Male	Married	-	-	Type2
20	Identifying the right medication.	Male	Married	-	-	Type2
21	Identifying the right medication time in Ramadan.	Female	-	High school or below	Unemployed	Type1
22	Identifying the right diet in Ramadan.	Female	-	High school or below	Unemployed	Type1
23	Identifying right medication amount in Ramadan.	Female	-	High school or below	Unemployed	-
24	Identifying the right medication amount in Ramadan.	Male	Married	-	-	Type2
25	Identifying the right medication.	Male	Married	Bachelor degree	-	-

These health-related complications can be overcome by setting up a forum for diabetic citizens and providing them with tips, policies, strategies, guidelines and best practices related to their illness. Such a forum can be tailored to the profile information associated with each encountered complications resulting from the current study. The forum can also be used by healthcare professionals to support their patients. This can be achieved through the four SECI model modes of socialisation, externalisation, combination and internalisation.

Socialisation is the first mode in the SECI model, and it is responsible for the dissemination of tacit knowledge among different individuals. Diabetic citizens in Saudi Arabia can socialise with other diabetics who match their diabetes type and profile information. This can enable those diabetic citizens to overcome different non-health-related complications through the observation of best practice performed by other diabetic individuals. The complication of *remembering when to take medication* encountered by males with type 2 diabetes mellitus can be overcome through the observation of other diabetic citizens who have the same diabetes type to capture best practices related to medication reminders. The complication of *undertaking physical activity* can be overcome by carrying out physical activities tailored to specific gender, employment status and diabetes type.

The externalisation mode can be applied to facilitate conversion of tacit knowledge into explicit knowledge among different individuals. The complication of *identifying the right medication dosage* can be overcome through publication of medication guidelines from healthcare professionals to diabetic citizens with type 2 diabetes mellitus. The other complication that can be overcome through externalisation is the difficulty in *identifying the right medication*. Healthcare professionals can publish strategies to assist citizens with type 2 diabetes mellitus to identify their appropriate medication.

The combination mode helps integrate different explicit knowledge to produce a new knowledge in an explicit form. The complications of *identifying the right medication time in Ramadan*, faced by citizens with type 1 diabetes mellitus, *identifying the right medication amount in Ramadan*, encountered by citizens with type1 and type 2 diabetes mellitus, and *identifying the appropriate diet in Ramadan*, encountered by citizens with type 1 diabetes mellitus, can be overcome through the dissemination of different explicit strategies in relation to how to deal with diabetes in the holy month of Ramadan. While these strategies are useful in dealing with such complications, it is important that these strategies are produced by healthcare professionals and healthcare service providers to ensure their effectiveness. Moreover, the complication of *coexisting with aspects of diabetes lifestyle* can be overcome through the combination mode by delivering relevant policies from healthcare professionals to females with type 1 diabetes mellitus.

The internalisation mode helps execute the conversion of knowledge from explicit into tacit through "learning by doing". Several complications can be overcome through the conversion of different best practices and guidelines from its explicit form into a tacit form. For example, the complication of *identifying the diet appropriate to the health condition* encountered by females with type 2 diabetes mellitus can be overcome through the conversion of best practices related to diet suitable to type 2 diabetes. Similarly, the complication of *undertaking any physical activity* can be overcome through the provision of training and exercising best practices suited to individuals who have type 2 diabetes mellitus, and those individuals can acquire these best practices through "learning by doing".

In order to facilitate the creation and sharing of the above knowledge, a knowledge web portal is designed and developed to support diabetics in Saudi Arabia from a knowledge management perspective. Various web tools can support the implementation of the sharing and dissemination of tacit and explicit knowledge related to diabetic citizens. These are tools, forums, blogs, social media and frequently asked questions (FAQ), which can be included in the web portal to provide an effective knowledge creation and sharing forum (see Figure *6.5*). A literature review on the web tools that support the SECI model is presented in Chapter Seven.

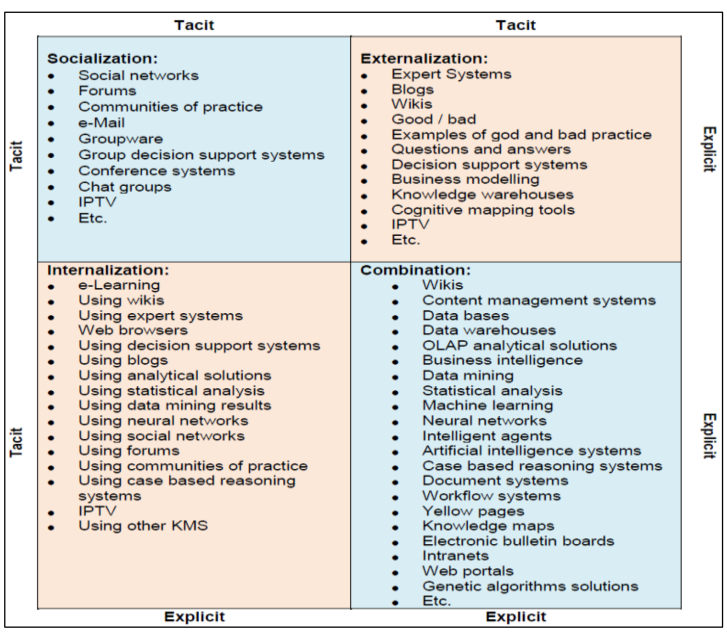

Figure 6.5. Web tools to support the SECI model

Source: (Natek, 2016)

The deployed results will also be closely monitored and maintained. The designed knowledge portal contains an optional survey to gather more information about encountered complications and profile information from visitors who are Saudi Arabian diabetics. The gathered data will be mined in periodical bases in order to extract useful associations of non-health-related complications and profile characteristics, and to update trends related to the current study. As mining forthcoming data may result in different association rules, solutions to be provided over the web portal may also vary for the purpose of addressing new complications and their associated profile information. Furthermore, all gathered data will be freely available to visitors and researchers who may look for such sources. The provision of the obtained data will overcome the difficulty we confronted regarding data gathering in the early stages of our study. This will help conduct future studies relevant to diabetes mellitus, thus providing a rich environment for management of diabetes and future studies.

6.3 Conclusion

This chapter highlights the contribution of DM to support knowledge management. The focus of DM in this thesis is concerned with discovering associations between non-health-related complications and the associated profile information of diabetic citizens in Saudi Arabia. Twenty-five extracted rules associate nine complications with different characteristics of diabetic citizens in the kingdom. These associations can help diabetic citizens cope with complications related to illness. They can contribute to the SECI model to provide effective dissemination and sharing of best practices and guidelines for diabetic citizens in the kingdom. The utilisation of such a model provides useful means for facilitating e-health to support diabetes care by offering self-management and education initiatives. The DM exercise supports the second layer of our framework. The third layer is related to the development of a web portal which provides a series of tacit and explicit knowledge interactions and conversions at two levels: individual diabetics and healthcare professionals. This knowledge web portal, which is described in the next chapter, provides effective application of the SECI model.

Chapter Seven: Web Portal for Diabetes Self-management and Education in Saudi Arabia

7.1 Introduction

The previous chapter demonstrated that there were a number of diabetes non-health-related complications that were extracted in the DM study. In this chapter, the design and development of our web portal is demonstrated. The web portal represents the third layer of our integrated framework, which applies the SECI model. The web portal aims to assist diabetic citizens in Saudi Arabia to control their diabetes mellitus and self-manage the non-health-related complications of the disease.

7.2 Web Portal for Diabetes Self-management and Education in Saudi Arabia

The utilisation of internet tools and technologies is involved in many aspects of our lives nowadays. One of the major reasons for using the internet is related to healthcare and the management of different diseases. The internet is used by people who suffer from chronic diseases in order to learn from other patients' experiences and to self-manage their illnesses (Ziebland et al., 2014). The literature review conducted by Ziebland and Wyke (2012) revealed seven motives for accessing health experiences of others on the internet: (1) finding information, (2) feeling supported, (3) maintaining relationships with others, (4) experiencing health services, (5) learning to relate the story, (6) visualising disease, and (7) affecting behaviour. In terms of diabetes mellitus, Ramadas et al. (2011) discussed the intervention of web-based technology for managing type 2 diabetes. They reviewed 13 web-based results on the positive impact of such intervention on the management of the disease. Another study showed how a web-based diabetes management system helped its users reduce their glycated haemoglobin (Kwon et al., 2004). It offered educational programs related to diabetes management, exercise, nutrition and recommendations for the patients with type 2 diabetes based on the information they entered, such as their medications and glucose levels.

In Saudi Arabia, the internet and its tools can be valuable tools to support the management of and education about different diseases. Internet penetration in Saudi Arabia rose from 13% in 2005 to 63.7% in 2014 and the number of internet users reached about 19.6 million

(CITC Annual Reports, 2014). The internet is commonly used to search for health-related information in Saudi Arabia (AlGhamdi and Moussa, 2012). However, there is a critical need to provide e-health initiatives to support diabetic citizens to cope with their daily life difficulties and support healthcare professionals in providing quality and consistency care to their patients.

Our DM study has revealed a number of non-health-related complications encountered by diabetic citizens in Saudi Arabia. These complications are related to identifying medication and its dosage, physical activities, remembering when to take medication, diet, coexisting with diabetes lifestyle and managing diabetes in Ramadan. These complications are associated with different characteristics of diabetic citizens such as their gender, marital status, education level, employment and diabetes type. The non-health-related complications that resulted from our DM pilot study are discussed in detail in Chapter Six and summarised again in the following two tables (see Table *7.1* and Table 7.2)

Table 7.1. Extracted non-health-related complications encountered by diabetic female citizens in Saudi Arabia

Rule No	Complication	Gender	Marital status	Education level	Employment status	Diabetes type
1	Identifying the right medication amount in Ramadan.	Female	Single	-	-	Type1
2	Identifying the diet appropriate to the health condition.	Female	-	High school or below	Unemployed	Type1
3	Coexisting with aspects of diabetes lifestyle.	Female	-	High school or below	Unemployed	Type1
4	Identifying the right medication amount in Ramadan.	Female	Single	-	Unemployed	Type1
5	Identifying the right medication time in Ramadan.	Female	-	High school or below	Unemployed	Type1
6	Identifying the right diet in Ramadan.	Female	-	High school or below	Unemployed	Type1
7	Identifying right medication amount in Ramadan.	Female	-	High school or below	Unemployed	-

Table 7.2. Extracted non-health-related complications encountered by diabetic male citizens in Saudi Arabia

Rule No	Complication	Gender	Marital status	Education level	Employment status	Diabetes type
1	Identifying the right medication dosage.	Male	Married	-	Employed	Type2
2	Undertaking any physical activity.	Male	Married	-	Employed	Type2
3	Remembering when to take medication.	Male	Married	-	-	Type2
4	Identifying the right medication dosage.	Male	married	-	Employed	-
5	Undertaking any physical activity.	Male	Married	Bachelor degree	Employed	-
6	Identifying the right medication.	Male	Married	-	Employed	-
7	Identifying the right medication.	Male	Married	-	Employed	Type2
8	Remembering when to take medication.	Male	Married	-	Employed	-
9	Identifying the right medication amount in Ramadan.	Male	Married	Bachelor degree	Employed	-
10	Identifying the right medication dosage.	Male	Married	-	-	Type2
11	Identifying the right medication.	Male	Married	Bachelor degree	Employed	-
12	Identifying the right medication amount in Ramadan.	Male	Married	-	Employed	Type2
13	Identifying the right medication amount in Ramadan.	Male	Married	-	Employed	-
14	Identifying the diet appropriate to the health condition.	Male	Married	-	Employed	Type2
15	Undertaking any physical activity.	Male	Married	-	-	Type2
16	Identifying the right medication.	Male	Married	-	-	Type2
17	Identifying the right medication amount in Ramadan.	Male	Married	-	-	Type2
18	Identifying the right medication.	Male	Married	Bachelor degree	-	-

Diabetes self-management and education can overcome many of these complications through enriching diabetes knowledge of diabetic individuals. The internet is an effective type of delivery method that has been found effective for such a purpose, as it facilitates the access of diabetic individuals to different diabetes self-management materials (Pereira et al., 2015). Due to its high penetration in Saudi Arabia, the utilisation of internet services can be effective in delivering appropriate diabetes self-management solutions to Saudi Arabian diabetic citizens as well, in order to empower them to overcome different non-health-related complications of diabetes mellitus. Moreover, the utilisation of the internet can support the management of diabetes mellitus among diabetic citizens who live in remote areas. This can have the consequence of better control of their diabetes and educate them about their health condition.

7.3 Web Tools for the SECI Model

As discussed in Chapter Four, our integrated framework focuses on the KM layer to be supported by a web portal (see Figure *7.1*). This third layer applies the SECI model to disseminate diabetes self-management solutions among diabetic citizens and healthcare professionals in Saudi Arabia, which is one of the objectives of the current thesis. The web portal aims to facilitate the provision of diabetes self-management and education through the application of socialisation, externalisation, combination and internalisation. The perceived implementation is seen to create valuable guidelines, strategies and best practices that can help diabetic citizens to control their disease.

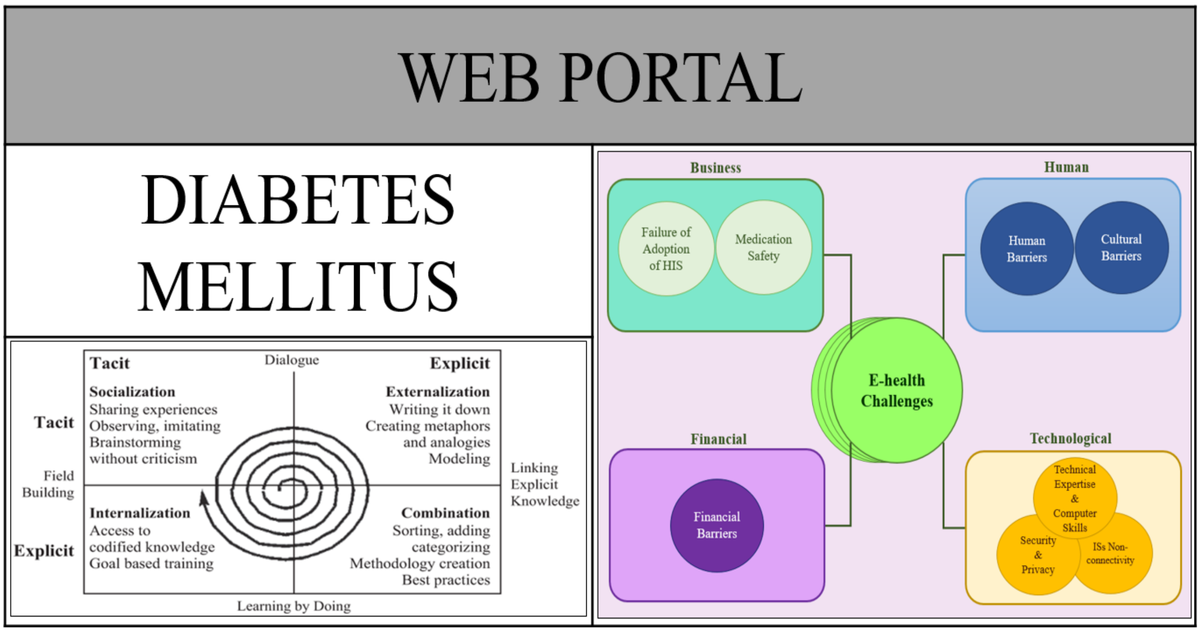

Figure 7.1. Embodiment of the KM layer of our framework in a web portal

The first objective in this chapter is to review the web tools that can apply each mode of the SECI mode. Researchers have demonstrated that socialisation, externalisation, combination and internalisation are performed through the internet by various tools provided by the Web 2.0 technologies (Chatti at el., 2007; Natek, 2016). Web 2.0 is an open source and interactive application, generated and controlled by the users, which in turn expands their knowledge skills as participants in business and social processes

(Constantinides and Fountain, 2008). Web 2.0 enhances the flow of knowledge as it enables the creation of informal networks of users which facilitates the generation, dissemination and editing of knowledge and informational content. There are a number of web tools that can support the four modes of the SECI model. These tools are outlined as follows (see Figure *7.2*):

Socialisation:

1. Forums are very useful tools to enable socialisation among individuals. Reward incentives can be used for the posts which are highly rated, and will encourage participation (Ray, 2014). Forums can allow anonymous participation which enables individuals who fear judgments and the loss of face to engage in discussions. This encourages participants' willingness to share knowledge, and is an important requirement according to Nonaka and Takeuchi (1995).
2. CoPs and wikis are useful tools to perform socialisation. According to Ray (2014) and Hoadley (2012), CoPs provided via wikis enables individuals to provide valuable knowledge related to their areas of expertise. Similar to web forums, wikis can enable anonymous participation. This can enable KM practices in cultures which are seen as high power distance cultures, such as Saudi Arabia.
3. Social media is another web tool that can enhance socialisation in the internet platform. Social media provides a feasible way of sharing tacit knowledge, such as expertise, understanding, experience and skills without the utilisation of language. In addition, different social media enable observations, imitation and practice by providing opportunities to individuals to participate in formal and informal communities, which are the space required for socialisation (Chatti et al., 2007).

Externalisation:

1. According to Chatti et al. (2007), blogs support externalisation by offering a space for everyone to capture knowledge. They also enable immediate documentation of thoughts through discussions in different blogs. They are powerful for KS in individualistic cultures. They can be suitable for sharing best practices and offers indirect communication, which can overcome the fear of assessment and criticisms. Moreover, blogs allow anonymous participation to overcome the barrier of structure in organisations. Blogs' utilisation in organisations can result

in long-term orientation organisations, which focus on long-term goals (Ray, 2014).

2. Wikis are also seen to be useful web tools for externalisation (Chatti et al., 2007). They facilitate the capturing of collective knowledge where every user can share her/his experience. This increases social interaction and empowers collaborative knowledge-capturing, as knowledge in wikis can be created and modified by different individuals. Therefore, wikis are seen as a helpful tool to overcome individualism, which is the national attribute that hinders externalisation. This knowledge can be in various forms, such as spoken or written words, different formats of images, sound tracks – such as music – and lectures. Furthermore, contributions in wikis, which can also be anonymous, can be supported by top management in organisations (Ray, 2014). This can overcome the problem of high power distance which occurs in cultures such as Saudi Arabia.
3. Besides its support to socialisation, social media can also support externalisation. Social media enable users to share and capture different knowledge that may be presented in different formats, such as text, images, videos or audios. Moreover, it can be facilitated through newly developed devices and software for KS and capturing (Chatti et al., 2007).
4. A question and answers page is another web tool that can support externalisation. It facilitates externalisation as it allows articulation and codifying of tacit knowledge. This process enables the conversion of knowledge from tacit form to explicit (Natek, 2016). Questions and answers are useful ways to externalise medical knowledge in the forms of patients' questions and answers provided by a healthcare professional.

Combination:

1. One of the effective web technologies for combination is a document system. According to Natek (2016), a document system allows participants to upload and download important documents of interest. It facilitates access to information. Nonaka and Takeuchi (1995) indicated that an open source to information is an important tool for combination. Moreover, uploading and downloading documents of interest ensures the practice of combination in Arabic culture, which performs combination only when the knowledge is considered to be valuable (Weir and Hutchings, 2005).

2. Wikis are also seen to be an effective tool for combination in the online community. Wikis build searchable and up to date learning content that can be distributed among different organisational boundaries (Chatti et al., 2007). In addition, wikis enable collaborative decision-making and decrease bureaucracy. This is a prerequisite for combination as consultative decision-making is effective practice for this mode (Nonaka and Takeuchi, 1995).
3. Blogs can support combination in a similar way to wikis. Blogs can provide valuable learning assists that are searchable and up to date and can be transferrable into a social context (Chatti et al., 2007). Furthermore, they allow collaborative decision-making and decrease bureaucracy.

Internalisation:

1. CoPs are effective web tools for internalisation (Natek, 2016). CoPs can be provided for participants through social media where work-groups transfer knowledge among staffs who share the same interests or who are looking for a particular knowledge. To overcome cultural boundaries, such as low uncertainty avoidance, rewarding valuable contributions will lead the organisation's community to value KS and increase it. Another way to reward contributions is by linking posts to the organisation's network to value knowledge and give those contributors reputations as experts, which also overcomes individualism and then increases KS. CoPs can be integrated with web forums by allowing participants with common interests to share their experiences and their best practices (Ray, 2014). Anonymous participation can be valuable in this type of web technology, especially in high power distance cultures such as Saudi Arabia. Another way to apply CoPs is to provide a shared repository for information resources, which can be used to support members of a community in their practices (Hoadley, 2012). Therefore, instructional videos can be a valuable repository for knowledge that can implement internalisation through a CoP.
2. Wikis are also an effective web tool for internalisation. Wikis enable individuals to contribute by sharing their experience in their speciality (Ray, 2014). Wikis can be implemented as a CoP. They help individuals to capture knowledge of others and enables users to easily edit webpage contents (Dickson, 2009). Wikis can be adopted by top management in organisations to facilitate KS. Also, anonymous

participation is effective to encourage KM practice in high power distance cultures.

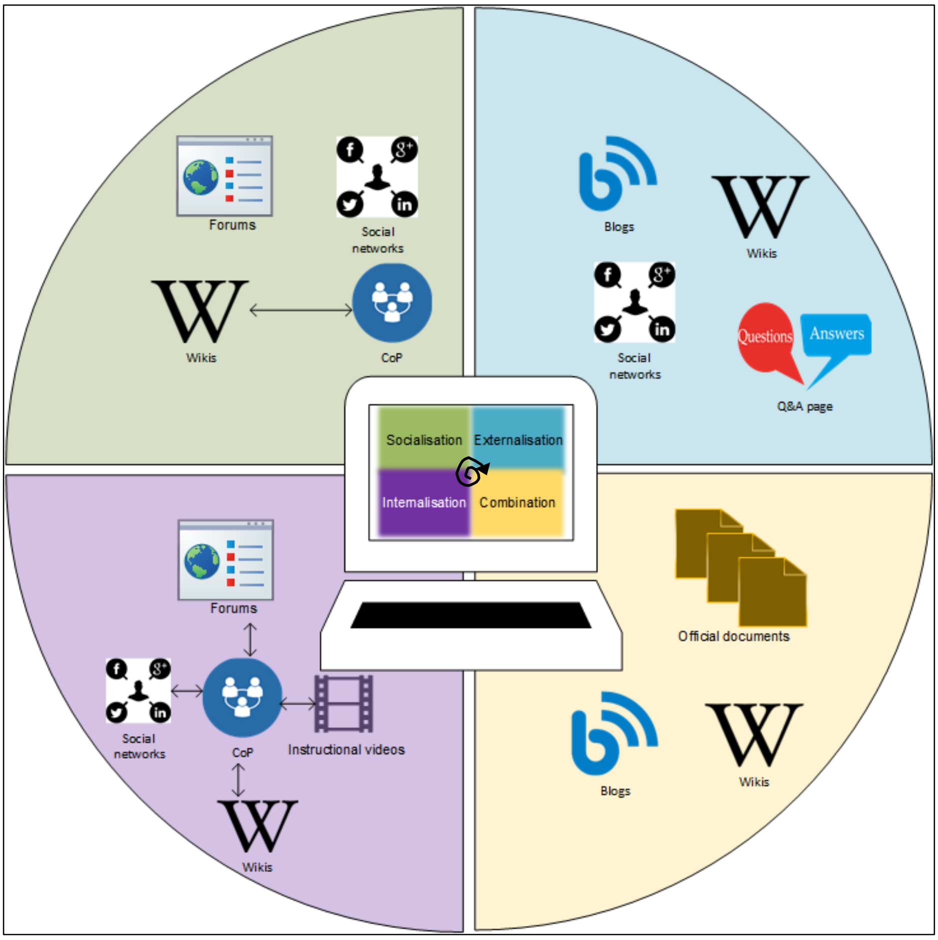

Figure 7.2. Application of the SECI model in the web

7.4 Web Portal Development

In this section, the design and implementation of our web portal is presented. The name of the web portal is Diabetes Self-management in the Kingdom of Saudi Arabia (DSMKSA). It is designed to support diabetic citizens and healthcare professionals in Saudi Arabia to provide effective creation and sharing of knowledge related to the control of diabetes mellitus, taking into consideration the barriers which have hindered e-health initiatives in Saudi Arabia.

The development of web portal is defined by Diffily (2006) as the process of building a new website, or modifying features of an existing one, involving eight phases illustrated as follows:

1. **Planning:** determining the reason why the web portal is needed. In this stage. The aims and objectives of the perceived web portal are defined.

2. **Content and substance:** determining the contents and substances to be presented in the web portal.
3. **Design:** This includes making the web portal's outline and layouts, using a given web design technique.
4. **Construction:** building the web portal and uploading its perceived contents.
5. **Testing:** evaluating the web portal to ensure that it works properly.
6. **Hosting:** deciding on the domain name of the web portal and selecting a hosting provider.
7. **Publicity:** publicising visitors to the web portal.
8. **Review:** reviewing and auditing the web portal to ensure its success.

In this study, the first five steps suggested by Diffily (2006) are undertaken to build our DSMKSA web portal. The remaining three steps are not being undertaken in this study, as they are beyond the scope of this thesis.

7.4.1. Planning of DSMKSA

The planning phase includes the identification of business objectives and the users' needs from the project (Diffily, 2006). Our study revealed a number of non-health-related complications encountered by diabetic citizens in Saudi Arabia (see Chapter Six). Therefore, the business objective of DSMKSA is to provide useful knowledge in relation to diabetes self-management and education to assist diabetic citizens and healthcare professionals in the kingdom in controlling the revealed complications. The knowledge provision process is taking place through the application of the SECI model in DSMKSA. Therefore, DSMKSA implements different web tools to support socialisation, externalisation, combination and internalisation.

In developing our web portal, we are aware of meeting the needs of the potential users of DSMKSA; diabetic citizens and healthcare professionals. Therefore, our web portal should support the conversion and dissemination of useful knowledge related to diabetes self-management and education guidelines, best practices, policies and strategies. The diabetes self-management and education knowledge to be presented in DSMKSA are selected based on the findings of the DM study, which revealed a number of diabetes non-health-related complications encountered by diabetic citizens in Saudi Arabia (see Chapter Six). To ensure accuracy of the provided knowledge, we aim only to share useful knowledge from trusted sources in the web portal. As described in Section 7.4.2, Content of DSMKSA, our web portal shares diabetes self-management knowledge from a list of websites that are seen to have sufficient expertise in the area of diabetes self-management and education.

Moreover, our web portal is also designed with respect to e-health barriers that can hinder successful utilisation of e-health initiatives in Saudi Arabia. The design of DSMKSA should take into consideration the barriers to ensure that our web portal constitutes a successful e-health initiative which can meet the needs of the diabetes mellitus community in Saudi Arabia.

7.4.2. Content of DSMKSA

The second stage in developing our web portal is to specify its contents. This stage encompasses all information and applications available in our portal (Diffily, 2006). This content can be in the form of guidelines, best practices, policies and strategies to overcome a number of diabetes non-health-related complications revealed by our DM study. To provide this content, it is important that the knowledge to be shared through our web portal is disseminated from a variety of trusted websites.

After the extraction of the diabetes non-health-related complications, we started searching the internet to find solutions for each extracted complication from our DM study. As a result, diabetes self-management and education guidelines, best practices, strategies and strategies are found in a number of web sources. This study focused on a set of approved and trusted medical sources listed below:

- **American Diabetes Association**

  The American Diabetes Association aims to support people with diabetes mellitus in their fight with the disease and its associated complications. The association provides research in relation to diabetes prevention and management and offers information related to the disease for many communities. In its website, the association applies a variety of tools to provide valuable information to diabetic visitors. This includes basic information about diabetes mellitus, food and physical activities best practices; and guidelines related to how to live with the disease and its complications. In addition, the association, through its website, provides means for diabetic individuals in the U.S to socialise with each other by announcing different events, camps and prevention programmes in different places in the country.

- **Daily Medical Info**

  Daily Medical Info is an Arabic medical website that aims to enrich the Arabic medical content on the internet with trusted and reliable medical information. The website was released in 2010, and its editorial board is comprised of a number of experts in information presentation to present medical information in a simple way from trusted scientific sources. Daily Medical Info is dedicated to providing Arabic medical content in the areas of medical awareness and health education. In addition, the website aims to facilitate the online interactions between healthcare professionals and patients and increase the medical awareness of individuals outside the medical field. Furthermore, it provides variety of services for non-specialist visitors, including the dissemination of medical news, the provision of consultation services in the area of health awareness and the presentation of medical infographics. The website covers different diseases and health aspects. In terms of diabetes mellitus, Daily Medical Info provides much content that can help in the management of different types of diabetes mellitus. In 2016, Daily Medical Info won the pioneers Arab Social Networking Award as the best website in the health category (Emirates Today, 2016).

- **Diabetes.co.uk**

  This is an online community which seeks to deliver supportive and comprehensive knowledge about diabetes mellitus for diabetic visitors from all over the world. It focuses on diabetes type 1 and diabetes, type 2 and provides guidelines, information and best practices to control these two type of diabetes mellitus in terms of medication, diet, physical activities and diabetes lifestyle. The website provides daily news and guides in relation to diabetes management and control. In addition, it offers a web forum to enable diabetic visitors to communicate with others in the diabetes mellitus community in order to find support, ask questions related to diabetes mellitus and disseminate their experience in relation to the disease.

- **Drugs.com**

  Drugs.com is an online pharmacy which focuses on KS of different medicines for many health conditions. It is the largest website known for providing information about medication on the internet. Its mission statement is to empower patients to control their health status by offering them appropriate knowledge related to their medications. This can reduce the medication errors of different diseases and result in better medication practices. The website is powered by a number of medical information suppliers including Cerner Multum, Wolters Kluwer Health and the American society of Health-System Pharmacists. Moreover, the website shares publications from Harvard Medical School and provides information about a variety of medical conditions from the Mayo Clinic. Besides many health conditions, Drugs.com provides appropriate knowledge related to different types of diabetes mellitus, and their medications, through a number of web services, such as news, questions and answers, videos, slideshows, articles, etc.

- **Diabetes UK**

  Diabetes UK is the leading UK charity for people diagnosed with diabetes mellitus. It focuses on fighting diabetes mellitus through the sharing of appropriate knowledge related to the disease. The website also aims to connect people who are affected by, or at risk of, diabetes mellitus. As it introduces itself on its website, Diabetes UK has experts of diabetes mellitus who can support, advise and help people with this chronic disease. People working with the Diabetes UK team include researchers, healthcare professionals, campaigners and volunteers who are interested in fighting diabetes mellitus and who can support diabetic individuals.

- **EndocrineWeb**

  EndocrineWeb is a website that aims to address endocrine disorders, including type 2 diabetes mellitus. The website provides useful information in relation to endocrine disorder prevention and treatment. The website provides a variety of articles, guidelines and best practices that can help in controlling different types of diabetes mellitus including type 1, type 2, pre-diabetes and gestational diabetes.

- **Joslin Diabetes Center**

  Joslin Diabetes Center is an independent and non-profit institution which is well known for its efficient expertise in diabetes care and research. The institution aims to support diabetic individuals to live long and healthy lives. The institution is affiliated with Harvard Medical School and it is dedicated to preventing and treating diabetes mellitus and reducing the number of diabetes cases globally.

- **Health Innovation Network**

  The Health Innovation Network (HIN) is an organisation which supports the adoption of innovations to improve the healthcare system in the UK. HIN collaborates with a number of partners in order to align education, training, medical research, informatics and innovation in healthcare in different clinical areas, including diabetes mellitus. The organisation has issued a toolkit about diabetes mellitus to increase the awareness of diabetes medication through insulin. In addition, the toolkit presents different aspects of insulin treatment and how to overcome its challenges.

In addition to the knowledge sources listed above, our web portal includes diabetes self-management and educational knowledge from sources such as the Ministry of Health in Saudi Arabia, which has issued guides in relation to diabetes aspects including appropriate diet, prevention and monitoring, and the Muslim Council of Britain, which has released a leaflet regarding how to control diabetes mellitus in Ramadan, as well as papers about diabetes self-management and control from digital libraries.

7.4.3.Design of DSMKSA

The designing phase is defined as the process of producing a plan for the aesthetics and objects of the website (Diffily, 2006). This phase involves the representation of the website content in a graphical model that can be used to build the website. According to Taylor et al. (2002) the web page layout approach is the main technique for web page design. In their study, they explain that many organisations apply this designing technique by sketching the actual web pages' layouts, functions and information by using templates or frames.

In order to ensure effective KS of different diabetes self-management and educational contents, Table *7.3* lists the tools to be selected by DSMKSA to support the four SECI modes. DSMKSA contains ten pages: Home Page, About DSMKSA, Forum, Official Documents, Diabetes Data, Diabetes Videos, Blogs, Diabetes Q&A, Diabetes Mellitus Daily and a Contact us page. Moreover, the design of DSMKSA contains a header and footer on each page of the web portal. The header is designed to present all the sections of the DSMKSA and a search box where users of the web portal can look up contents in the web portal. The footer, on the other hand, is designed to contain information regarding the Facebook and Twitter accounts of DSMKSA as they are the most popular social media in Saudi Arabia (Gmi_blogger, 2016; SocialBakers, 2017). DSMKSA sections are designed using the web page layout approach with respect to its content, interface design, user navigation, user interaction and the visual design of the web portal. The design of DSMKSA sections is illustrated in the following sub-sections.

Table 7.3 Web tools to support socialisation, externalisation, combination and internalisation

Socialisation	**Externalisation**	**Combination**	**Internalisation**
Forums	Blogs	Document system	Community of practice
Community of practice	Wikis	Wikis	Wikis
Social media	Social media	Blogs	
	Q&A page		

7.4.3.1. Home page

The home page of DSMKSA introduces the web portal to its visitors. This page contains the logo of the DSMKSA web portal at the top of the page, followed by the web portal name. An important component of the home page is the optional survey. In this survey, the visitors to DSMKSA can express their views towards statements related to the diabetes no-health-related complications they encounter. The survey can assist researchers in the area of diabetes mellitus by emerging a repository which can be used in future researches. In addition, the home page provides tweets from popular diabetes-related Twitter accounts in Saudi Arabia to incorporate socialisation with other diabetes communities, and to externalisation of useful knowledge related to diabetes mellitus. The design of the home page is illustrated in Figure *7.3*.

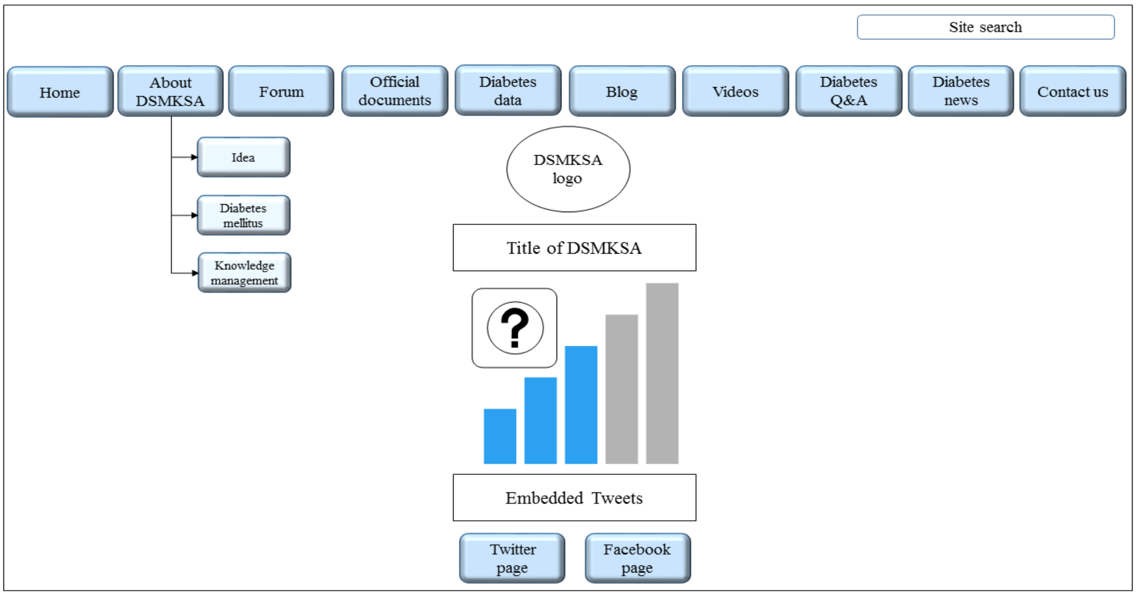

Figure 7.3. Design of DSMKSA homepage

7.4.3.2. About DSMKSA

The 'about' page is concerned with providing information related to the web portal and its associated conceptual process. This page has four sections: the first section is the DSMKSA Idea, which states the aim of the web portal as presented to visitors. The second section includes knowledge about diabetes mellitus and its prevalence in Saudi Arabia and globally. The third section provides descriptions about KM in supporting diabetes mellitus, whereas the fourth section is concerned with the idea of diabetes self-management and education.

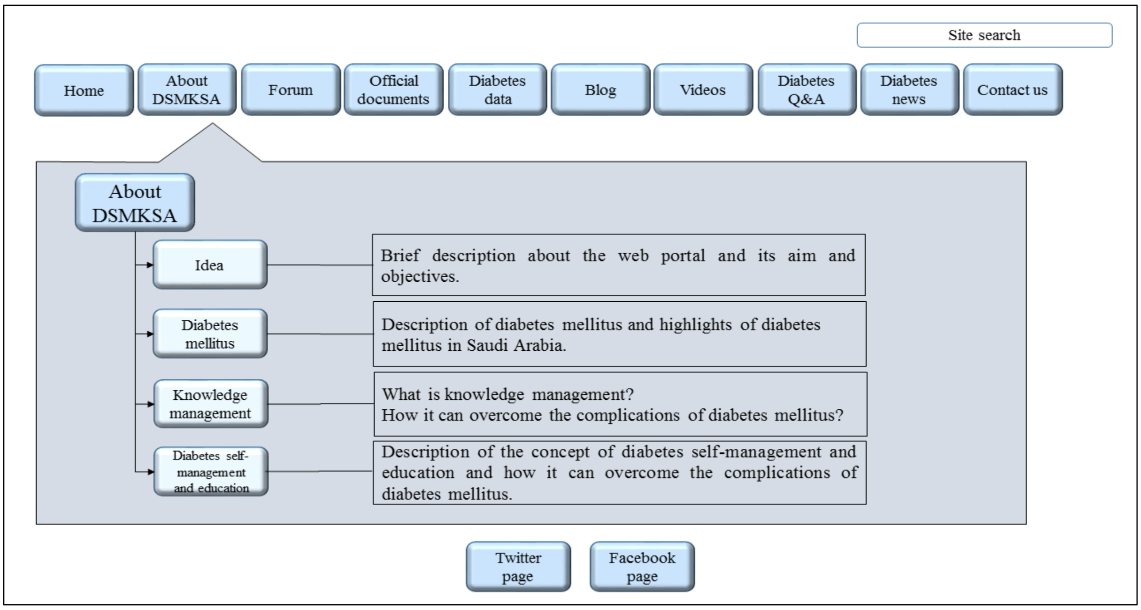

Figure 7.4. Design of About DSMKSA page in DSMKSA

7.4.3.3. Forum

A very important part of DSMKSA is the web forum. Web forums can enable socialisation between different users in the online environment. Our web portal is linked with one of the most visited diabetes web forums in the country, https://www.dmeducation.com/vb/. In this forum, different diabetic individuals meet and learn from each other about guidelines and best practices.

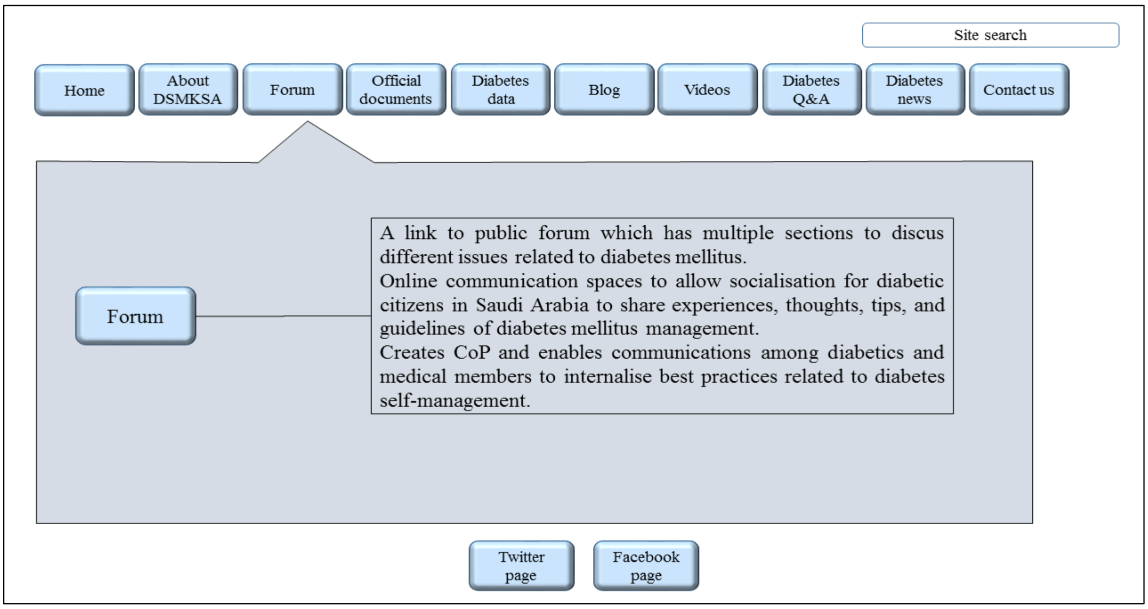

Figure 7.5. Design of the forum link in DSMKSA

7.4.3.4. Official documents

The official document page provides useful guidelines, strategies and policies related to diabetes self-management from trusted sources to the diabetic visitors of DSMKSA. This page applies the combination mode as it integrates different explicit knowledge from different sources. The documents provided on this page can help visitors get familiar with diabetes mellitus and learn tips in preparing healthy food. In addition, this page offers best practices about insulin and its appropriate dosage, as well as guidelines in relation to managing diabetes during Ramada.

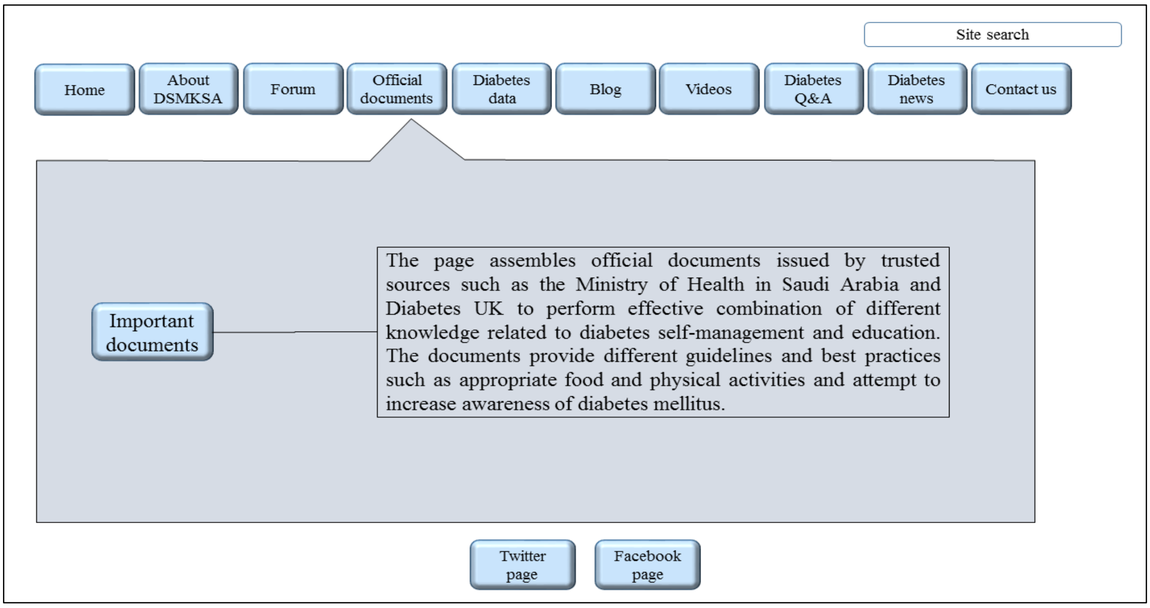

Figure 7.6. Design of the official documents page in DSMKSA

7.4.3.5. Diabetes data

The diabetes data page provides open source datasets to support future studies in relation to diabetes mellitus. The datasets are extracted from the optional survey offered on the first page and will be available to all visitors to DSMKSA. Therefore, the diabetes data page applies the externalisation mode as it externalises hidden information to other visitors.

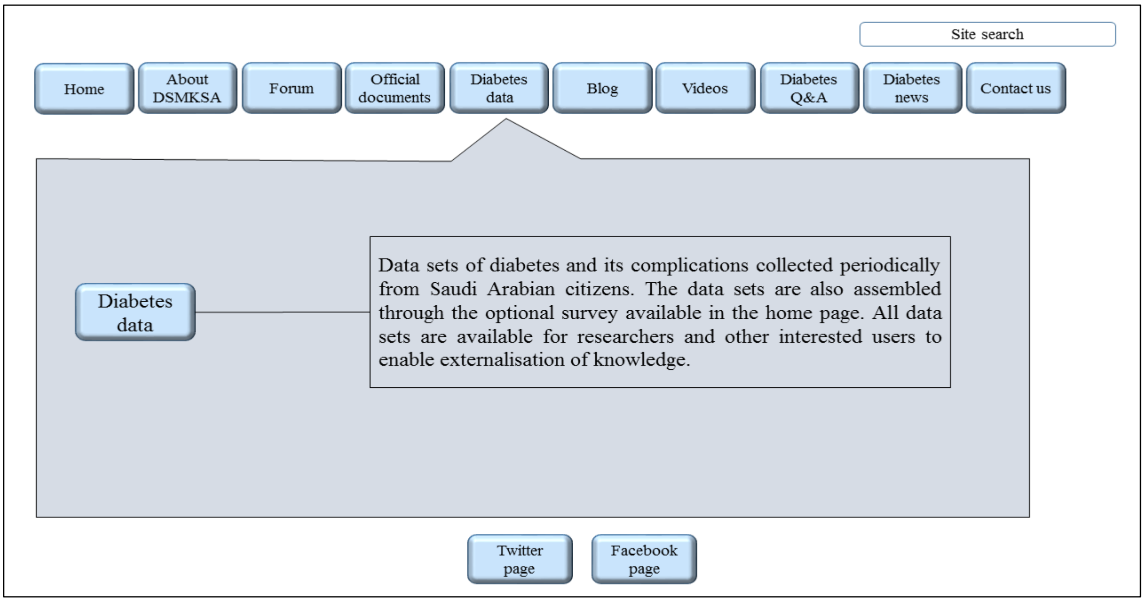

Figure 7.7. Design of the diabetes data page in DSMKSA

7.4.3.6. Blogs

Blogs facilitate the externalisation of knowledge from different users. Blogs, in addition, facilitate combination, is they combine different types of explicit knowledge in one place. In DSMKSA, the blog contains different threads in relation to diabetes medication, diet and physical activities. Moreover, it covers topics such as diabetes management in Ramadan and coexisting with diabetes mellitus.

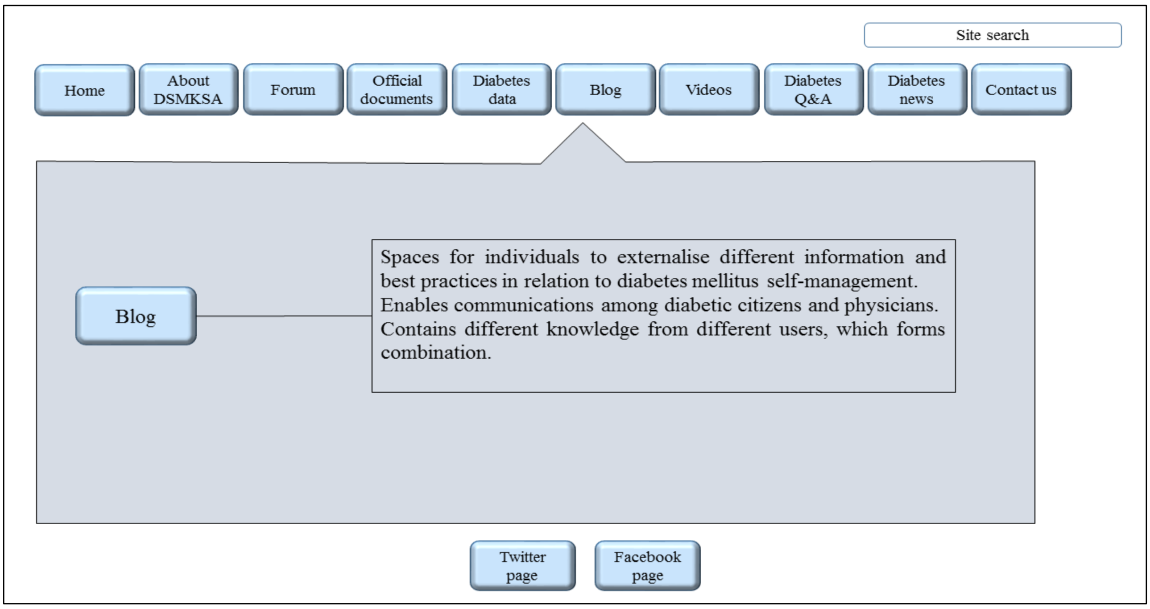

Figure 7.8. Design of the blog page in DSMKSA

7.4.3.7. Diabetes videos

Diabetes videos constitutes a CoP of videos related to a number of diabetes self-management and education best practices and guidelines. On this page, a variety of educational videos are provided to address different diabetes non-health-related complications, including symptoms of diabetes mellitus, exercise, diabetes medication, appropriate diet and managing diabetes in Ramadan. The diabetes video pages offer great opportunities for internalisation, as visitors can learn from the provided videos and practice what they have learned – “learning by doing”.

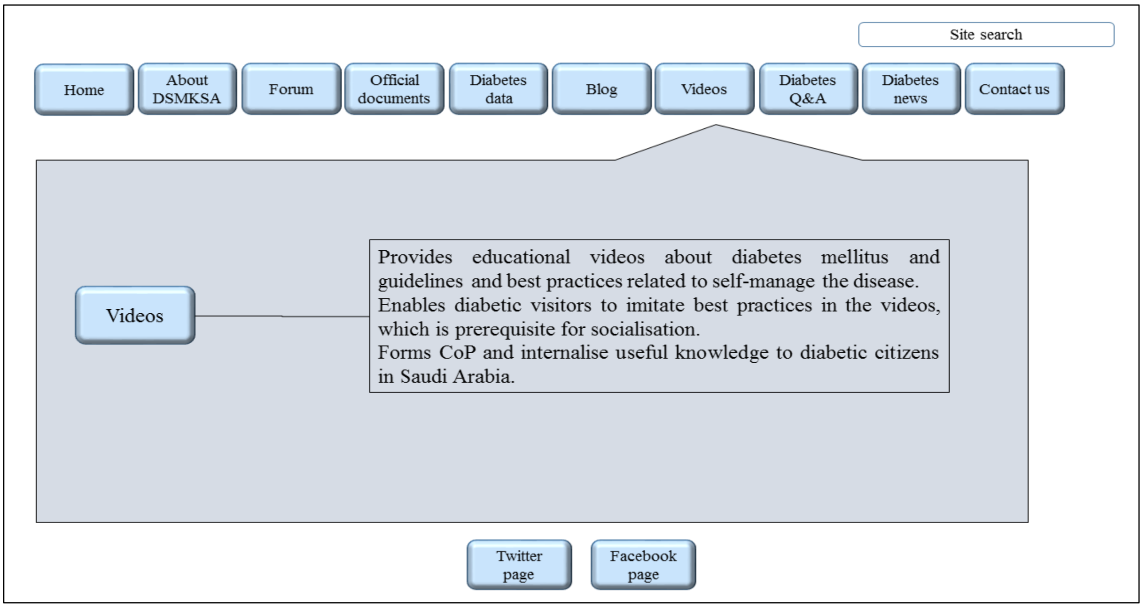

Figure 7.9. Design of the videos page in DSMKSA

7.4.3.8. Diabetes Q&A

The Diabetes Q&A page provides answers to a number of diabetes complications, in the form of ‘question and answer’. In this page, five questions are presented, together with their answers, which are captured from trusted sources in the web. The questions answered in this page relate to identifying the right medication, medication and diet in Ramadan, and diabetes medication in general. The Q&A page applies the externalisation publishing guidelines and best practices from different sources, including healthcare professionals.

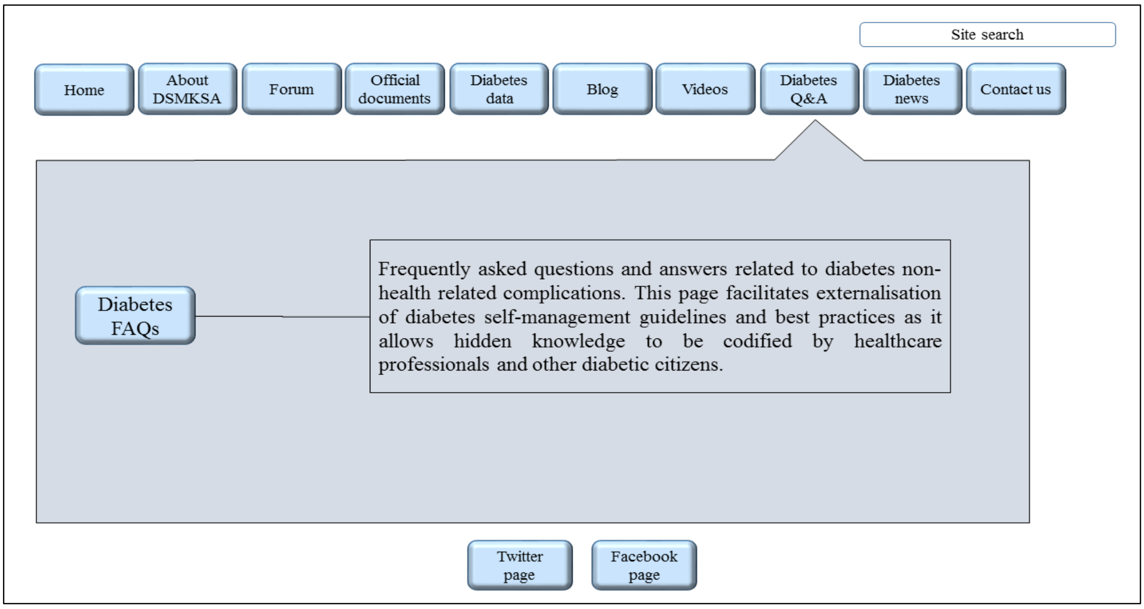

Figure 7.10. Design of the diabetes Q&A page in DSMKSA

7.4.3.9. Diabetes Mellitus Daily

This page generates daily newsletters consisting of different news and articles related to different aspects of diabetes mellitus. The newsletters assemble different published materials about the disease from a variety of sources, including wikis, which can support CoPs for successful socialisation. In addition, wikis can support externalisation, combination and internalisation of useful knowledge related to diabetes education.

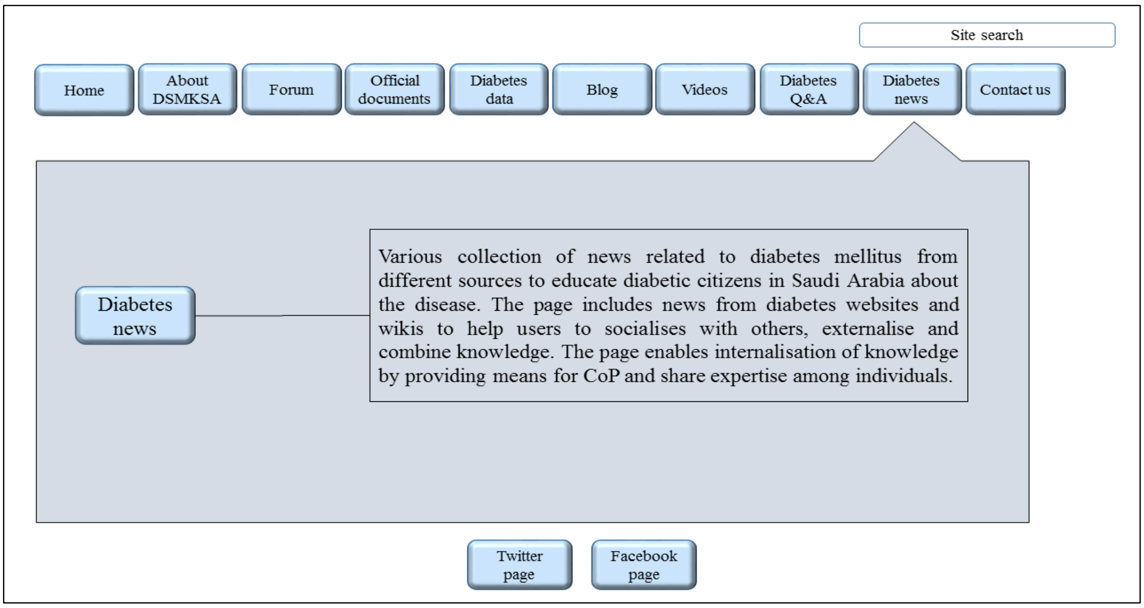

Figure 7.11. Design of the diabetes daily page in DSMKSA

7.4.3.10. Contact us

The Contact us page is provided to enable visitors to DSMKSA to contact the web portal’s admin regarding suggestions and recommendations to improve the portal and its content. This page offers users ways to contact the web portal admin via email and social media accounts for Facebook and Twitter. In addition, the page presents a map of the admin location.

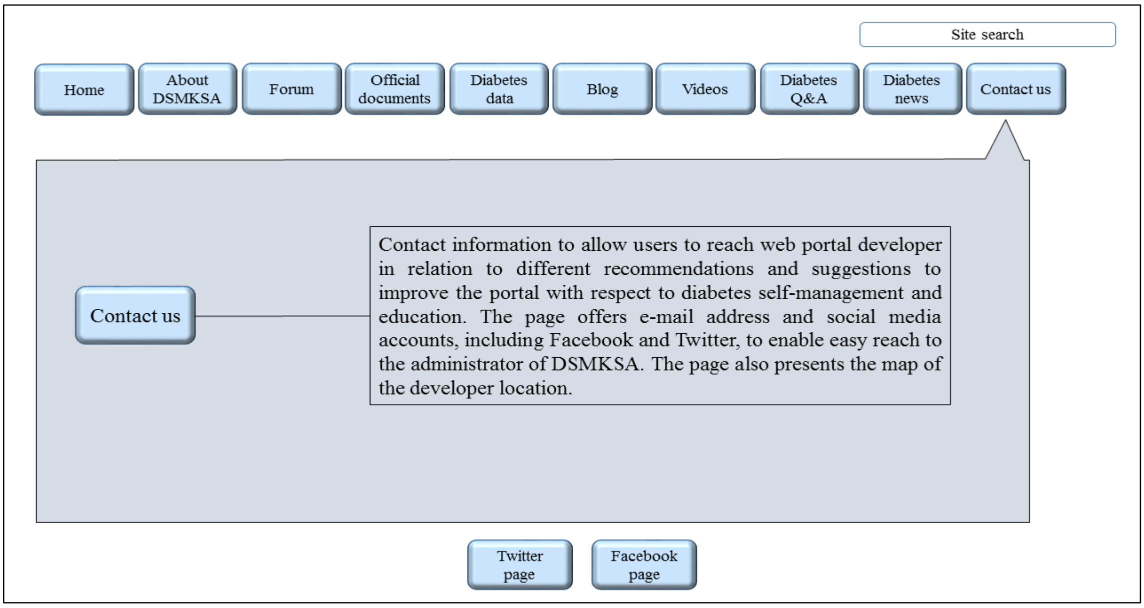

Figure 7.12. Design of the Contact us page in DSMKSA

7.4.4. Construction of DSMKSA

Website construction is defined by Diffily (2006) as the process of converting the design into codes. In the DSMKSA website, the construction is made using a website builder website, wix.com. The service provides drag-and-drop features, which makes it easier to build our portal by only adding its different features.

It is important that, before building the web portal, we need to be aware of the e-health barriers in Saudi Arabia, to ensure that the designed web portal is effective. Chapter Five revealed a number of e-health barriers from the perspectives of citizens, healthcare professionals and IT specialists in Saudi Arabia. These barriers are taken into account to ensure that our web portal design avoids any revealed issues from our e-health barriers study. The e-health barriers identified by respondents to our questionnaire are summarised as follows:

1. Human barriers. This barrier is associated with negative beliefs towards technology, lack of trust on e-health solutions and resistance to change from traditional records to electronic records. DSMKSA is designed to address this barrier by ensuring that the content of the web portal is valuable to its visitors and is imported from trusted sources.
2. Cultural barriers. This indicates the preferences of Saudi Arabian people for physical interactions. This barrier is not applicable in our web portal as it only disseminates knowledge to visitors from other sources on the web.

3. Connectivity of information systems. This barrier is concerned with the absence of a national healthcare system in the form of e-health. DSMKSA address this barrier by connecting different citizens and healthcare professionals of diabetes mellitus from different parts of Saudi Arabia.
4. Technical expertise and computer skills. These are associated with the poor interface design of information systems, the absence of guidelines in how to use e-health solutions and poor maintenance of these systems. The web builder tool used in this project provides instant technical support, which ensures that our web portal works properly at any time. In addition, DSMKSA implements a graphical designed interface to make sure that the interface of our web portal is friendly and easy to use to all visitors.
5. Failure of adoption of HIS. This barrier is caused by the deficient technical support during and after implementation of HISs. This barrier is attributed to the deficient technical support in different e-health initiatives in Saudi Arabia. In DSMKSA, the technical support is provided around the clock, which provides sufficient technical support to our web portal.
6. Security and privacy. This barrier is associated with the ease of accessing patients' records. DSMKSA does not request or store personal and private information. However, the portal ensures that the log-in procedures to its blogs and the associated web forum are private and accurate.
7. Financial barriers. This factor is associated with the cost of adoption of e-health solutions. DSMKSA is designed with affordable expenses to ensure its success and continuity.

7.4.5. Testing of DSMKSA

The testing phase is concerned with evaluating to what extent the designed website has met its set goals and objectives (Diffily, 2006). There are different methodologies for evaluating websites. One of the widely used methodologies is the heuristic evaluation guidelines (Nielsen and Molich, 1990). The heuristic evaluation method is very effective, fast and cheap in finding usability issues (Sivaji et al., 2011; Rusu et al., 2011), which is evaluated from ten dimensions as follows:

1. Visibility of the system status.
2. Match between system and the real world.
3. User control and freedom.
4. Consistency and standards.
5. Error prevention.
6. Recognition rather than recall.
7. Flexibility and efficiency of use.
8. Aesthetic and minimalist design.
9. Error recovery.
10. Help and documentation.

The recommended rating for this evaluation is given below:

Table 7.4. Rating of the heuristic evaluation

Rating	Description
0	No usability problem
1	Cosmetic problem – fix only if extra time is available.
2	Minor usability problem – give a low priority.
3	Major usability problem- give a high priority.
4	Catastrophic- fix before the product is released.

Our web portal, DSMKSA, is evaluated using the heuristic evaluation criteria. The evaluation process started with assigning the number of participants who should evaluate DSMKSA. According to Alassaf and Amr (1997), five participants is an appropriate number for this type of evaluation. Another consideration regarding participants, the diversity of their background and skills, plays a significant role in finding usability issues in a project. Therefore, the evaluation of DSMKSA applied the heuristic evaluation method. The number of participants in the evaluation is eight participants. Three of the participants are diabetic citizens in Saudi Arabia and another three participants are healthcare professionals. The remaining two participants are IT specialists who have sufficient expertise in website evaluation.

The evaluation session started with a workshop to describe the aim of DSMKSA. The participants were then asked to visit the web portal for the first time to familiarise themselves with its features. Afterwards, the evaluation questions were sent to each participant to visit the web portal again and evaluate it.

The evaluation questions form starts with an ethical statement to allow participants to express their agreement to participate in this evaluation study. After the ethical statements, the participants were asked to specify their role and their experience in healthcare. Participants who are diabetic citizens were asked to specify their experience with the disease. The profiles of participants are listed in Table *7.5*5:

Table 7.5. Participants' profile in our web portal evaluation study

Participants group	**Participant ID**	**Years of experience**						
		Less than 1 year	**1 -5**	**6-10**	**11-15**	**16-20**	**21-25**	**Over 25 years**
Diabetic citizens	P1		√					
	P2		√					
	P3			√				
Healthcare professionals	P4			√				
	P5				√			
	P6				√			
IT specialists	P7				√			
	P8						√	

The feedback from the participants to our web portal evaluation does not indicate any major issues related to the usability of DSMKSA. A summary of participants' feedback is listed in Table *7.6*:

Table 7.6. DSMKSA evaluation form and participants' feedback

Heuristics	Statements	No issues 0	Cosmetic problem 1	Minor problem 2	Major problem 3	Catastrophic 4
Visibility of System Status	DSMKSA provides instant feedback to the users when working with the portal.	7	1			
Match Between System and the Real Word	Information in DSMKSA appears to be in logical order.	5	3			
User Control and Freedom	DSMKSA supports user freedom and control.	6	2			
Consistency and Standards	The design of DSMKSA is consistent and standardised in all pages.	6	2			
Error Prevention	DSMKSA seems to be designed carefully to avoid errors.	5	3			
Recognition Rather than Recall	DSMKSA provides instructions for use of its contents.	4	3	1		
Flexibility and Efficiency of Use	DSMKSA is relevant to experienced and inexperienced users.	6	2			
Aesthetic and Minimalist Design	DSMKSA presents relevant information in relevant visibility.	5	3			
Error Recovery	DSMKSA enables users to indicate errors and provide solutions to it.	3	4	1		
Help and Documentation	DSMKSA provides help and documentation about the site and its features.	5	3			

For *the visibility of system status*, the majority of participants (87.50%) indicated that there is no usability issue in relation to this heuristic. However, only one participant, who is a diabetic citizen, indicated that the visibility of system status is a cosmetic issue.

In the second heuristic, *match between system and the real world*, over half of participants (62.50%) indicated that there is no issue in relation to this factor. However, three participants, one participant from each group, indicated that DSMKSA has a cosmetic issue in relation to this heuristic.

In terms of *user control and freedom* and *consistency and standards,* the majority of participants (75.00%) indicated that our web portal does not have any usability issue in relation to these two heuristics. Nevertheless, there are two participants, one diabetic citizen and one IT specialist, who indicated that the two heuristics are cosmetic.

In relation to *error prevention*, for over half of participants (62.50%) this heuristic does not have any usability issues. Only two diabetic citizens and one IT specialists indicated that DSMKSA has a cosmetic usability issue in relation to *error prevention*.

Half of participants (50.00%) indicated that the heuristic recognition rather than recall in our web portal has no usability issue. However, two participants, one diabetic citizen and one healthcare professional, indicated that this issue is cosmetic in DSMKSA. Moreover, only one participant, who is an IT specialist, indicated that this heuristic is a minor issue in DSMKSA.

In *the flexibility and efficiency to use*, the majority of participants (75.00%) indicated that this heuristic has no usability issues in DSMKSA. Nevertheless, two participants, one diabetic citizen and one healthcare professional, indicated that this issue is cosmetic in DSMKSA.

In relation to *aesthetic and minimalist design*, over half of participants (62.50%) indicated that our web portal does not have any usability issues in relation to this heuristic. However, three participants, who relate to each group of participants, indicated that our DSMKSA web portal has a cosmetic issue in relation to aesthetic and minimalist design.

Regarding the heuristic of *error recovery*, half of the participants (50.00%) indicated that DSMKSA has a cosmetic usability issue in relation to error indication and recovery. Three participants, one diabetic citizen and two healthcare professionals, indicated that DSMKSA does not have any issues in relation to this heuristic. One participant, who is an IT specialist, indicated this this heuristic constitutes a minor usability issue in DSMKSA.

In the final heuristic, *help and documentation*, the majority of participants (62.50%) indicated that this heuristic does not constitute a usability issue in DSMKSA. Three participants, one from each group of respondents, indicated that DSMKSA has a cosmetic issue with this heuristic.

7.5 DSMKSA Screenshots

This section contains screenshots from DSMKSA. The screenshots cover all sections of our web portal.

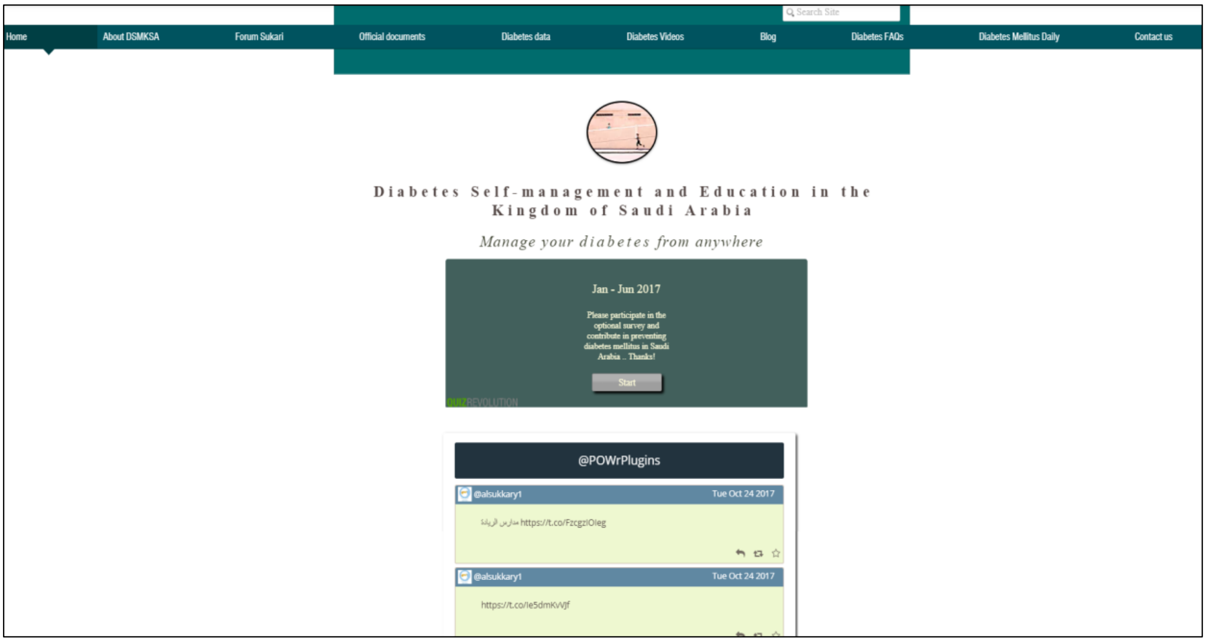

Figure 7.13. Home page of DSMKSA

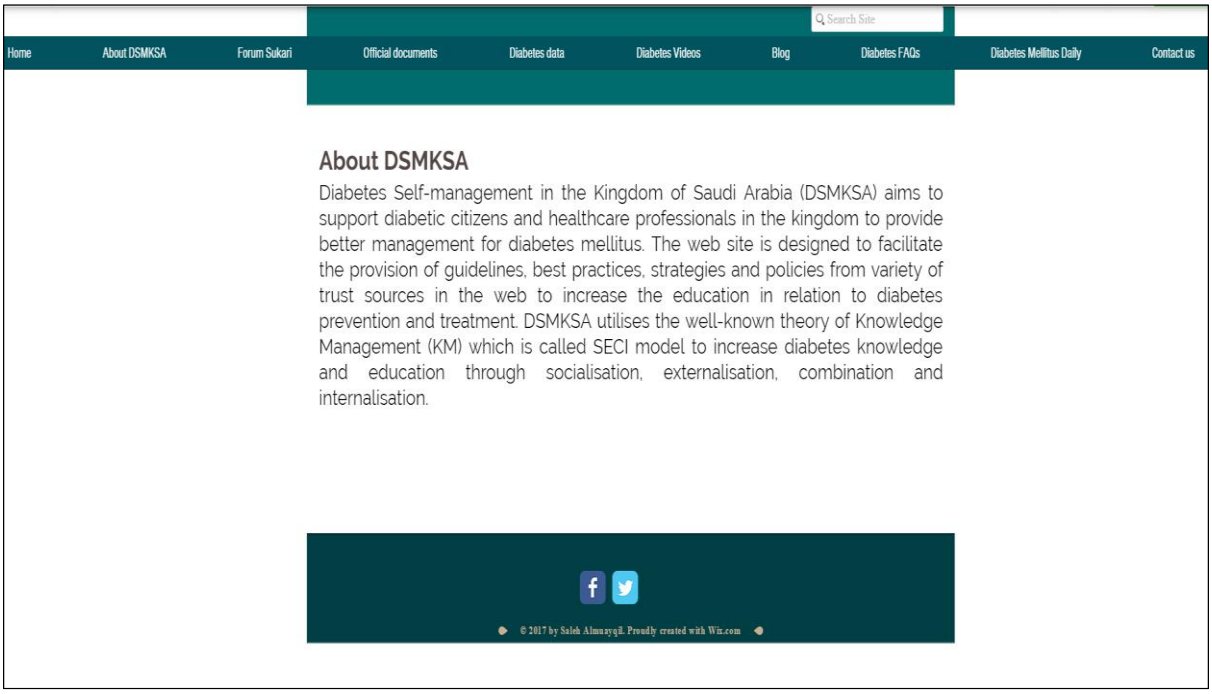

Figure 7.14. About DSMKSA page

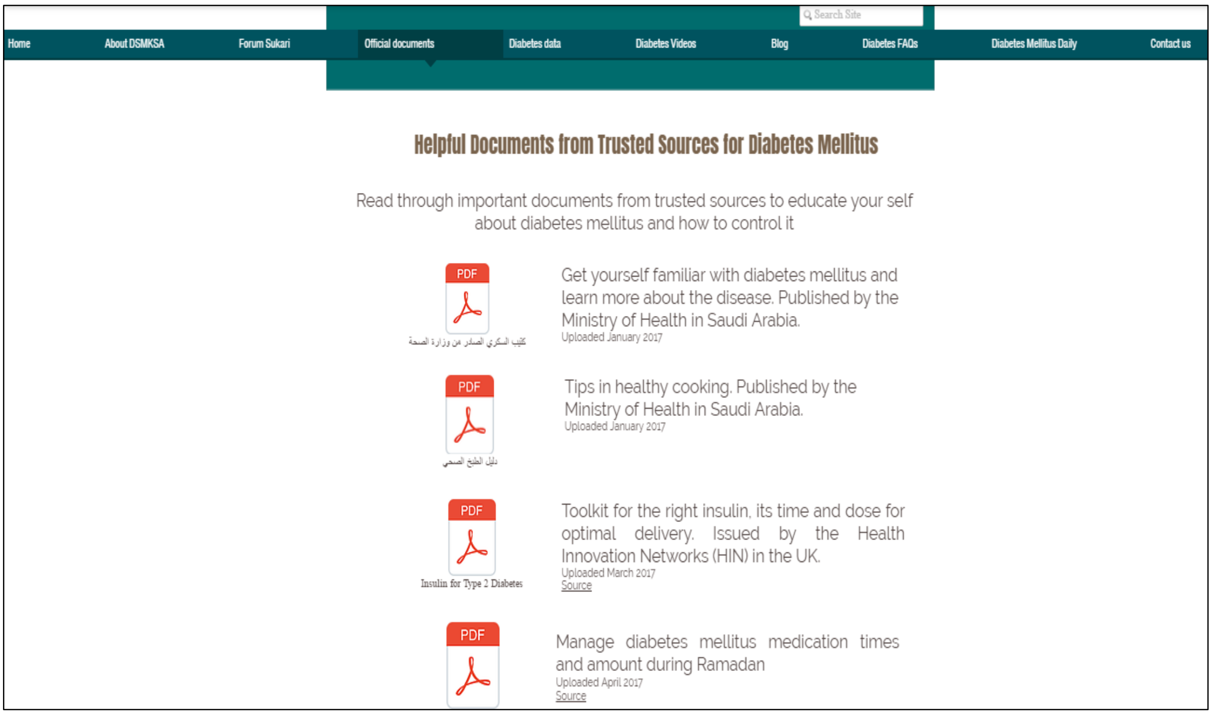

Figure 7.15. Official documents page in DSMKSA

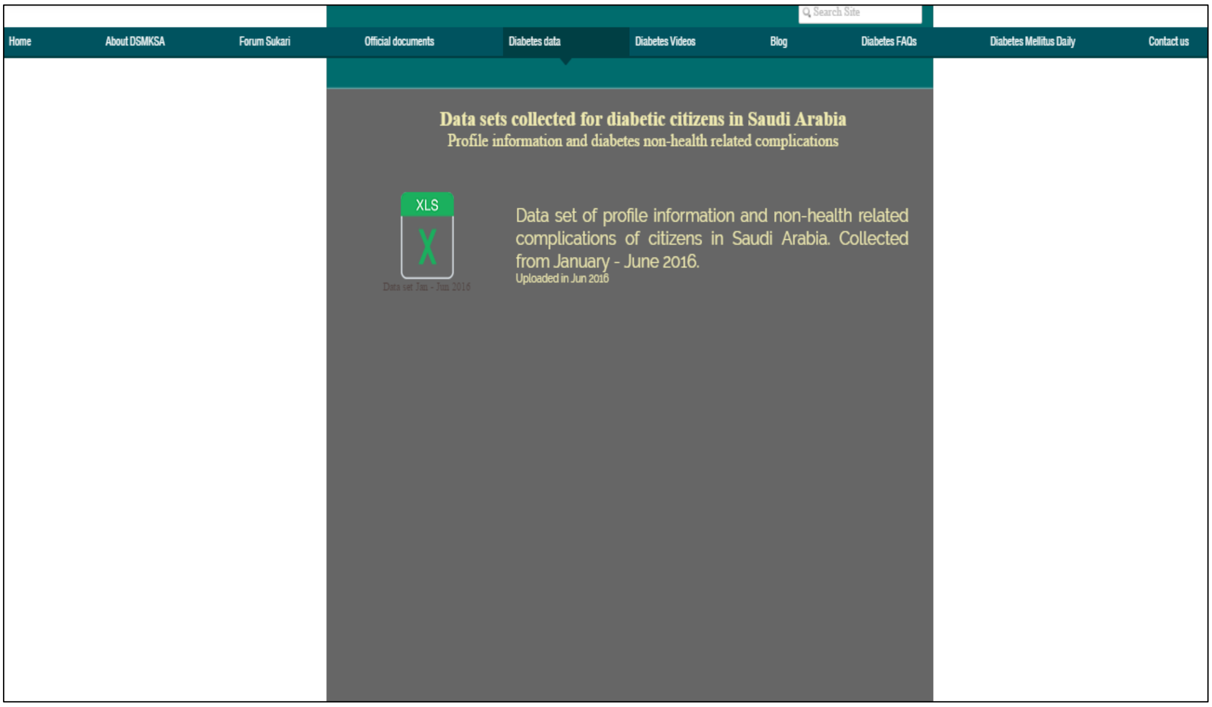

Figure 7.16. Diabetes datasets page in DSMKSA

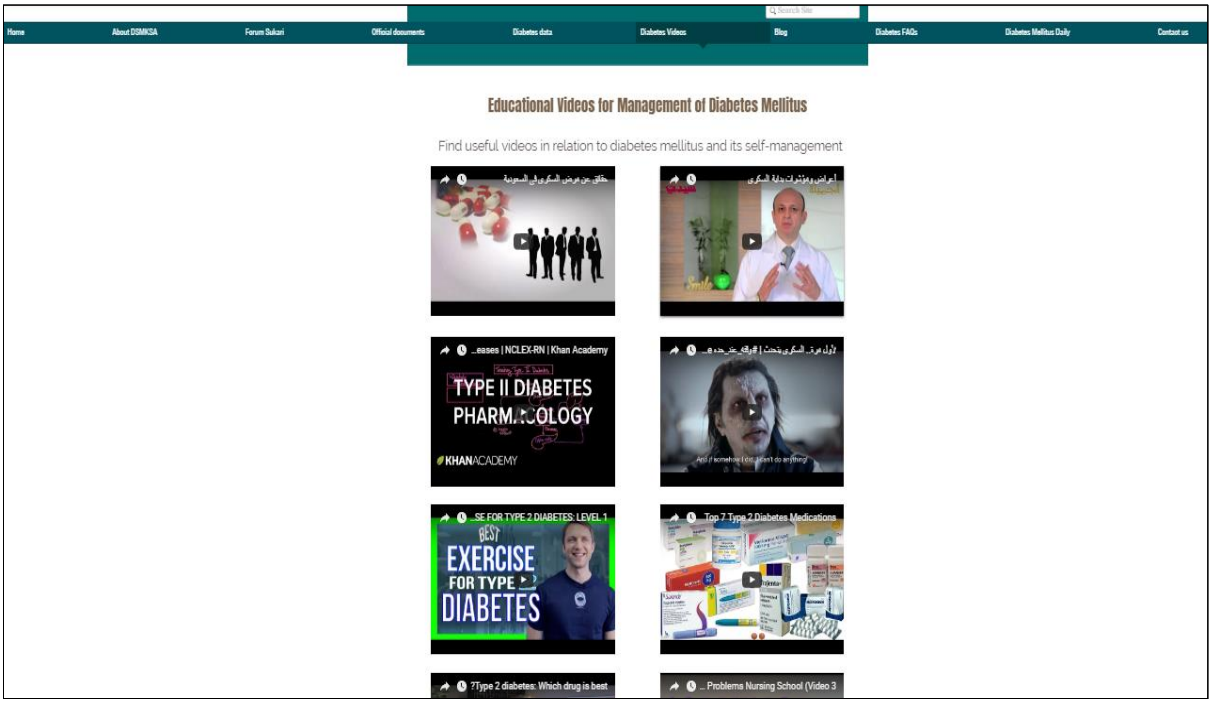

Figure 7.17. Diabetes videos page in DSMKSA

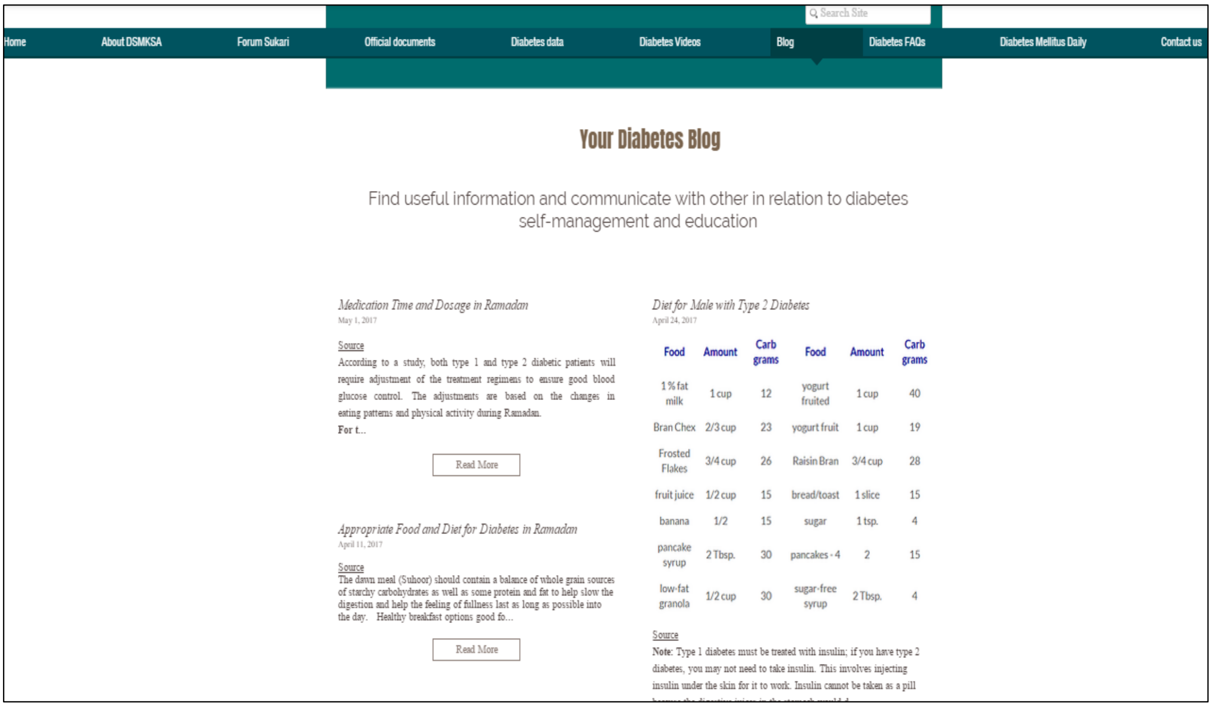

Figure 7.18. Blog page in DSMKSA

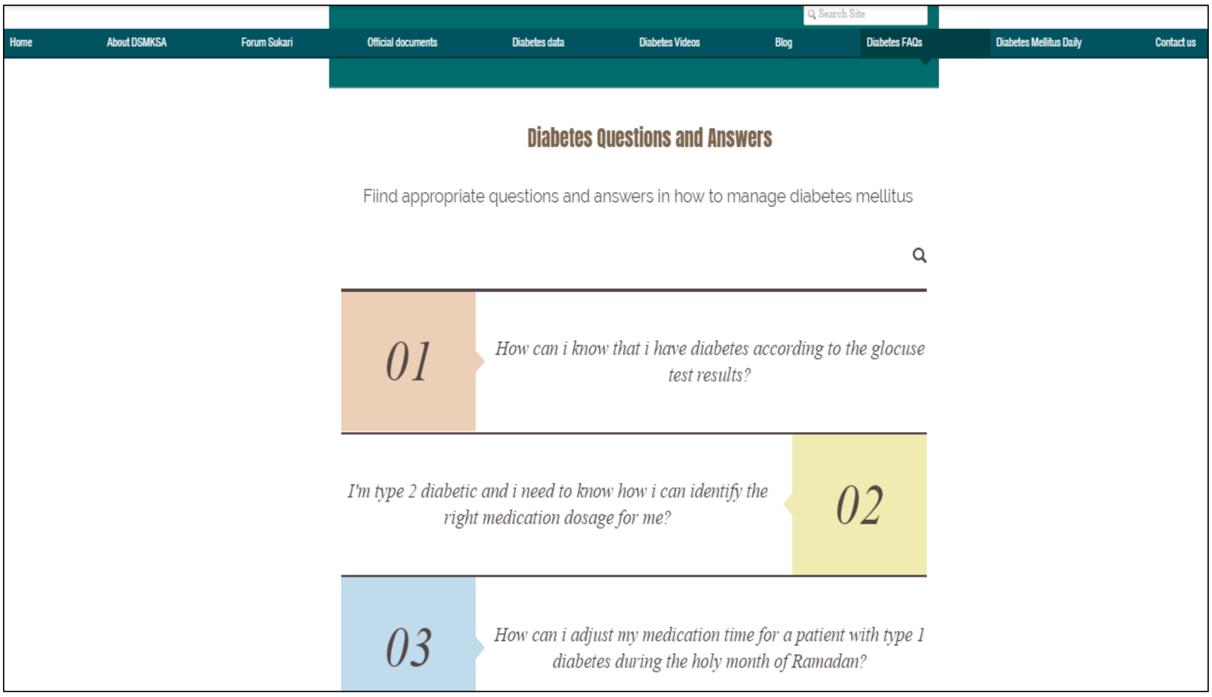

Figure 7.19. Questions and answers page in DSMKSA

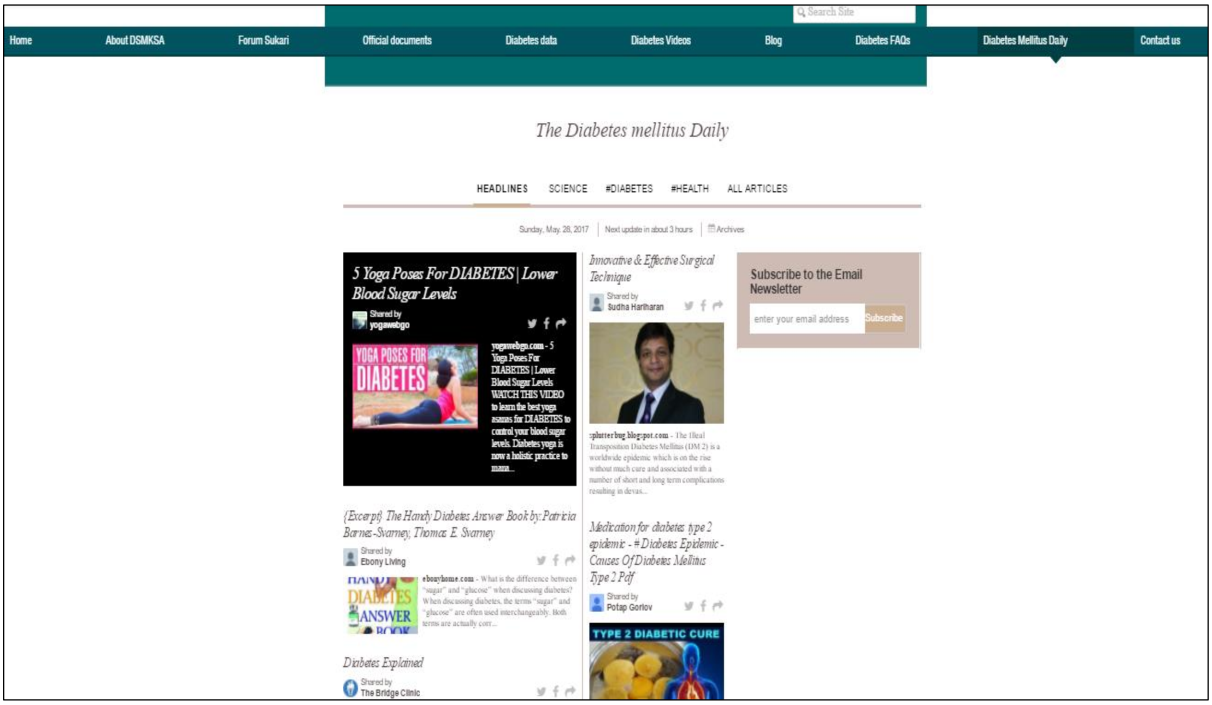

Figure 7.20. Diabetes Daily news page in DSMKSA

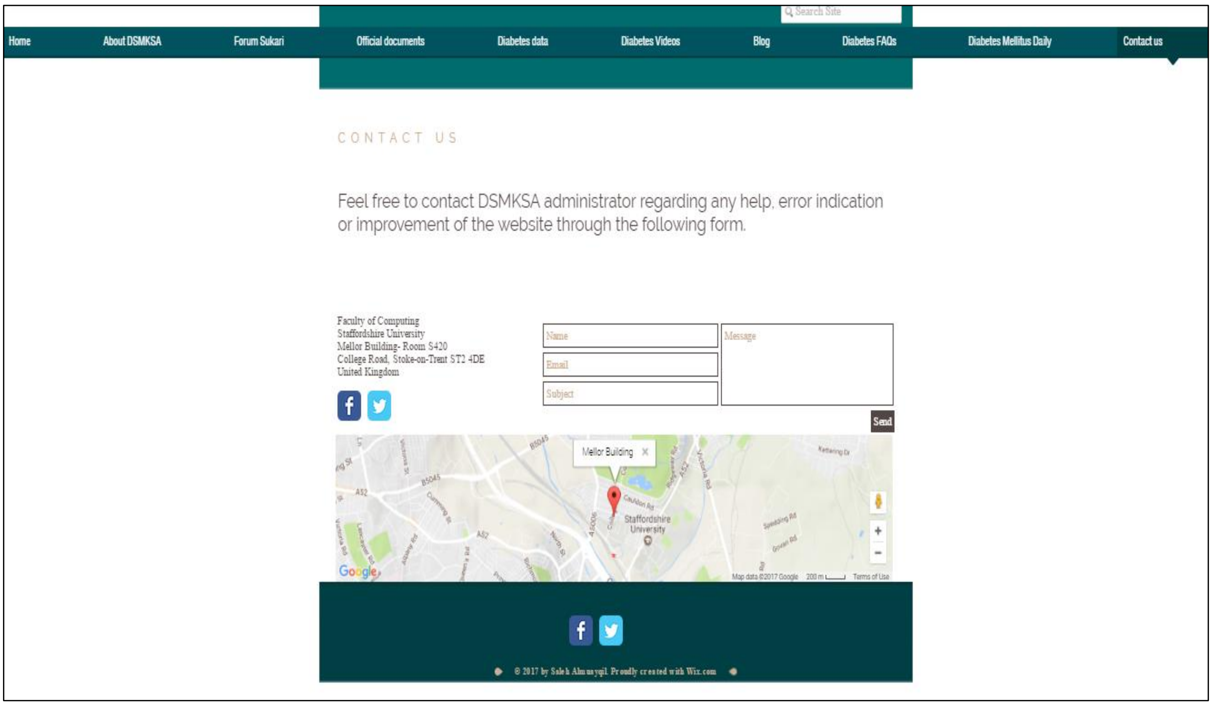

Figure 7.21. Contact us page in DSMKSA

7.6 Conclusion

Internet technology nowadays plays a significant role in the facilitation of control of diabetes mellitus. In this chapter, a web portal was designed to support diabetic citizens in Saudi Arabia to manage their diabetes difficulties. The web portal aims to address the non-health-related complications revealed from our DM study in Chapter Six. Our web portal disseminates knowledge related to diabetes self-management and education. Therefore, different technologies are implemented in our web portal, including forums to support socialisation, blogs to support externalisation and combination, diabetes videos and wikis to support internalisation and so on.

The design of our web portal was accomplished using the layout approach. After the web portal was built, we conducted a usability evaluation session using the heuristic evaluation approach. The results from the evaluation shows good usability standards for our web portal. In the following chapter, we discuss the validation of our framework and the evaluation of our designed web portal.

Chapter Eight: Validation of the Framework and Evaluation of the Web Portal

8.1 Introduction

This chapter presents the validation and evaluation of our work. A workshop was held to conduct this part and consisted of two sessions. The first part focused on the validation of our integrated framework, whilst the second related to the evaluation of our web portal, DSMKSA. The workshop was held in a Primary Healthcare Center (PHC) in Saudi Arabia and was carried out with nine participants who participated in both sessions.

8.2 The Framework Validation

One of the main objectives in this thesis is to validate the developed framework. Validation can be defined as a set of processes which aim to determine how accurately a model represents the real world from the perspective of the intended uses of the model (Sommerville and Prechelt, 2008). In this research, the proposed framework is validated through a panel of diabetic citizens, healthcare professionals and IT specialists who have adequate computing experience. The validation session took place in a workshop held in a PHC in Saudi Arabia. The validation workshop was followed by an evaluation session, in the same workshop, to evaluate the web portal design for this study. As the two workshops were linked with each other, participants who participated in the framework validation session were also involved in the evaluation process of our web portal. Both workshops had nine participants. According to Nielsen and Molich (1990), aggregate of five participants can indicate about two-third of the issues in an evaluation study. Furthermore, expanding the number of participants from five to ten wouldn't affect the result.

The framework is validated although its conduction of real results related to layer 1 - e-health barriers and diabetes complications, and layer 2 - knowledge capturing through DM. Chapter Five has investigated e-health barriers hindering e-health's successful utilisation in Saudi Arabia, which are related to layer 1. Chapter Six focuses on layer 2 as it has mined non-health-related complications data of diabetes mellitus encountered by Saudi Arabian diabetic citizens. In this chapter, the framework is further validated to ensure its capabilities in addressing e-health barriers and supporting diabetic citizens in

Saudi Arabia, through the integration of two fields of study, namely knowledge management and data mining.

8.3 Validation Proses

8.3.1. Design of the validation

The validation session took place in a PHC in Saudi Arabia. The validation of our framework is carried out with nine participants relating to three different groups: diabetic citizens, healthcare professionals and IT specialists. The validation session was conducted in a workshop with the intended participants. The workshop lasted approximately five hours divided between validation and evaluation. The process of the validation session took around two hours and 30 minutes as follows:

1. A presentation is given focusing on the aim and objectives of this study and the framework. The framework was presented to participants with a description of all its components and capabilities (see Figure *8.1*).

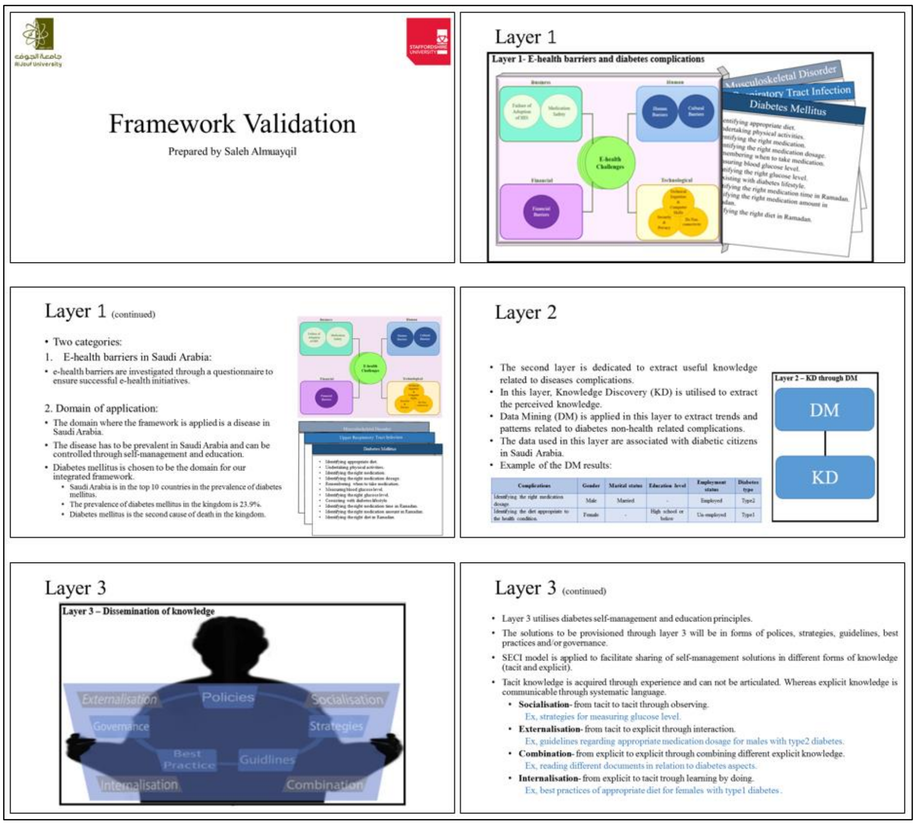

Figure 8.1. Validation slides

2. Follows the presentation, the findings from our e-health barriers study and the knowledge discovered from our survey related to non-health-related complications of Saudi Arabian diabetic citizens.
3. The application of our web portal to demonstrate the integration of KM and DM is also presented (see Figure *8.2*).

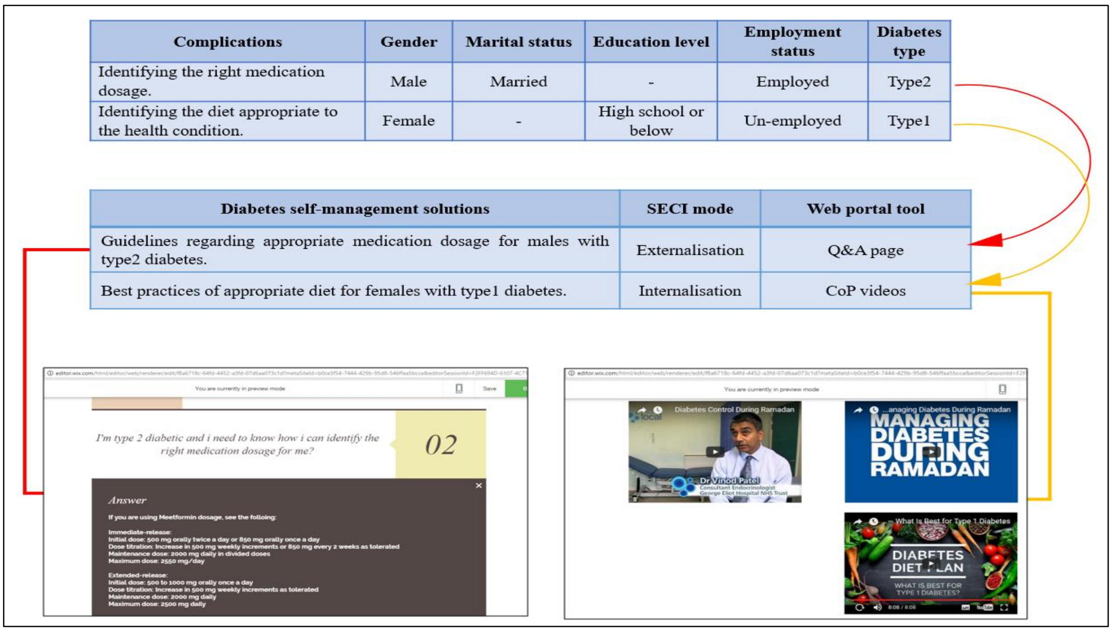

Figure 8.2. Scenario of framework and web portal implementation using real results from our study

4. Discussion session with participants. Participants were invited to ask questions related to the framework and its associated components, and given opportunities to comment in relation to the validation form.
5. The validation form was given to participants. The design of the validation form contained four parts. The first part contained a statements relating to the consent form and the ethical consideration of the study. In the first part, participants also indicated their understanding of the research and its objectives. In the second part, participants were asked to specify their role in healthcare by choosing among diabetic citizens, healthcare professionals and IT specialists. Participants were also asked to specify their years of experience in healthcare. In the third part of the validation form, participants were asked to answer multiple choice questions. In each statement, participants read the statement and specified their answers in the scale from strongly disagree, with a value of one, to strongly agree where, with the value of five. The last part of the validation form contained two open-ended statements. In the first statement, participants were asked to add their comments,

views and suggestions in relation to improvement of the framework. In the second statement participants were asked to mention any factor that can hinder the application of the framework by Saudi Arabian citizens (see appendix C.1).

8.3.2. Participants' profile

When the participants were provided with the validation form during the workshop, the majority of participants completed the form immediately. However, some participants preferred to spend more time on the framework and the validation form. Therefore, all participants in the workshop were provided with the presentation slides and the contact information of the researcher in case they had any questions. A few days later, all nine participants who attended the workshop completed the forms of validation and evaluation. Despite participants' representation of different categories, participants were selected to participate in this study based on their knowledge and expertise in computing. That is, all participants have sufficient expertise in the field of computing and a good understanding to the area of KM in particular. The profile of participants is summarised in Table *8.1* and illustrated in Figure *8.3* as follows:

Table 8.1. Profile information of participants to the validation study of our framework

Participants group	Participant ID	Years of experience						
		Less than 1 year	1 -5	6-10	11-15	16-20	21-25	Over 25 years
Diabetic citizens	P1		√					
	P2		√					
	P3			√				
Healthcare professionals	P4			√				
	P5				√			
	P6				√			
IT specialists	P7		√					
	P8				√			

Participants group	Participant ID	Years of experience						
		Less than 1 year	1 -5	6-10	11-15	16-20	21-25	Over 25 years
	P9						√	

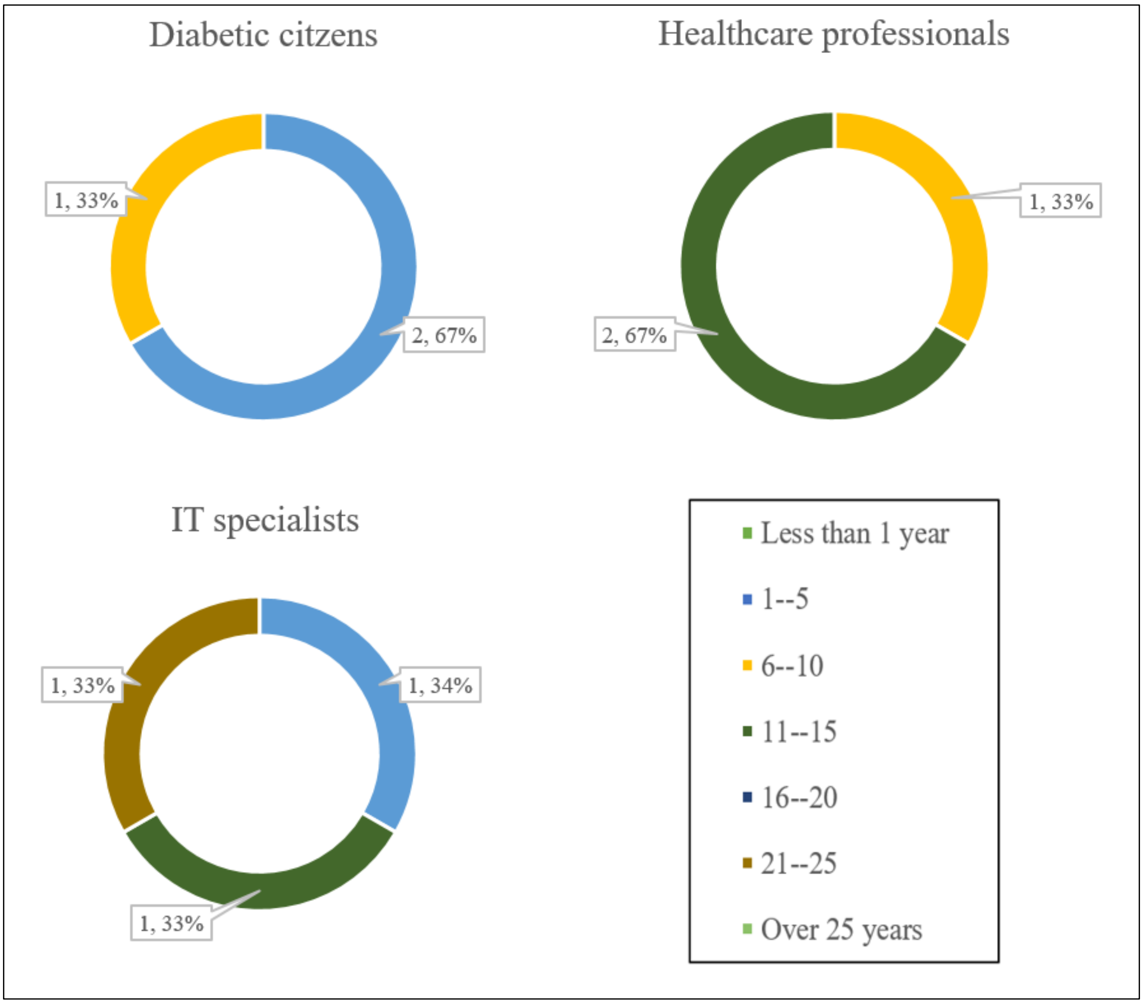

Figure 8.3. Experience of participants in healthcare

8.4 Findings and Discussion of the Validation

Our integrated framework was validated based on its three layers, and in terms of the consideration of e-health challenges, new knowledge about diabetes diseases in Saudi Arabia and KM of diabetes disease. A set of statements is given to the participants to indicate the extent that they agree or disagree with each statement.

8.4.1. E-health barriers and prevalent diseases in Saudi Arabia

The validation of the first layer is accomplished through three statements. The first focused on e-health issues in Saudi Arabia. Two diabetic citizens strongly agreed and one agreed with this statement. Two healthcare professionals and two IT specialists agreed and one participant from each group strongly agreed with this statement (mean= 4.44).

In the second statement which relates to diabetes diseases in Saudi Arabia, two diabetic citizens agreed and one strongly agree with this statement. Two healthcare professionals strongly agreed with this statement whilst one healthcare professional participant agreed. All three IT specialists who participated in this validation study strongly agreed that our framework addresses relevant diseases in Saudi Arabia (mean=4.67).

The third statement tests to what extent the integrated framework addresses appropriate issues related to diabetes mellitus. Two diabetic citizen agreed with this statement whilst one agreed strongly. Two healthcare professionals agreed strongly with this statement whereas one participant agreed. Similarly to healthcare professionals, two IT specialist participants strongly agreed and one IT specialist agreed with this statement (mean= 4.56) (see Figure *8.4*).

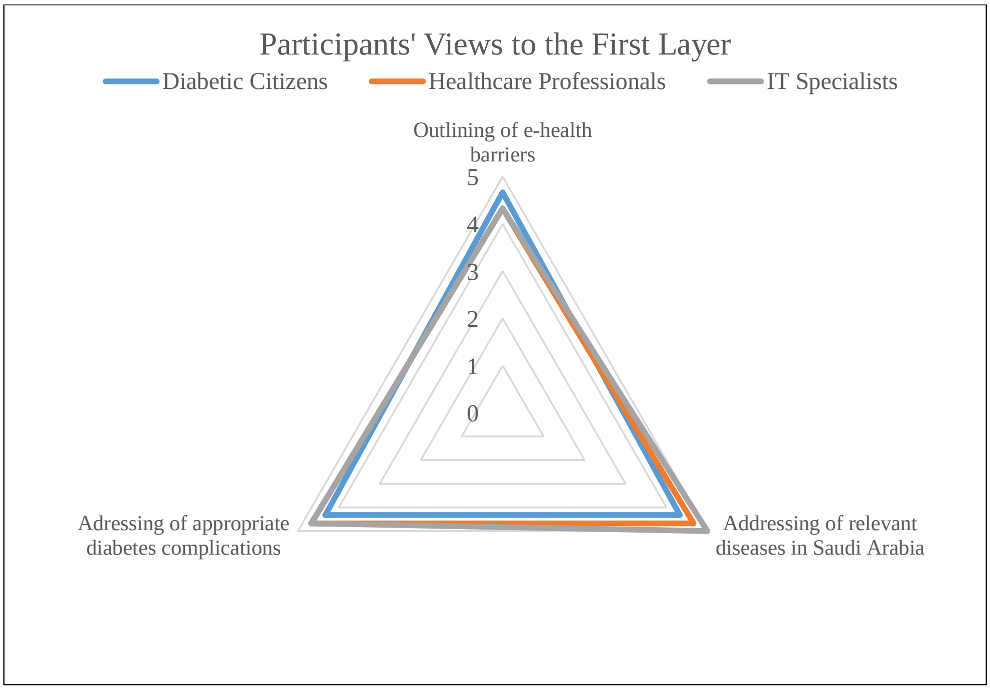

Figure 8.4. Feedback of participant groups to statements related to the first layer

8.4.2. Knowledge discovery about diabetes issues

The validation of the knowledge mining capabilities with our integrated framework is accomplished through one statement, assessing whether the framework has captured new knowledge related to diabetes mellitus. Two diabetic citizens and two IT specialists agreed with this statement and one participant from each group strongly agreed. Two healthcare professionals, however, strongly agreed with this statement whereas one participant agreed (mean=4.44) (see Figure *8.5*).

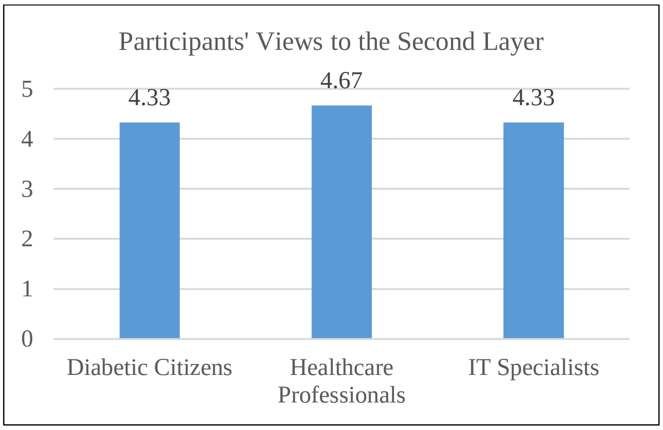

Figure 8.5. Feedback of participant groups to stamens related to the second layer

8.4.3. Knowledge dissemination

The third layer to be validated in our integrated framework is the ability to disseminate useful knowledge. This capability is validated through six statements. The first statement tests whether guidelines, best practices, policies, strategies and governance are able to assist diabetic citizens in Saudi Arabia with the non-health-related complications of diabetes mellitus. Two diabetic citizens and two IT specialists agreed and one participant from each group strongly agreed with this statement. Two healthcare professionals strongly agreed with this statement whilst one participant agreed (mean= 4.44).

The second statement in the knowledge dissemination dimension measures whether the framework provides a mechanism to share useful knowledge to diabetic citizens and healthcare professionals. Three diabetic citizens agreed with this statement. Two healthcare professionals and two IT specialists, however, agreed with this statement whilst one participant from each group chose the neutral option with this statement (mean= 3.89).

The third statement in this dimension measures whether our integrated framework facilitates sharing of tacit strategies among different individuals. Participants from each participants' group shared the same responses, as two participants agreed with this statement and one participant strongly agreed (mean= 4.33).

The fourth statement in the knowledge dissemination dimension measures whether our integrated framework provides an approach to convert guidelines from its tacit form of knowledge into explicit. Diabetic citizens and IT specialists responded similarly to this statement as, from each participants' group, two participants agreed and one participant strongly agreed with this statement. Two healthcare professionals agreed with this statement and the remaining healthcare professional participant chose the neutral answer (mean= 4.11).

In the fifth statement, whether the framework facilitates sharing of different explicit policies among different individuals, diabetic citizens and healthcare professionals shared the same answers. From each group of participants, two participants agreed and one participant strongly agreed with this statement. From the IT specialist participants group, however, two participants agreed with this statement whilst one participant chose the neutral answer (mean= 4.11).

The last statement in the knowledge dissemination dimension measures to what extent the framework supports the conversion of explicit best practices into tacit. Diabetic citizens and healthcare professionals shared the same answers, as from each participants group, two participants agreed and one participant strongly agreed with the statement. The three IT specialists who participated in this validation study shared the same answer, as all of them agreed to this statement (mean= 4.22) (see Figure *8.6*).

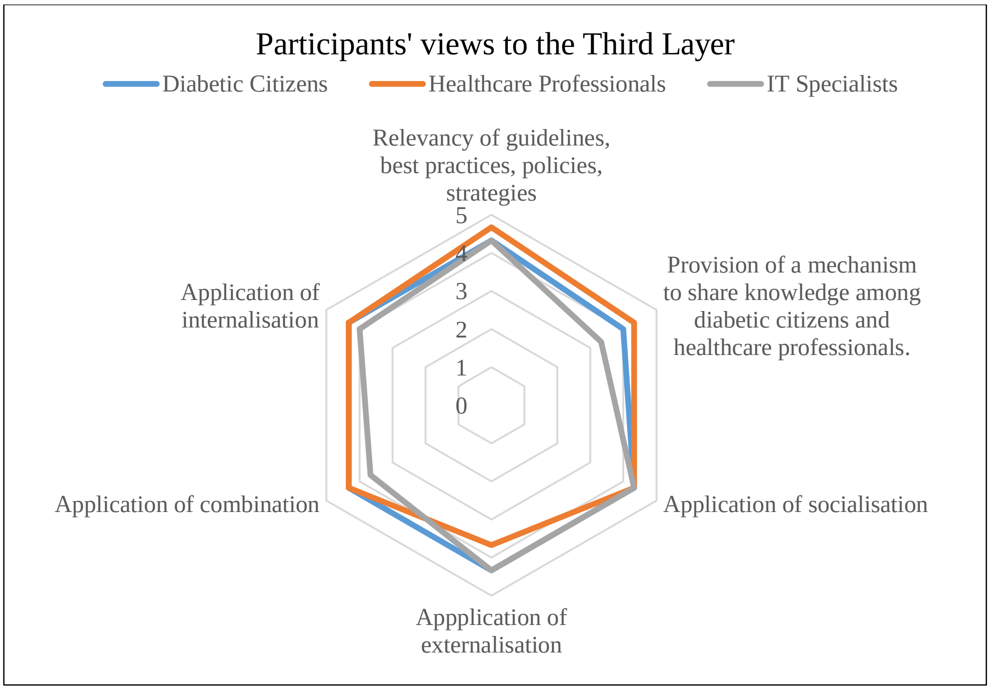

Figure 8.6. Feedback of participant groups to stamens related to the third layer

8.4.4. Qualitative feedback

Furthermore, the validation of our framework contained two open-ended statements to give further comments on any specific issues. Improvements and/or hindrances from using it. One participant suggested that the direction of the flow of the diagram from layer 1, e-health barriers and diabetes complications, and layer 2, the KD through DM, to layer 3, the knowledge management and dissemination, should be clarified. Therefore the head of the two arrows have been modified to be pointing towards layer 3 to indicate that the data flow from layer 1 and layer 2 feeds into layer 3 and not the other way around. In addition, another participant suggested clarifying the other KD approaches than can be used in the framework. This modification is also added in the revised framework in Section 8.5.

8.5 Validation Results Summary and Improvement of the Framework

The views of every participant group were also analysed to determine their views towards each layer of our framework. The analyses show consistency between the analyses of each group view to each layer with the analysis in the previous section, where the analyses of each statement within each layer took place (see Table *8.2*).

Table 8.2. Participants' feedback to the framework based on each layer and each participants' group

	Layer 1				Layer 2		Layer 3						
Statements	Outlining of e-health barriers	Addressing of relevant diseases in Saudi Arabia	Addressing of appropriate diabetes complications	**Mean for Each Group**	Capturing of knowledge related to diabetes mellitus	**Mean for Each Group**	Relevancy of guidelines, best practices, policies, strategies	Provision of a mechanism to share knowledge among diabetic citizens and healthcare professionals.	Application of socialisation	Application of externalisation	Application of combination	Application of internalisation	**Mean for Each Group**
Diabetic Citizens	4.67	4.33	4.33	4.44	4.33	4.33	4.33	4.00	4.33	4.33	4.33	4.33	4.28
Healthcare Professionals	4.33	4.67	4.67	4.56	4.67	4.67	4.67	4.33	4.33	3.67	4.33	4.33	4.28
IT Specialists	4.33	5.00	4.67	4.67	4.33	4.33	4.33	3.33	4.33	4.33	3.67	4.00	4.00
Mean for Each Statement	4.44	4.67	4.56	**4.56**	4.44	**4.44**	4.44	3.89	4.33	4.11	4.11	4.22	**4.18**

Diabetic participants ranked the first layer as the highest among the other layers (mean= 4.44). The second layer is ranked second by this group of participants (mean= 4.33). The third layer was ranked third by diabetic citizen participants based on their mean score of their answers (mean= 4.28). Healthcare professionals indicated their satisfaction with the framework's support to all its layers. This group of participants ranked the second layer first as the answers to its statements gained the highest mean value (mean= 4.67). The first layer became secondly (mean= 4.56) and the third layer was ranked thirdly by this group of participants. The IT specialists' ranking for each layer is similar to the diabetic citizens ranking, as the first layer became the first (mean= 4.67), the second layer came the second (mean= 4.33) and the third layer became the third place (mean= 4.00). This indicates that IT specialists are satisfied with the framework support of all its features (see Figure *8.7*).

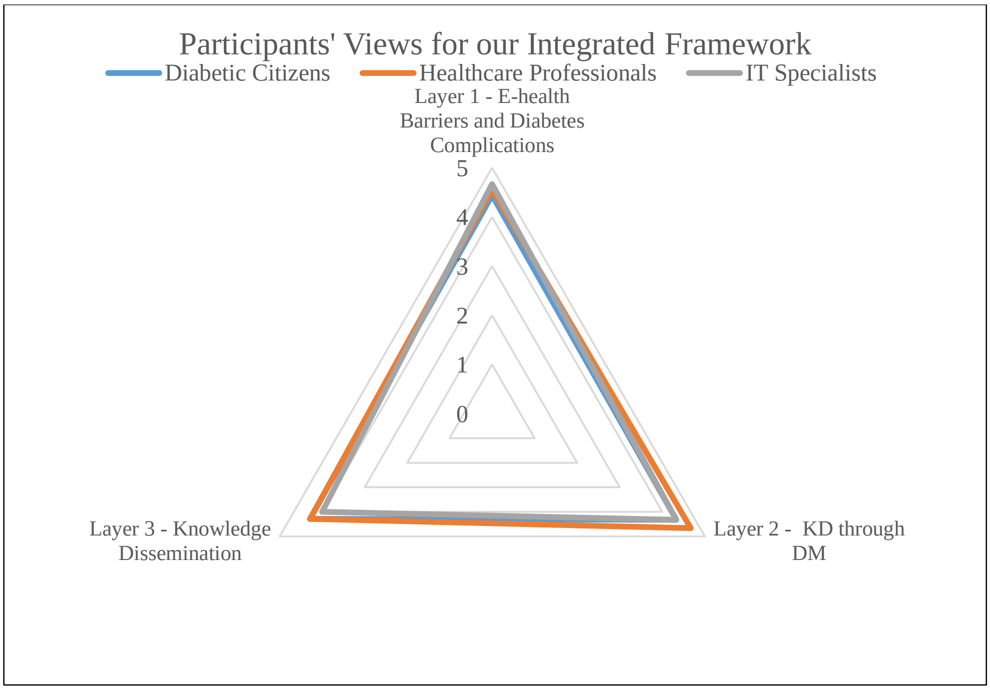

Figure 8.7. Participants' views to framework layers

The overall participants' views on each layer of our framework are also conducted to measure whether our findings are consistent with the mean scores of each group view to each layer; and each group's views to statements related the three layers. For statements concerning the first layer, e-health barriers and disease complications, the mean score of participants responses is extremely high (mean=4.56). This indicates that all participant groups are satisfied with the framework support of e-health barriers and appropriate diseases in Saudi Arabia. Participants also expressed their satisfaction with the knowledge extraction capabilities of our integrated framework based on the mean score of their responses (mean= 4.44). In relation to the third layer of our framework, participants were satisfied with the ability of our framework to disseminate appropriate knowledge (mean= 4.18) (see Figure *8.8*).

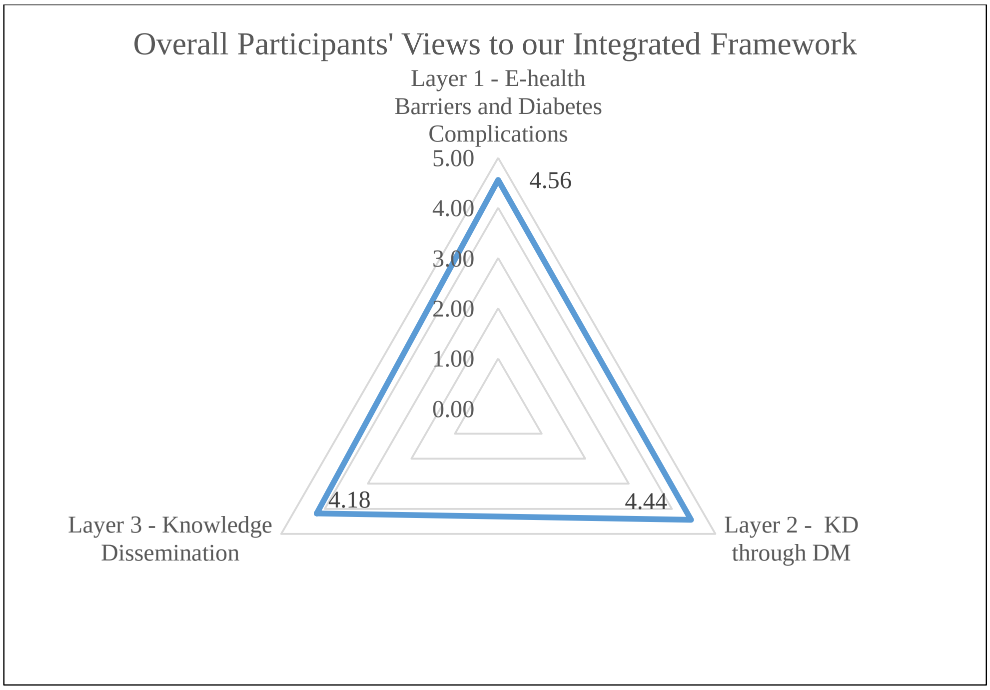

Figure 8.8. Overall participants' views to the framework components

The findings from our validation show that participants are satisfied with the capabilities of our integrated framework. Participants believe that our framework takes into account e-health barriers in Saudi Arabia. The e-health barriers included in our framework are consistent with our previous study which revealed a number of the e-health barriers. Participants also believed that our framework addresses appropriate diseases in Saudi Arabia, including diabetes mellitus and its complications. Diseases addressed in our framework are very common in Saudi Arabia and are in compliance with the official reports from the MOH in Saudi Arabia that the three disease being undertaken in our framework are mostly prevalent in the kingdom. These diseases are upper respiratory tract infection, musculoskeletal disorders and diabetes mellitus as illustrated in Chapter Four.

Participants also believe that the framework facilitates knowledge extraction and disseminates appropriate knowledge. The reason beyond this agreement might be the implementation of DM and other KD approaches that are feasible in discovering useful knowledge. Moreover, our framework implements a well-known model of knowledge creation that is widely utilised in different domains. Figure *8.9* shows that all participant groups indicated their agreement to the framework's support to all of its perceived functions. This includes the participants' satisfaction in relation to the ten different features of the framework.

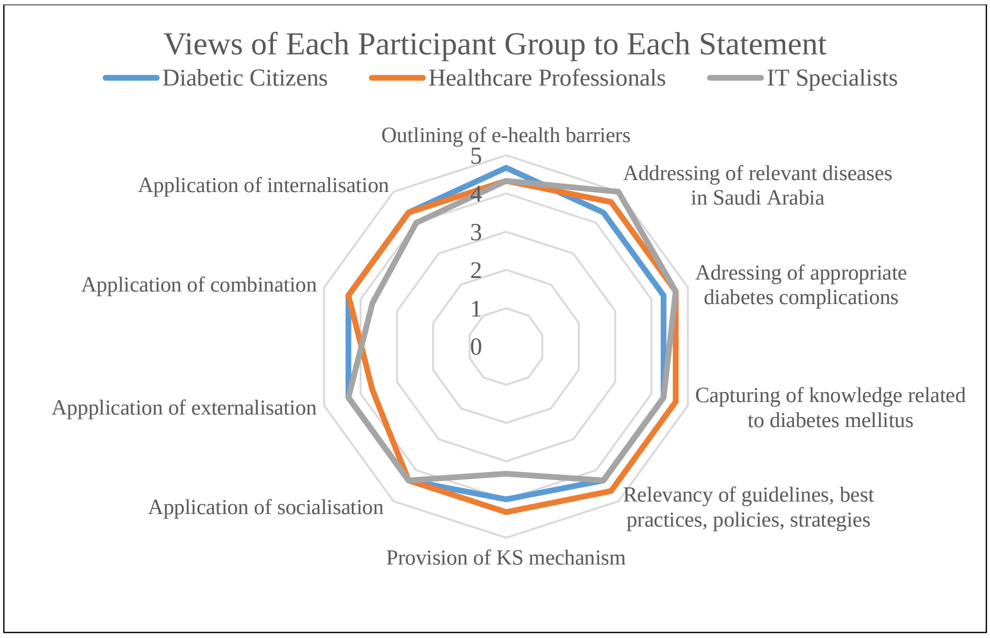

Figure 8.9. Participants' feedback to each function of the framework

As discussed in previous section, the qualitative feedback indicated that one participant suggested improving the design of our framework. The suggested improvement is to clarify the direction of flow of the data from layer 1 and layer 2 to layer 3. In addition, layer 2 is revised to indicate other KD approaches that can be used in this framework. The improved design of our integrated framework is presented in Figure *8.10* as follows.

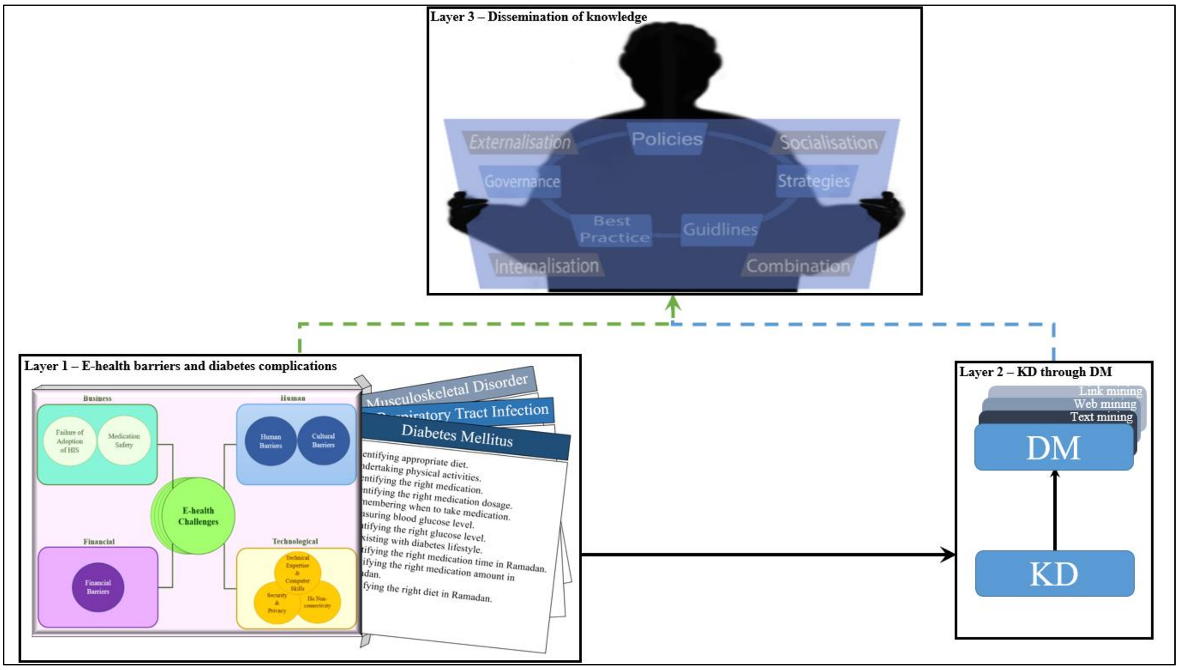

Figure 8.10. Improved framework after participants' feedback

8.6 DSMKSA Evaluation

Besides the framework validation, another major objective of this thesis is to evaluate the designed web portal. Evaluation differs from validation as the former aims to review processes, activities and strategies through the generation of a set of questions to determine whether the objectives of the project have been achieved (B Kahan and Goodstadt, 2005). According to Barbara Kahan (2008), evaluation helps in assessing the impact of a programme or a project and helps to determine whether the project has fulfilled its objectives.

In this study, our web portal, DSMKSA, is evaluated to ensure that it fulfils its objectives. DSMKSA is designed to embody the third layer of our integrated framework. The web portal disseminates diabetes self-management and education knowledge through the application of the SECI model. As stated in Chapter Four, DSMKSA will be evaluated to ensure that it utilises our proposed framework properly. The evaluation session took place in an evaluation workshop. The evaluation session followed the validation session in the same workshop. This allowed the same participants who participated in the framework validation to be involved in the evaluation study of our web portal.

8.7 Evaluation Process and Design

The DSMKSA evaluation study took place in the validation and evaluation workshop after the framework validation session ended. The workshop took place at the same PHC in Saudi Arabia and with the same participants as the validation. Similar to the validation part of this workshop, the web portal evaluation session took two and half hours and followed similar procedures, as follows:

1. A 60-minute presentation. The aim of the web portal is described to participants. Participants were also provided with the type of web tools used in DSMKSA to support different modes of the SECI model (see Figure *8.11*).

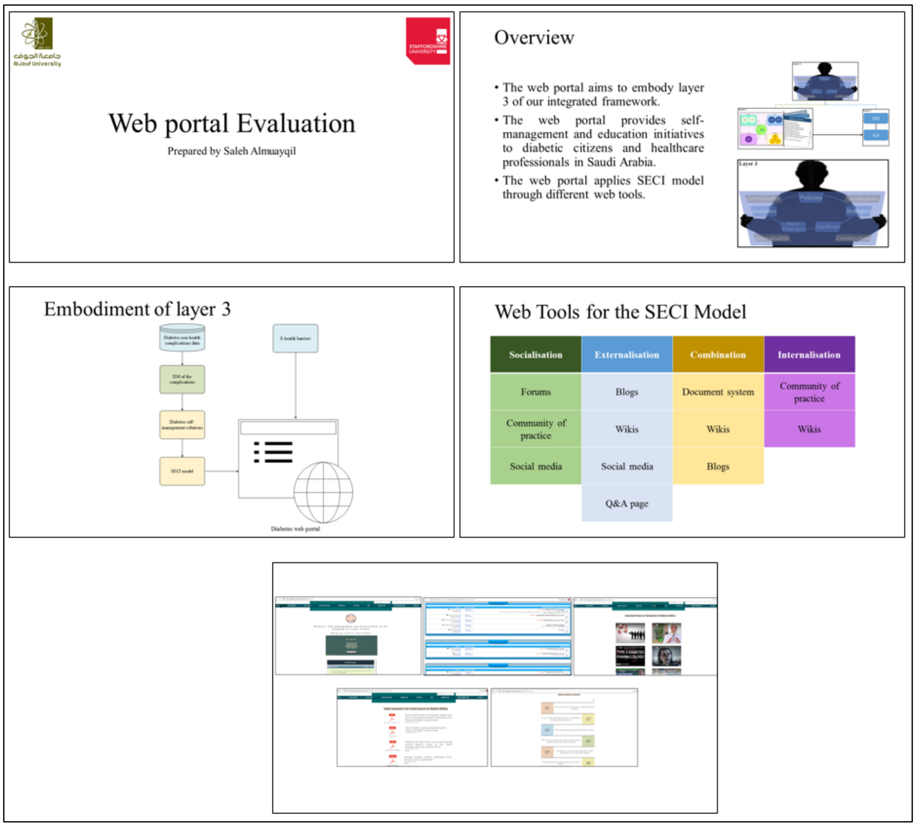

Figure 8.11. DSMKSA evaluation slides

2. Participants' utilisation of the web portal. Participants took their time in using DSMKSA and were allowed to ask any questions in relation to the web portal. This session took approximately 60 minutes.
3. Evaluation forms were given to participants.

The DSMKSA evaluation form contained four parts. The first part was contained statements related to participants' understanding of the research, their agreement to participate and their ethical rights of the research. The second part concerned with the profile information of participants, such as their role in the healthcare domain and their years of experience. The third part contained multiple choice statements about the application of the SECI model in DSMKSA. In this part, participants were asked to choose between strongly disagree to strongly agree, where one represents strongly disagree and five represents strongly agree. The fourth part of the evaluation contained one open-ended statement where participants can add comments in relation to improving the web portal (see Appendix C.2).

Similar to the validation session, some participants preferred to take more time in responding to this evaluation form. Consequently, all participants in the workshop were provided with the evaluation slides, the evaluation form and the contact information of the researcher in case of any issues encountered by participants. All participants who were involved in the evaluation session completed the evaluation form in a few days after the evaluation workshop.

8.8 Evaluation Findings

The evaluation of our web portal is implemented in terms of its application for each mode of the SECI mode. Therefore, the evaluation responses are analysed in four categories, where each category represents one SECI model application.

8.8.1. Socialisation

The evaluation contained three statements to measure the application of the socialization mode in DSMKSA. In the first statement, which measured if forums apply socialisation in our web portal, all participants expressed their agreement that forums are an effective tool to apply socialisation in DSMKSA. From the diabetic citizen participants, two agreed to this statement and one strongly agreed. All healthcare professionals strongly agreed to this statement. IT specialists, moreover, agreed that forums are an effective tool to apply socialisation in DSMKSA (mean= 4.44).

The next statement in the socialisation dimension tests whether CoP are effective in applying socialisation in DSMKSA. The majority of participants expressed their agreement to this statements as two diabetic citizens agreed with this statement whilst the remaining diabetic citizen participant strongly agreed. From the healthcare professionals group of participants, two participants strongly agreed that CoP are effective in applying socialisation in DSMKSA whilst the remaining healthcare professional chose a neutral response. Similar to the diabetic citizen participants, IT specialists expressed their agreement to this statement as two IT specialists agreed to this statement and one participant strongly agreed (mean=4.33).

The third statement in this dimension tested whether social media are effective in applying socialisation in DSMKSA. Diabetic citizens and IT specialists shared the same view regarding this statement, as two participants strongly agreed and one participant from each group agreed whereas one participant from each group agreed with this statement.

All healthcare professionals, however, strongly agreed that social media are effective tools in applying socialisation in DSMKSA (mean= 4.78) (see Figure *8.12*).

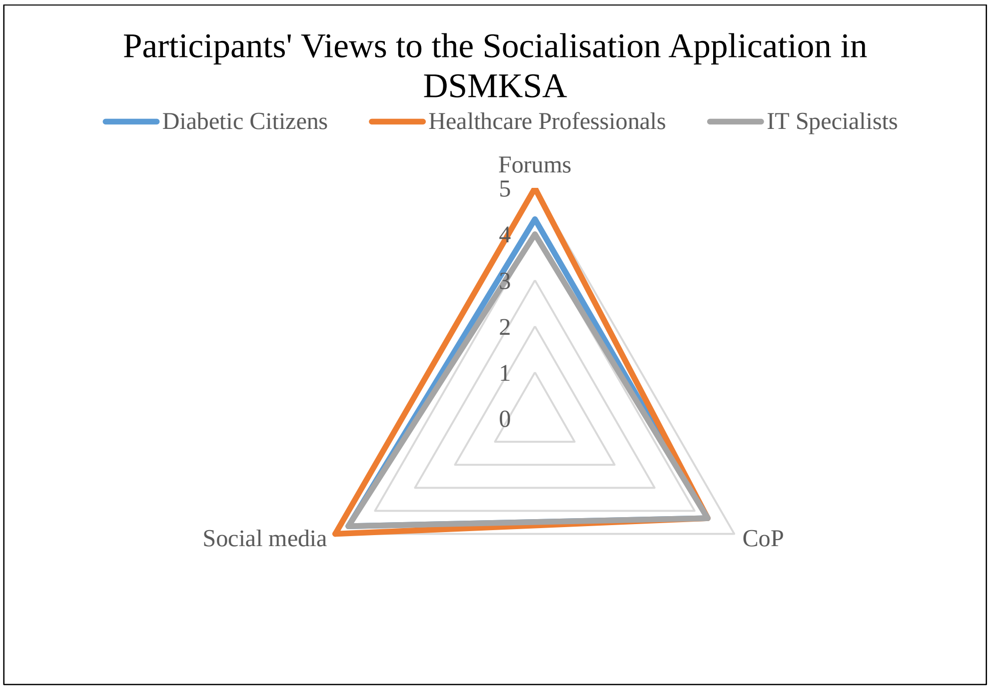

Figure 8.12. Participants’ feedback to statements related to the application of socialisation in DSMKSA

8.8.2. Externalisation

The second dimension in the evaluation of DSMKSA includes four statements to measure the application of externalisation in our web portal. In the first statement, whether blogs are effective in applying externalisation in DSMKSA, two diabetic citizen participants agreed to this statement whilst the remaining diabetic participant strongly agreed with the statement. In the healthcare professionals group of participants, the answers to this statements are divided equally as one participant strongly agreed and another participant agreed with this statement. The remaining healthcare professional participant chose the neutral option for this statement. IT specialists, however, were similar to the diabetic citizen participants, as two participants agreed and one participant strongly agreed that blogs are effective in externalizing knowledge in DSMKSA (mean= 4.22).

In the second statement, wikis are effective tools to apply externalisation in DSMKSA, two diabetic citizens agreed with this statement and one strongly agreed. In the healthcare professionals group of participants, one participant strongly agreed with this statement, one agreed and one participant chose the neutral option. In the IT specialists group of participants, two participants strongly agreed with this statement and one participant agreed (mean= 4.33).

The third statement measure whether social media are effective in applying externalisation in DSMKSA. Two diabetic citizens agreed to this statement and the remaining diabetic participant strongly agreed. Two healthcare professionals agreed with this statement whilst one healthcare professional chose the neutral option. From the IT specialists group of participants, two participants strongly agreed that social media are effective tool to apply externalisation in DSMKSA, whereas the remaining IT specialist participant agreed with this statement (mean= 4.44).

The last statement in the externalisation dimension tests the usefulness of the Q&A page in applying externalisation in DSMKSA. Participants from the diabetic citizens expressed their agreement to this statement, as two diabetic citizens strongly agreed and one diabetic citizen agreed with this statement. The three healthcare professionals who participated in this evaluation strongly agreed that the Q&A page applies externalisation effectively in DSMKSA. In the IT specialist group of participants, two participant agreed and one participants strongly agreed to this statement (mean= 4.67) (see Figure *8.13*).

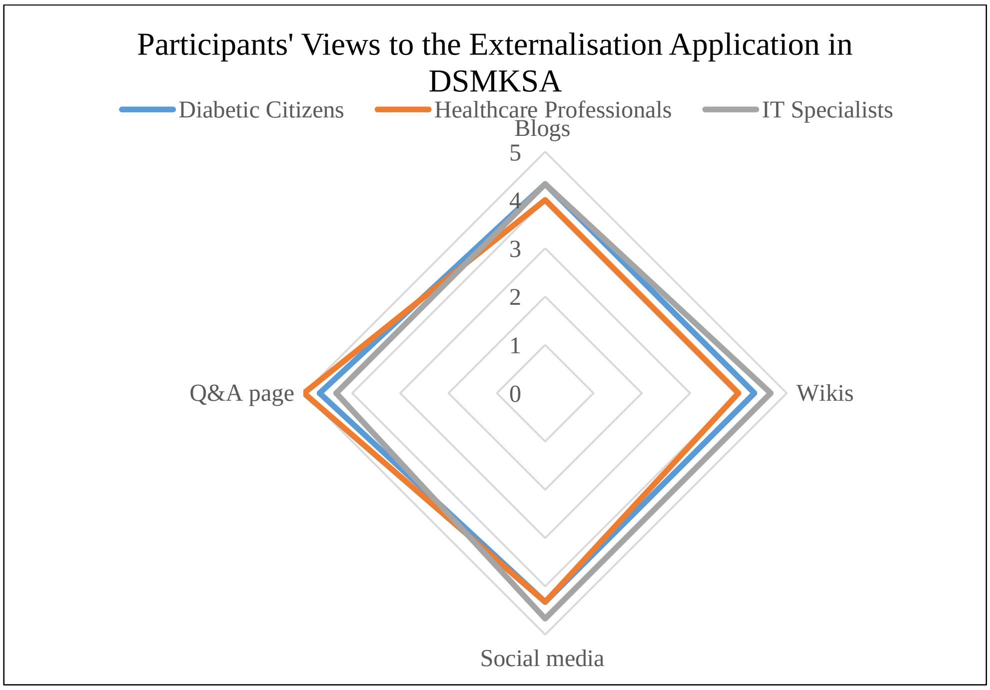

Figure 8.13. Participants' feedback to statements related to the application of externalisation in DSMKSA

8.8.3. Combination

The third dimension in this evaluation session measures to what extent the combination mode is applied in DSMKSA. Three statements were presented to participants in this dimension. In the first statement, the official documents page is effective in applying combination in DSMKSA, diabetic citizens and healthcare professionals answered this statement similarly as, from each group of participants, two strongly agreed and one agreed to this statement. IT specialists, however, answered this statement differently, as one participant from this group of participants strongly agreed, one agreed and one chose neutral in relation to this statement (mean= 4.44).

The second statement measures whether wikis are effective in applying combination in DSMKSA. In the diabetic citizen participants group, two participants strongly agreed with this statement whereas the remaining diabetic citizen agreed. Two healthcare professional participants, however, were not sure in relation to this statement as they chose the neutral option whilst the remaining healthcare professional participant strongly agreed with this statement. IT specialists expressed their agreement to this statement as two IT specialists participants agreed to this statement and the remaining participant strongly agreed (mean= 4.22).

The third statement tests whether blogs are effective tools for combination in DSMKSA. From the three diabetic citizens who participated in this study, two participants strongly agreed and one participant agreed with this statement. In the healthcare professional participants, however, one participant strongly agreed and one participant agreed with this statement whilst the remaining healthcare professional participant chose the neutral option. In the IT specialist participants' group, the answers were similar to the diabetic citizen participants, as two participants strongly agreed with this statement and one participant agreed (mean= 4.44) (see Figure *8.14*).

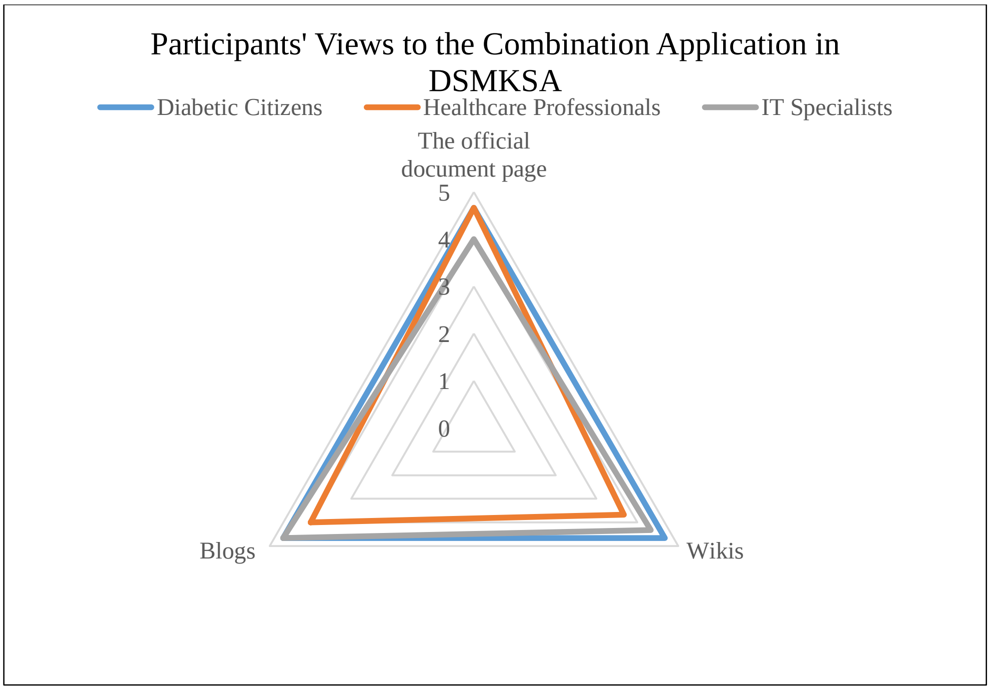

Figure 8.14. Participants’ feedback to statements related to the application of combination in DSMKSA

8.8.4. Internalisation

In the fourth dimension of the DSMKSA evaluation, participants were presented with two statements in relation to the application of the internalisation mode in DSMKSA. In the first statement, CoP are effective in applying internalisation in DSMKSA, two diabetic citizen participants strongly agreed with this statement whilst one diabetic participant agreed. In the healthcare professional participants group, one participant strongly agreed with this statement, one agreed and one chose the neutral option. In the last participants group, IT specialists, two participants agreed with this statement whereas the remaining participant strongly agreed (mean= 4.33).

The second statement in the internalisation dimension measures to what extent wikis have applied the internalisation mode in DSMKSA. Two diabetic citizen participants agreed that wikis are effective tools in applying internalisation whilst one participant strongly agreed with this statement. Two healthcare professional participants strongly agreed with this statement whilst the remaining participant chose the neutral option. Similar to diabetic citizens, two IT specialists strongly agreed and one IT specialist agreed that wikis are effective tools for internalisation in DSMKSA (mean= 4.33) (see Figure *8.15*).

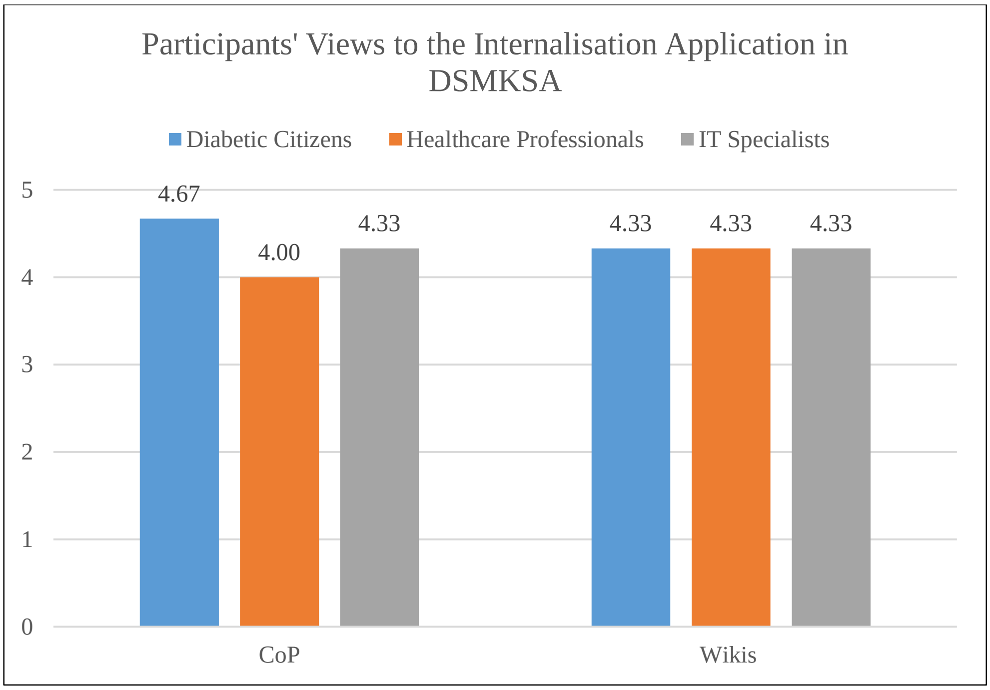

Figure 8.15. Participants' feedback to statements related to the application of internalisation in DSMKSA

8.9 Evaluation Results Summary

The analysis of the participant's feedback to the web portal evaluation shows their satisfaction towards the DSMKSA support of each mode of the SECI model. This section shows the overall mean score for each mode application based on the feedback from each group. The findings from this analyses show consistency with the findings from the analyses in Section 8.8 (see Table *8.3*).

Table 8.3. Participants' feedback to the web portal evaluation

	Socialisation				Externalisation					Combination				Internalisation		
Statements	Forum is an effective in socialisation in relation to diabetes self-management and education in DSMKSA.	Community of practices are effective in socialisation in relation to diabetes self-management and education in DSMKSA.	Social media are effective in socialisation in relation to diabetes self-management and education in DSMKSA.	**Mean for Each Group**	Blogs are effective in externalisation in relation to diabetes self-management and education in DSMKSA.	Wikis are effective in externalisation in relation to diabetes self-management and education in DSMKSA.	Social media are way in externalisation in relation to diabetes self-management and education in DSMKSA.	Diabetes Q&As page is effective in externalisation in relation to diabetes self-management and education in DSMKSA.	**Mean for Each Group**	The official document page is effective in integrating different explicit knowledge related to diabetes self-management and education in DSMKSA.	Wikis are effective in integrating different explicit knowledge related to diabetes self-management and education in DSMKSA.	Blogs are effective in integrating different explicit knowledge related to diabetes self-management and education in DSMKSA.	**Mean for Each Group**	Comity of practices in DSMKSA are effective in acquiring and internalising explicit knowledge related to diabetes self-management and education.	Wikis in DSMKSA are effective in acquiring and internalising explicit knowledge related to diabetes self-management and education.	**Mean for Each Group**
Diabetic Citizens	4.33	4.33	4.67	4.44	4.33	4.33	4.33	4.67	4.42	4.67	4.67	4.67	4.67	4.67	4.33	4.50
Healthcare Professionals	5.00	4.33	5.00	4.78	4.00	4.00	4.33	5.00	4.33	4.67	3.67	4.00	4.11	4.00	4.33	4.17
IT Specialists	4.00	4.33	4.67	4.33	4.33	4.67	4.67	4.33	4.50	4.00	4.33	4.67	4.33	4.33	4.33	4.33
Mean for Each Statement	4.44	4.33	4.78	**4.52**	4.22	4.33	4.44	4.67	**4.42**	4.44	4.22	4.44	**4.37**	4.33	4.33	**4.33**

Diabetic citizens believe that DSMKSA support combination better than any other mode (mean= 4.67). Diabetic citizens ranked the application internalisation in DSMKSA secondly (mean= 4.50). The application of socialisation came in the third place (mean= 4.44). Diabetic citizens ranked the application on externalisation in DSMKSA in fourth place (mean= 4.42). Healthcare professionals ranked the application of the four modes in our web portal differently. Healthcare professionals ranked the application of socialisation first as the best mode applied in DSMKSA (mean= 4.78). The second ranked application is the externalisation mode (mean= 4.33). In third place is the application of internalisation (mean= 4.17). The fourth ranked application by healthcare professionals is combination (mean=4.11). IT specialists ranked the application of externalisation in DSMKSA in first place (mean= 4.50). The remaining three applications, socialisation, combination and internalisation came in the next place (mean=4.33) (see Figure *8.16*).

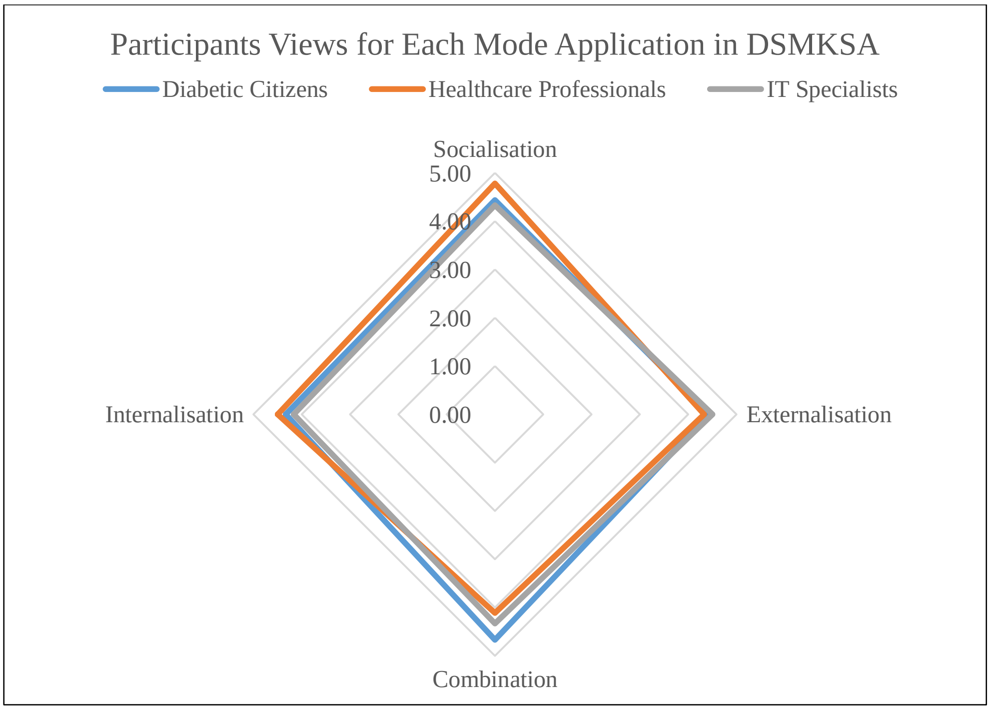

Figure 8.16. Participants views to the application of the SECI model in DSMKSA

The findings of participant groups to each layer are consistent with the overall mean score of the application of socialization, externalisation, combination and internalisation in our web portal. In the socialization mode, the nine participants scored the highest mean value (mean= 4.52), showing the highest satisfaction of participants in relation to the application of socialization in DSMKSA among other SECI modes. In the application of externalisation, participants scored the second highest mean value (mean= 4.42). The application of combination came in the third place in terms of participants satisfaction as the mean value became third (mean= 4.37). Finally, the application of the internalisation mode came fourth based on its mean value (mean= 4.33). The findings indicate that DSMKSA supports the application of socialization, externalisation, combination and internalisation effectively according to the mean values scored by participants for each mode (see Figure *8.17*).

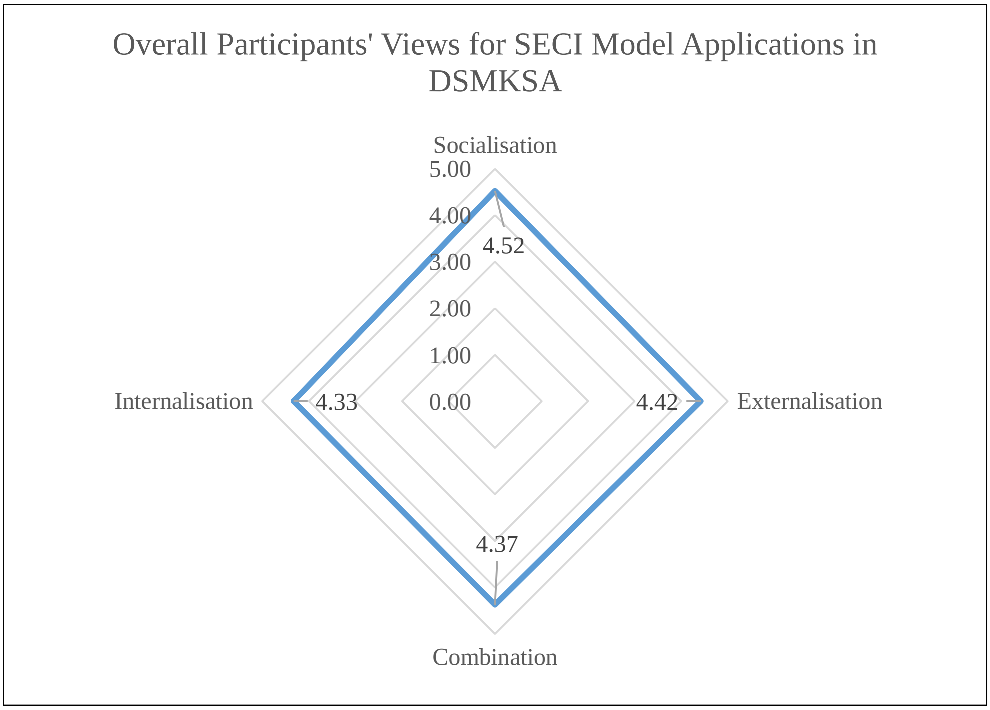

Figure 8.17. Participants' views to DSMKSA using the mean scores of their answers.

The findings from the web portal validation show that participants are satisfied with the application of the SECI model in DSMKSA. Participants were happy with the utilisation of different web tools to support the four mode of the SECI model. The findings are consistent with the literature review presented in Chapter Seven that showed that different web tools can support different modes of the SECI model. Nevertheless, different participant groups have different preferences in relation to the application of the SECI model in DSMKSA. Diabetic citizens prefer the application of the combination mode more than any other application, whereas healthcare professionals preferred the application of socialisation. IT specialists, lastly, preferred the application of externalisation in DSMKSA more than any other application. Figure *8.18* illustrates participants’ agreement to the different web tools utilised in the web portal to apply the four modes of the SECI model.

The differences in participants' views towards the various applications of DSMKSA may be caused by differences in the interests of the three groups. Diabetic citizens prefer to collect manuals and codified guidelines to help them in tackling their diabetes complications. Healthcare professionals, on the other hand, acknowledged the value of socialisation among different patients and its significance in overcoming different complications of diabetes mellitus. IT specialists preferred the externalisation application as their background and expertise prefer the tools that are implemented to codify useful knowledge. Figure *8.18* shows each group's feedback towards each tool in DSMKSA.

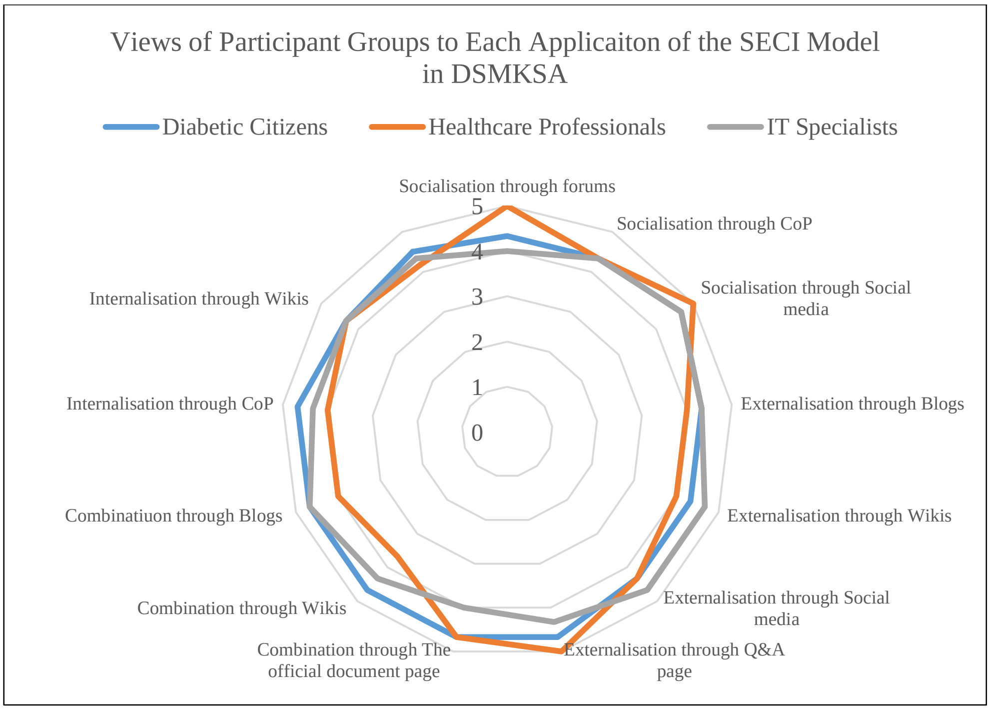

Figure 8.18. Participants' feedback to the application of each web tool in DSMKSA

8.10 Conclusion

This chapter demonstrated the validation and evaluation parts of our study. The integrated framework was validated through a workshop in a PHC in Saudi Arabia. Nine participants who participated in the validation session expressed their satisfaction with the framework and its components. Only two participants suggested a small improvement in the design to show the flow of data from the first two layers into layer 3 and the KD approaches to be used in layer 2. The framework was validated besides the conduction of real results related to layer 1, e-health barriers, and layer 2, diabetes complications, to confirm its capabilities. In the same workshop, our web portal was evaluated by the same participants as the validation session. The results from the web portal evaluation also show participants' satisfaction with the web portal's implementation of each mode of the SECI model. The next chapter is the conclusion of this thesis.

Chapter Nine: Conclusion

9.1 Introduction

E-health and KM in Saudi Arabia experience a number of factors that hinder the application of the two fields in the Kingdom. Such deficiencies result in insufficient practice of diabetes self-management and education to support the fast-growing number of diabetic citizens, as well as healthcare professionals, in Saudi Arabia. The current research has developed a framework which integrates KM and KD to support the diabetes community in Saudi Arabia. This integrated framework provides a forum to include not only human knowledge and experience but also knowledge discovered from data. It applied the SECI model through a number of web tools to support diabetes self-management and education in the Kingdom. Additionally, the framework is ambitious in its approach as it promotes the merits of KM in the Saudi Arabian healthcare sector by including number of these tools familiar to citizens; this should help to tackle the barriers discussed in Chapter One. The framework, eventually, aims to encourage the practice of self-management and education in major country in terms of the prevalence of diabetes mellitus such as Saudi Arabia.

The first chapter has indicated several objectives to be achieved in this research. Several objectives were accomplished in previous chapters. In this chapter, we review the work accomplished and the objectives achieved throughout this thesis. The first part of this chapter summarises the current research. The second part highlights the research contributions followed by the limitations faced whilst conducting this study. The final part of the current chapter indicates opportunities for future research.

9.2 Research Summary

9.2.1. Context of investigation

Chapter Two used secondary research to conduct a literature review related to this study, focusing on two main domains: e-health and diabetes mellitus in Saudi Arabia. Regarding the first domain, Chapter Two concentrated on defining e-health and discusses its potential advantages in the healthcare domain, and discussed the issues related to e-health barriers in Saudi Arabia. Despite the efforts of the government of Saudi Arabia to adopt different ICT systems in the healthcare domain, progress is impeded by the eight barriers from four main categories: business, human, technology and finance. The literature review in this chapter also indicated a limited number of studies regarding implementation of e-health initiatives in Saudi Arabia from a few hospitals.

Chapter Two also conducted a literature review of diabetes mellitus, a secondary research discussed its prevalence worldwide and in Saudi Arabia. The literature review has also investigated several complications, in particular those related to the non-health-related complications encountered by diabetic patients. In this chapter, 11 non-health-related complications of diabetes mellitus were highlighted and needed to be addressed in the context of Saudi Arabia through education and self-management initiatives via various means, including e-health. However, the suggested solutions experience insufficient practice in the Kingdom.

9.2.2. Theoretical underpinning

This research used two fields providing a theoretical basis to the current study: KM and DM. Chapter Three discussed the field of KM, the SECI model, the advantages and challenges of the KM approach. The secondary research in this chapter has indicated a number of factors that can hinder the practice of KM, including national and organisational cultures. Moreover, the literature review has indicated the difficulties applying the SECI model at a universal level. As this study concentrated on the context of Saudi Arabia, the validity of the SECI model in this context was discussed and suggestions to apply this model successfully in Saudi Arabia were provided. Chapter Seven conducted a literature review in relation to how to apply the SECI model using web tools and technologies. The review has identified seven tools which can apply socialisation, externalisation, combination and internalisation effectively. These tools also showed promising impact in sharing knowledge and overcoming a number of KM hindrances, including individualism, fear of criticism, organisational structure and low uncertainty avoidance. In addition, the web tools are seen to overcome different barriers of the SECI model, such as high power distance and limited access to information.

Chapter Three also discussed DM, being the second theoretical base of this research. It started with defining DM, discussed its advantages and reviewed the three methodologies of DM, including KDD, SEMMA and CRISP-DM. It also discussed the various algorithms and techniques associated with data description, segmentation, classification, and dependency analysis.

9.2.3. Investigation of the research problems

Primary research was conducted in this study to investigate the research problems. This research has two contexts to investigate: e-health barriers in Saudi Arabia and non-health-related complications of diabetes mellitus. The eight e-health barriers were investigated through a questionnaire and discussed in Chapter Five. The questionnaire was disseminated to three participant groups: citizens, healthcare professionals and IT specialists in Saudi Arabia. The total number of participants who completed the questionnaire was 201, constituting a 69.7% response rate. The questionnaire study has revealed four barriers encountered by citizens, six barriers encountered by healthcare professionals and three barriers encountered by IT specialists. The revealed e-health barriers highlighted the importance of taking them into account when developing any e-health solution. Moreover, the barriers were ranked according to each group of participants. Citizens and healthcare professionals ranked the barrier of non-connectivity of information systems as the first barrier hindering e-health successful utilisation in Saudi Arabia, whereas IT specialists believe that the lack of medication safety constitutes the major challenge in adopting e-health in the Saudi Arabia healthcare domain.

The second primary research used DM to elicit the non-health-related complications encountered by diabetic citizens in Saudi Arabia. The DM study aimed to associate different complications with the profile of diabetic citizens in Saudi Arabia. Therefore, the DM study used CRISP-DM, association rules mining and the Apriori algorithm to accomplish this study. It revealed 25 valid rules that were validated through the k-fold cross validation approach. The study show that the validated rules can be deployed through the implementation of the SECI model to disseminate useful knowledge related to diabetes self-management and education in the form of guidelines, best practices, strategies and policies. The DM study was presented in Chapter Six.

9.2.4. Addressing the research problems

Chapter Four has discussed the development of the integrated framework of KM and KD, identified the related components, taking into consideration issues such as the lack of KM implementation in the Saudi Arabian healthcare sector and the study of diabetes non-health-related complications. The framework was designed in three layers. The first layer of the framework outlines the e-health barriers in Saudi Arabia and the non-health-related difficulties of diabetic citizens in Saudi Arabia.

The second layer of the framework, KD, focuses on extracting trends related to diabetes mellitus in Saudi Arabia. Diabetes mellitus in Saudi Arabia was chosen to be the domain of application of our integrated framework. Therefore, the framework constitutes an e-health solution to support the community of diabetes mellitus in Saudi Arabia. Besides the usefulness of the DM in investigating a number of non-health related complications of diabetes mellitus, the approach is also promising in overcoming these complications by underpinning 25 of these complications as a first step in addressing them. The third layer of the framework, KM, provides an effective way to overcome the extracted rules related to non-health-related complications encountered by Saudi Arabian diabetic citizens and their profile information. Our framework utilises the SECI model to disseminate useful diabetes self-management and education guidelines and best practices with respect to the profile information of the diabetic citizens.

The provision of diabetes self-management and education guidelines and best practices were facilitated through a web portal. The web portal was planned and designed using a web development methodology in Chapter Seven. In this web portal, a number of web tools were implemented in order to apply the four modes of the SECI model, including forums, blogs, diabetes videos, diabetes documents, diabetes FAQs and a diabetes daily news-letter. In addition, the web portal was designed with respect to the e-health barriers revealed from our questionnaire study in Chapter Five. The usability of the web portal was tested using the heuristic evaluation guidelines (Nielsen and Molich, 1990). Eight participants relate to three groups: diabetic citizens, healthcare professionals and IT specialists who agreed that there was good usability of the web portal.

9.2.5. Framework validation and web portal evaluation

A workshop was conducted in a PHC in Saudi Arabia to validate the integrated framework and evaluate the diabetes web portal designed for this study. The workshop was discussed in Chapter Eight, in which nine participants were involved, and indicated that the framework supports addressing relevant e-health barriers and diabetes complications in Saudi Arabia. In addition, participants indicated that the framework utilises a useful approach to extract knowledge related to diabetes mellitus and provides an effective mechanism for sharing useful knowledge to stakeholders. Minor modifications to the framework were suggested by two participants to illustrate the framework's data flow and the other KD techniques can be used through the framework. The feedback to the framework validation confirms our findings from the secondary research in relation to prevalent diseases in Saudi Arabia: diabetes non-health-related complications, usability of DM to extract knowledge and the effectiveness of the SECI model to disseminate useful knowledge related to diabetes mellitus.

Participants also indicated that the web portal effectively supports the application of the four modes of the SECI model through the utilisation of different web tools and technologies. The feedback from the evaluation session suggests that the web tools identified from the literature review as supportive to the SECI model are effective in implementing socialisation, externalisation, combination and internalisation in a web environment. Table 9.1 summarises the research objectives, method of investigation and associated outcomes.

Table 9.1. Research objectives and outcomes

NO	Objective	Method of investigation	Main outcome	Chapter
1	To develop an integrated framework of KM and KD.	Integration of KM and KD.	Integrated framework of using DM and the SECI model to encourage KM of diabetes self-management end education guidelines and best practices. Lack of KM practice in healthcare in Saudi Arabia.	4
2	To conduct a literature review and identify barriers to e-health in Saudi Arabia.	Literature review from published documents and industry reports.	Studies of e-health systems to support diabetic patients are limited to few hospitals. Highlighted eight barriers relate to business, human, technology and finance. Lack of e-health systems to support diabetic citizens in healthcare professionals in Saudi Arabia.	2
3	To investigate e-health barriers in Saudi Arabia from the perspectives of citizens, healthcare professionals	Primary research through questionnaire analysis.	Citizens encountered four barriers, healthcare professionals encountered six, barriers and IT specialists encountered three barriers. Citizens and healthcare	5

NO	Objective	Method of investigation	Main outcome	Chapter
	and IT specialists through a statistical study.		professionals ranked non-connectivity of information systems as the first barrier of e-health in Saudi Arabia, whereas IT specialists ranked the lack of medication safety as the major obstacle.	
4	To conduct a literature review for KM and KM models and applications in the healthcare sector.	Literature review from published documents and industry reports.	Comprehensive understanding of knowledge, KM, and the SECI model and its advantages. Identification of KM and the SECI model limitations related which are culturally embedded. Lack of KM application to enrich patients' knowledge in Saudi Arabia.	3, 4
5	To conduct a literature review for KD to identify methods and applications in the healthcare sector.	Literature review from published documents and industry reports.	Understanding of DM ant its methodologies, techniques and algorithms. Lack of utilisation of DM to extract non-health-related complications.	3,4
6	To conduct a literature review for diabetes mellitus and its complications and prevalence globally and in Saudi Arabia.	Literature review from published documents and industry reports.	Understanding of diabetes mellitus, its prevalence in and outside Saudi Arabia and its complications including the non-health-related ones. Insufficient effort to educate patients about their illnesses in Saudi Arabia. Insufficient studies related to identifying non-health-related complications in Saudi Arabia. Lack of diabetes self-management and education practice in Saudi Arabia.	2
7	To collect related data to investigate current non-health-related complication for diabetes mellitus in Saudi Arabia.	Published survey in Saudi Arabia.	277 participants completed the questionnaire.	6
8	To apply DM to the collected data of diabetes mellitus.	Primary research through DM study of dataset of diabetic citizens in Saudi Arabia.	25 association rules of diabetic citizens' profile information and the non-health-related complications are valid.	6
9	To conduct a literature review for web tools that apply the SECI model.	Literature review from published	Seven web tools are selected to apply the SECI model on the web portal.	7

NO	Objective	Method of investigation	Main outcome	Chapter
		documents and industry reports.		
10	To build a web portal to support diabetes education and self-management in Saudi Arabia.	To plan, design and test the web portal through trusted methodologies.	Web portal was planned and designed using the web development lifecycle suggested by Diffily (2006). Usability evaluation of the web portal was conducted using the heuristic evaluation approach. The findings indicated good usability of the web portal.	7
11	To validate the developed framework.	Workshop conducted with nine participants in Saudi Arabia to validate the framework components.	Positive feedback of the validity of the framework.	8
12	To evaluate the designed web portal.	Workshop conducted with nine participants in Saudi Arabia to evaluate the application of the SECI model in the web portal.	Positive feedback of the evaluation of the web portal.	8

9.3 Research Contributions

The current research has produced a number of academic contributions. These contributions are presented as follows:

- A novel holistic framework integrates KM and KD to overcome barriers to e-health in the Saudi Arabian healthcare sector. The novel framework integrates KM and KD. KD applied association rules to find trends related to diabetes non-health-related complications in Saudi Arabia, whilst KM aims to provide citizens with diabetes, healthcare professionals and IT specialists with the relevant solutions in relation to overcoming these complications.
- The integration of KM and KD is implemented in a new domain. That is, the proposed framework aims to overcome difficulties and problems of Saudi citizens with diabetes mellitus. Beside the many health-related complications associated

with this disease, diabetic citizens also face difficulties and challenges related to controlling the disease, the management of diabetes and adherence to appropriate dosage of their medication. Scholars have witnessed these difficulties faced by diabetic patients in different countries in the world. The numbers from the literature have shown that Saudi Arabia has a considerable number of diabetic citizens. Our study investigates whether Saudi diabetic citizens face these difficulties partially or entirely. The framework that we are proposing overcomes any evoked difficulty in order to support Saudi diabetic citizens in their treatment. We formed focus groups of Saudi citizens with diabetes to investigate these difficulties and issues hindering their management of diabetes independently. Following this, the gathered data were analysed by using data mining technique to find useful trends regarding the participants' difficulties and issues. The KM layer in our framework provides Saudi diabetic citizens with useful tips and educational programmes to overcome the difficulties they encounter; this can improve their adherence to their medication and strengthen their awareness, knowledge and education of diabetes mellitus.

- Ranking of e-health barriers in Saudi Arabia from the perspectives of Saudi Arabian citizens, healthcare professionals and IT specialists. Eight factors identified from the literature were perceived to be hindering e-health utilisation in Saudi Arabia. In this research, we investigated these barriers and ranked them from the point of view of each stakeholder. The current study is the first to rank e-health barriers from the perspectives of three stakeholders of ICT in the healthcare domain.
- Increasing KM practice in the Saudi Arabian healthcare domain. The proposed framework implements the SECI model to provide a tailored KM approach to help diabetic citizens self-manage and monitor their health conditions and support healthcare providers to share guidelines, best practices and strategies. The SECI model aims to convert and disseminate both types of knowledge, tacit and explicit, and provide diabetic citizens in the Kingdom with support related to diet, exercise, medication usage and schedule, and recommend appropriate guidelines to coexist with the disease. Citizens, through the internalisation mode, are "learning by doing" and, through externalisation, healthcare providers are disseminating their best practices. Socialisation and combination modes aim at facilitating the

exchange of knowledge, practices and concerns among diabetic citizens and healthcare professionals through a dedicated web-based forum. In addition, the SECI model plays a significant role in the novel framework to facilitate the solutions for the obstacles hindering successful implementation to e-health in Saudi Arabia. That is after analysing the data related to the barriers of e-health, the SECI model can effectively provide relevant knowledge to healthcare professionals who may be seeking or sharing best practices, strategies, guidelines, governance and policies; and to citizens who need to contact specific healthcare services or professionals for advice or help. The application of the SECI model in the novel framework ensures the feasibility of its utilisation in the Saudi Arabian healthcare environment. Therefore, the research outlines the difficulties of applying Nonaka's SECI model to other countries, as the model is based on Japanese organisations. It suggests practical solutions for use in Saudi Arabia for knowledge transfer within the segments of the SECI model.

- The utilisation of DM to extract diabetes non-health-related complications. The literature review has indicated numerous studies to utilise DM to support people with diabetes mellitus. Nevertheless, there is a deficiency in term of utilising DM to investigate the non-health-related complications encountered by diabetic individuals. The current research aims to fill this gap by applying DM to extract trends in relation to the non-health-related complications encountered by diabetic citizens in Saudi Arabia.
- Filling the gap in relation to patients' education in Saudi Arabia. The literature highlighted the deficient effort to educate patients in their disease in Saudi Arabia. The current research contributes to the healthcare society in the Kingdom by increasing the awareness of education among patients and medical staff.
- The implementation of the SECI model to disseminate useful knowledge related to diabetes self-management and education. Despite the usefulness of the SECI model in disseminating useful knowledge in different domains, the model lacks in its implementation to support people with diabetes to self-manage and educate them about their disease. The current study applied the SECI model to disseminate useful diabetes self-management and education recommendations and showed promising impact in empowering diabetic citizens in Saudi Arabia in relation to coexisting with different aspects of diabetes mellitus.

- Generation of an open-source dataset for diabetes research. The current research indicated deficiency of open-source data related to the non-health-related complications of diabetes mellitus. The dataset will be gathered through diabetic visitors to our web portal via an optional survey and will be published in the portal periodically.
- Extension of the SECI model to convert and disseminate knowledge stored in technological media. The SECI model was initially proposed to convert human knowledge between tacit and explicit and facilitates its dissemination. In this research, the SECI model was extended to share and transform the two types of knowledge that are stored in databases and multimedia through the application of a number of web tools that can apply the four modes.
- Increasing studies of e-health systems in Saudi Arabia. The literature review indicated that the number of studies of e-health systems in the Kingdom is limited to few hospitals. These systems are dedicated to patients of those hospitals and lacks serving other patients outside these organisations. This research contributes the e-health area in Saudi Arabia by increasing research and providing a system that can benefit all diabetic citizens in the Kingdom regardless of their locations and the healthcare organisation they are associated with.

The current thesis also produce the following contribution which is related to clinical practice:

- Development of a web portal to support the community of diabetes mellitus using the SECI model. Despite the high prevalence of diabetes mellitus in Saudi Arabia, there are still deficiencies regarding utilising web technologies to increase the awareness of diabetes community in the Kingdom using effective KM approach. Internet technology is a valuable tool for providing educational content. The application of the SECI model in the web environment provides an effective solution to disseminate useful knowledge to support people with diabetes mellitus, especially for those who live in remote areas. The portal, in addition, addresses the deficient implementation of e-health systems to support the diabetic community in the Kingdom.

9.4 Research Limitations

The research has recognised five limitations. The first limitation is related to the lack of an open-source dataset to complete the DM study. The required dataset should include the profile information of diabetic citizens in Saudi Arabia as well as the non-health-related complications of diabetes mellitus encountered by these diabetic individuals. The deficiency of such a dataset enforced the researcher to build a survey to collect the data required for the DM study.

The second limitation is the limited number of participants in the DM study. The DM analysis has revealed a number of rules that were validated through a k-fold cross-validation approach. However, the number of participants to our study was limited to 277 participants. More participants in the study may have produced better results in relation to the non-health-related complications encountered by those diabetic citizens.

Another limitation of the current research is the fact that the research focuses on issues in the context of Saudi Arabia whereas the main researcher is based in the U.K. The two primary studies of this research involved participants from Saudi Arabia. In addition, the validation and evaluation workshop was conducted with Saudi Arabian participants. Conducting such studies while being away from the domain of the study constituted a major challenge regarding working remotely with participants of this research.

The fourth limitation of this study is the deficiency of KM experts in Saudi Arabia. This has an impact on the validation study of our proposed framework and the evaluation of the web portal and led us to involve participants with adequate experience in computing instead of KM experts in both studies.

The fifth limitation is related to time constraints to complete this study. The current research conducted a number of literature reviews relating to e-health, diabetes mellitus, KM and DM. In addition, the research underwent two primary studies to investigate e-health barriers and address diabetes complications in Saudi Arabia. Moreover, this thesis developed a framework and a web portal which were validated and evaluated accordingly. The research was conducted in limited period of time (2013-2017).

9.5 Opportunities for Future Research

The discussion in the current research has identified five areas for future research. These are illustrated as follows:

- The application of the integrated framework in this thesis concentrated on overcoming complications related to diabetes mellitus. One future research opportunity would be the application of the framework to overcome other diseases in Saudi Arabia. As mentioned in Chapter Four, the literature review indicated other prevalent diseases in Saudi Arabia, such as upper respiratory tract infections and musculoskeletal disorders. These conditions are less critical than diabetes mellitus in the Kingdom. However, they have higher prevalence and also can be self-managed. The application of the framework to extract complications encountered by patients of upper respiratory tract infections and musculoskeletal disorders and disseminate guidelines and best practice can provide a useful initiative to tackle these diseases.
- The current research focused on DM as a KD approach to extract trends from patients' datasets. The utilisation of other KD approaches such as text mining, web mining and link mining offers an opportunity for future research. The application of these KD approaches can also produce a valuable contribution to the healthcare domain and/or be integrated with KM.
- Diabetes mellitus in Saudi Arabia is the domain of application of this study. Another future research area would be the application of the proposed framework in different domains in Saudi Arabia. Potential domains include education, military, industry and engineering, where ICT has been utilised for a period of time. Moreover, the application of the proposed framework in one of those domains in the Kingdom offers promising feasibility as the obstacles to KM and the SECI model can be the same, as these are mainly based on cultural aspects.
- Application of the proposed framework in other countries is another opportunity for future research. Despite the increasing numbers of diabetic patients in Saudi Arabia, other surrounding countries are also recognized by the extreme prevalence of this chronic disease. According to the International Diabetes Federation (2015), countries such as Kuwait, the United Arab Emirates, Qatar, Oman and Egypt are also seen to have a considerable number of diabetic patients. In addition, these

countries share the same cultural norms as Saudi Arabia. This means that the suggested solutions to apply the SECI model in the Kingdom, can also be effective when applying the same model in those communities.

- The current research developed a web portal which implements an optional survey. The survey asks visitors to participate in questions related to the complications they may encounter. Gathered data will be analysed in periodical bases in order to extract new, non-health-related complications of diabetes mellitus. Accordingly, more guidelines and best practices provided in the web portal will be provided to address the newly elicited complications (see Figure *9.1*).

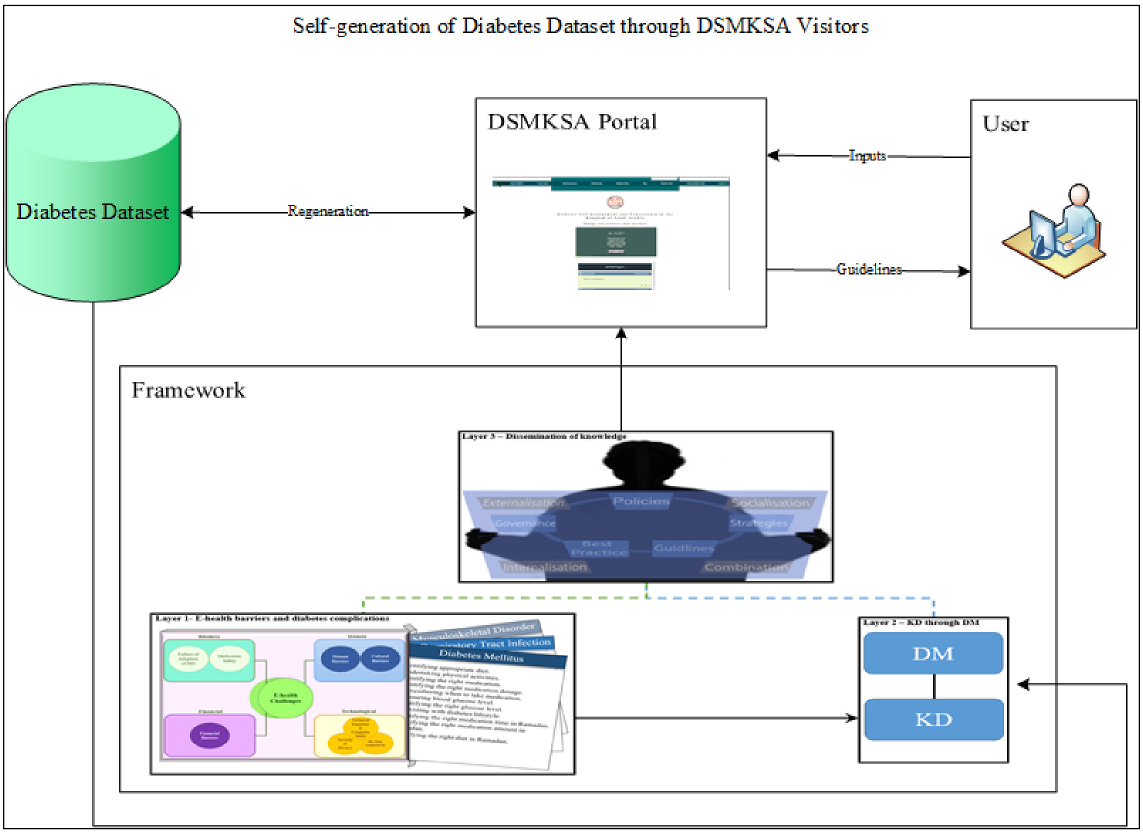

Figure 9.1. Generation of diabetes dataset via visitors to our web portal

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Appendices

Appendix A: E-health Questionnaire

A.1. Research description (English version)

STAFFORDSHIRE UNIVERSITY

PARTICIPANT INFORMATION FOR RESEARCH PROJECT

Researcher Contact Information	
Name	Saleh Naif Almuayqil
Phone	00966 530 666 704 - 0044 759 751 7373
E-mail	A031451C@student.staffs.ac.uk

Description

This study is being undertaken as part of the Ph.D research study for Saleh Naif Almuayqil. The research is sponsored by the Ministry of Higher Education in Saudi Arabia. The sponsor of this research will not have access to the obtained data.

The purpose of this research is to develop a framework to overcome the barriers of implementing e-health solutions in the healthcare sector in Saudi Arabia. As a researcher, I request your help by participating to the questionnaire of this study. This study will benefit the healthcare sector in Saudi Arabia as it will provide solutions to overcome barriers in order to implement e-health initiatives.

If you agree to participate, you will be asked to complete two sections. The first section includes question about your profile information. The second section has two types of multiple choice questions. This section includes statements about barriers of adoption electronic health records in Saudi Arabia. In this section you will be asked to determine your opinions for each statement by choosing among two types of options: 1. Yes, No, or I don’t know; 2. Strongly agree, Agree, Neutral, Disagree, Strongly disagree, or I don’t know. The questions can be completely answered in 30 – 40 minutes. The questionnaire can be completed online and once you answer the questions your responses will be sent directly to the researcher.

There are no direct benefits to you for participating in this research. There are no risks associated with participation. All comments and responses you provide will be anonymous and confidentially treated. Names of participants are not required. If you have any questions about the questions or this study, please contact the researcher via the contact information provided above.

A.2. Research description (Arabic version)

STAFFORDSHIRE UNIVERSITY	**معلومات للمشاركين في مشروع بحثي**
عنوان البحث	
اطار عمل مدمج لإدارة و اكتشاف المعرفة في مجال الرعاية الصحية	
معلومات الإتصال بالباحث	
الأسم	صالح نايف المعيقل
الهاتف	٠٠٤٤٧٥٩٧٥١٧٣٧٣ - ٠٠٩٦٦٥٣٠٦٦٦٧٠٤
البريد الإلكتروني	A031451C@student.staffs.ac.uk
وصف البحث	
هذه الاستبانة يتم الأخذ بها كجزء من دراسة الدكتوراه للطالب صالح نايف المعيقل و المبتعث عن طريق وزارة التعليم العالي في المملكة العربية السعودية. وزارة التعليم العالي في المملكة لن يكون لديها صلاحية الوصول الى البيانات التي سيتم الحصول عليها من خلال هذه الأستبانة. تهدف هذه الدراسة الى تطوير اطار عمل للتغلب على عوائق تبني حلول الصحة الإلكترونية في مجال الرعاية الصحية في المملكة العربية السعودية. كباحث أساسي في هذه الدراسة، أطلب منكم المساعدة من خلال المشاركة في الأستبانة الخاص بهذه الدراسة. الفائدة النهائية لهذه الدراسة ستنصب في مصلحة قطاع الرعاية الصحية في المملكة العربية السعودية من خلال توفير حلول لتجاوز معوقات تطبيق مبادرات الصحة الإلكترونية. في حال موافقتكم على المشاركة، سيطلب منكم الاجابة على جزئين من الأسئلة. الجزء الأول يحتوي على اسئلة تتعلق بمعلوماتكم الخاصة. الجزء الثاني يحتوي على نوعين من اسئلة الأختيار المتعدد. هذا الجزئ من الأستبانة يحتوي على عبارات تتعلق بعوائق تطبيق السجلات الصحية الإلكترونية في المملكة وسوف يطلب منك تحديد وجهة نظرك لكل عبارة من خلال الأختيار بين نوعين من الأختيارات: النوع الأول من الاختيار المتعدد هو نعم، لا، أو لا أعلم. النوع الثاني من الأختيارات هو أوافق بشدة، أوافق، محايد، لا أوافق، لا أوافق بشدة، أو لا أعلم. يمكن الإجابة على هذه الإستبانة بشكل كامل خلال ٣٠ – ٤٠ دقيقة.يمكنكم تعبئة هذه الإستبانة بشكل الكتروني عن طريق رابط انترنت وفي حال اجابتكم على الأسئلة سيتم ارسال اجاباتكم الى الباحث مباشرة. لا توجد فوائد مباشرة لكم على مشاركتكم في هذه الدراسة. كما لاتوجد مخاطر مترتبة على مشاركتكم. جميع اجاباتكم وتعليقاتكم ستكون مجهولة الأسم وسوف يتم التعامل معها بشكل سري. أسماء المشاركين في هذا الأستبيان غير مطلوبة. في حال كانت لديكم اية أستفسارات تتعلق بالأسئلة او هذه الدراسة يرجى منكم التواصل مع الباحث من خلال معلومات الأتصال في أعلى الصفحة.	

A.3. Ethical Approval for the E-health Questionnaire

Submit completed forms to K266 Octagon (Stafford Students) S213 Mellor or R101 Science Centre (Stoke Students)

STAFFORDSHIRE UNIVERSITY
FAST-TRACK ETHICAL APPROVAL FORM (STUDENTS)

Tick one box: ☐ TAUGHT POSTGRADUATE project ☐ UNDERGRADUATE project
☑ PhD/MPhil project ☐ TAUGHT POSTGRADUATE MODULE assignment
☐ TAUGHT UNDERGRADUATE MODULE assignment
☐ Other project (Please state … … … … … … … … … … … … … … … … … … …)

Title of Course on which enrolled … … **Computing Science** … … … … … … … … … … … … …

Tick one box: Full-Time Study ☑ or Part-Time Study ☐

Title of project…**Integrated Framework of Knowledge Management and Knowledge discovery in Healthcare**…

Name of student researcher … …**Saleh Almuayqil**… … … … … … … … … … … … … … … … … …

Student Number… … …**12031451**… … … … … … … … … … … … … … … … … … … …

Student Researchers- please note that certain professional organisations have ethical guidelines that you may need to consult when completing this form.

Supervisors/Module Tutors - please seek guidance from the Chair of your Faculty Ethics Committee if you are uncertain about any ethical issue arising from this application.

		YES	NO	N/A
1	Will you describe the main procedures to participants in advance, so that they are informed about what to expect?	✓		
2	Will you tell participants that their participation is voluntary?	✓		
3	Will you obtain written consent for participation?	✓		
4	If the research is observational, will you ask participants for their consent to being observed?	✓		
5	Will you tell participants that they may withdraw from the research at any time and for any reason?	✓		
6	With questionnaires and interviews will you give participants the option of omitting questions they do not want to answer?	✓		
7	Will you tell participants that their data will be treated with full confidentiality and that, if published, it will not be identifiable as theirs?	✓		
8	Will you give participants the opportunity to be debriefed i.e. to find out more about the study and its results?	✓		

If you have ticked No to any of Q1-8 you should complete the full Ethics Approval Form.

		YES	NO	N/A
9	Will your project deliberately mislead participants in any way?		✓	
10	Is there any realistic risk of any participants experiencing either physical or psychological distress or discomfort?		✓	
11	Is the nature of the research such that contentious or sensitive issues might be involved?		✓	

If you have ticked Yes to 9, 10 or 11 you should complete the full Ethics Approval Form. In relation to question 10 this should include details of what you will tell participants to do if they should experience any problems (e.g. who they can contact for help). You may also need to consider risk assessment issues.

Fast Track Students

Submit completed forms to K266 Octagon (Stafford Students) S213 Mellor or R101 Science Centre (Stoke Students)

			YES	NO	N/A
12	Does your project involve work with animals?			✓	
13	Do participants fall into any of the following special groups? **Note that you may also need to obtain satisfactory CRB clearance (or equivalent for overseas students)**	Children (under 18 years of age) People with communication or learning difficulties Patients People in custody People who could be regarded as vulnerable People engaged in illegal activities (eg drug taking)		✓	
14	Does the project involve external funding or external collaboration where the funding body or external collaborative partner requires the University to provide evidence that the project had been subject to ethical scrutiny?			✓	

If you have ticked **Yes** to 12, 13 or 14 you should complete the full Ethics Approval Form. There is an obligation on student and supervisor to bring to the attention of the Faculty Ethics Committee any issues with ethical implications not clearly covered by the above checklist.

If you have ticked **Yes** to 13 and your participants are **patients** you must follow the Guidelines for Ethical Approval of NHS Projects.

STUDENT RESEARCHER
Provide in the boxes below (plus any other appended details) information required in support of your application. THEN SIGN THE FORM.

	Please Tick Boxes
I consider that this project has no significant ethical implications requiring a full ethics submission to the Faculty Ethics Committee.	✓
Give a brief description of participants and procedure (methods, tests used etc) in up to 150 words. An online questionnaire to be carried out by group pf citizens in Saudi Arabia. No specific organisations are involved; individuals are randomly selected; no medical information is elicited. The questionnaire will be sent to about 200 individuals covering three categories of participants through social networks and personal contact, no inclusion or exclusion criteria. The age will be between over 18 and 60 years old, distributed equally through gender and educational levels. No vulnerable individuals are required to participate.	
I also confirm that: ii) All key documents e.g. consent form, information sheet, questionnaire/interview are appended to this application.	✓
Or ii) Any key documents e.g. consent form, information sheet, questionnaire/interview schedules which need to be finalised following initial investigations will be submitted for approval by the project supervisor/module leader before they are used in primary data collection.	

Signed… … [signature] … … … … Print Name..Saleh Almuayqil.. Date.6/12/2014
(Student Researcher)

Please note that any variation to that contained within this document that in any way affects ethical issues of the stated research requires the appending of new ethical details. New ethical consent may need to be sought.

The completed form (and any attachments) should be submitted for consideration by your Supervisor/Module Tutor

Fast Track Students

Submit completed forms to K266 Octagon (Stafford Students) S213 Mellor or R101 Science Centre (Stoke Students)

SUPERVISOR/MODULE TUTOR
PLEASE CONFIRM THE FOLLOWING:

	Please Tick Box
I consider that this project has no significant ethical implications requiring a full ethics submission to the Faculty Ethics Committee	✓
i) I have checked and approved the key documents required for this proposal (e.g. consent form, information sheet, questionnaire, interview schedule) Or	✓
ii) I have checked and approved draft documents required for this proposal which provide a basis for the preliminary investigations which will inform the main research study. I have informed the student researcher that finalised and additional documents (e.g. consent form, information sheet, questionnaire, interview schedule) must be submitted for approval by me before they are used for primary data collection.	

SUPERVISOR AND SECOND ACADEMIC SIGNATORY

STATEMENT OF ETHICAL APPROVAL (please delete as appropriate)

1) THIS PROJECT HAS BEEN CONSIDERED USING AGREED UNIVERSITY PROCEDURES AND IS NOW APPROVED

2) THIS PROJECT HAS BEEN APPROVED IN PRINCIPLE AS INVOLVING NO SIGNIFICANT ETHICAL IMPLICATIONS, BUT FINAL APPROVAL FOR DATA COLLECTION IS SUBJECT TO THE SUBMISSION OF KEY DOCUMENTS FOR APPROVAL BY SUPERVISOR (see Appendix A)

Signed… A. S. Atlam … … Print Name… A. S. Atlam … … Date…15/12/2014
(Supervisor/Module Tutor)

Signed… [signature] … Print Name C. C. CHIBELUSHI Date… 15/12/201
(Second Academic Signatory)

APPENDIX A
AUTHORISATION FOR USE OF KEY DOCUMENTS

Completion of Appendix A is required when for good reasons key documents are not available when a fast track application is approved by the supervisor/module leader and second academic signatory.

I have now checked and approved all the key documents associated with this proposal e.g. consent form, information sheet, questionnaire, interview schedule

Signed… … … … … … … … … … … … Print Name… … … … … … … … … … … Date… … … …
(Supervisor/Module Tutor)

PLEASE FORWARD A COPY OF THIS FORM TO THE CHAIR OF YOUR FACULTY ETHICS PANEL

Form Received by Chair of Faculty Ethics Panel
Signed… … … … … … … … … … … … Print Name… … … … … … … … … … … Date… … … …
(Chair, Faculty Ethics Panel)

Fast Track Students

A.4. Profile of participants

In this section of the study you will be asked to provide demographical information about yourself. Please choose one answer for each question.

Please specify your gender:

- Male
- Female

Please specify your age:

- 18 – 30
- 31 – 40
- 41 – 50
- 51 – 60
- Over 60

Please specify your education level:

- High school
- Bachelor
- Master
- Doctorate

Please specify your computer skills:

- Low (don’t use computer or other electronic devices)
- Medium (I use basic computer applications i.e., MS-Office, e-mail or web browsing)
- High (I deal with hardware maintenance and use specialists software such as databases and networking programs)

Please specify your role in healthcare organisation:

- Citizen
- Medics/healthcare (doctor –nurse – pharmacist – laboratory technician)
- IT specialists

A.5. Questionnaire statements

A.5.1. Citizens

- **Connectivity of Information Systems**

Sub-barriers	Statements	Yes		No		I'm not sure		Mean	Total Participants
		R	%	R	%	R	%		
Absence of national healthcare systems	I use electronic health records								
	I use electronic health records in more than one hospital in Saudi Arabia								
	I can access my electronic health records from any hospital in Saudi Arabia								

- **Technical Expertise and Computer Skills**

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
Poor interface design	The electronic health records I'm using are difficult to use														
	The electronic health records I'm using use difficult terminologies														
	The information in the electronic health records is inaccurate														
	I'm not able to modify my profile details														
No guidelines	Working with electronic health records needs skills in using computer applications														
	There are guidelines for using my electronic health records														
	I have been trained in how to use my electronic health records														
Lack of experience in computer applications	I use computers for checking my email														
	I use computers for browsing the internet														
	I use a computer to accomplish tasks at my workplace														
	I download applications to my computer skilfully														
Insufficient access	I always have access to a computer to check my email														
	I have access to a computer for browsing the internet														
Poor maintenance	The speed of the computer I am using is adequate														
	The speed of the internet connection I'm using is adequate														
	The computer I am using is well maintained periodically.														

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
	The internet connection I am using is well maintained periodically.														

- **Human Barriers**

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
Negative believes	Electronic health records can create technical problems														
	Electronic health records can create legal problems														
	Electronic health records can create administrative problems														
	Electronic health records are beneficial for professional but not for the citizens														
	Implementation of electronic health records can decrease productivity of health professionals														
Lack of trust	My electronic health records can be out of date														
	Electronic health records can lose my data														
	Using electronic health records can be complicated														
	Electronic health records can give incorrect medication information														
	Electronic health records can give me incorrect medical appointments dates														
	Electronic health records can give me incorrect laboratory test results														
	Electronic health records can allow unauthorised people to access my information														
Resistance to change	Changing from traditional health to e-health requires long time to be accomplished														
	Changing to e-health need citizens to be trained in how to use them														
	I think that implementing health information systems can reduce job opportunities in the healthcare profession														
	Using electronic health records affects the relationship with my doctor														

- **Cultural Barriers**

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
Physical interaction	I prefer meeting with my doctor to get information about my medication														
	I prefer paper based medical records more than electronic health records														
	Electronic health records are less detailed than traditional health														

- **Financial Barriers**

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
Very costly to adopt IT in healthcare	The expenditure spent on adopting IT in health should be spent on building new hospitals														
	The expenditure spent on adopting IT in health should be spent to provide more employment opportunities														

- **Security and Privacy**

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
Easy to access citizens medical records	My electronic health records are accessed without my permission														
	My electronic health records are disseminated without my permission														
	My electronic health records are updated without my permission														
	I'm not able to control the access of others to my electronic health records														
	I'm not able to determine who should see my electronic health records														
	I'm not informed of people who had access to my electronic health records														
	My electronic health records were corrupted														
	I'm not able to access my electronic health records from other countries														
	I can access other citizen's electronic health records														
	My electronic health records are missing														

A.5.2. Healthcare professionals

- **Connectivity of Information Systems**

Sub-barriers	Statements	Yes		No		I'm not sure		Mean	Total number of Participants
		R	%	R	%	R	%		
Absence of national healthcare systems	I use electronic health records for citizens								

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
Absence of national healthcare system	I use electronic health records in more than one hospital														
	I'm able to view my citizens' health records from other healthcare institutions in Saudi Arabia														
	I'm able to update the laboratory test results electronically for citizens who are visiting from other healthcare organisations														
	I'm able to disseminate citizens' health records electronically with other healthcare institutions in Saudi Arabia when necessary														

- **Technical Expertise and computer Skills**

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
Poor interface design	The electronic health records I'm using are difficult to use														
	The electronic health records I'm using use difficult terminologies														
	The information in the electronic health records is inaccurate														
No guidelines	Working with electronic health records needs skills in using computer applications														
	There are guidelines for using my electronic health records														
	I have been trained in how to use my electronic health records														
Lack of experience in computer	I use computers for checking my email														
	I use computers for browsing the internet														
	I use a computer to accomplish tasks at my workplace														

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
	I download applications to my computer skilfully														
Insufficient access	I have access to a computer to check my email														
	I have access to a computer for browsing the internet														
	There are sufficient amount of computers in my workplace														
Poor maintenance	The speed of the computer I am using is adequate														
	The speed of the internet connection I'm using is adequate														
	The computer I am using is well maintained periodically.														
	The internet connection I am using is well maintained periodically.														

- **Adoption of Health Information Services (HIS)**

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
Technical support	The electronic health records system I'm using responds slowly														
	The electronic health records system I'm using is unable to view my citizens' progress														
	Technical support for the electronic health records system is always available														
Planning	Electronic health records support the work flow of healthcare professionals														
	Electronic health records help me accessing my citizens' medical appointments														
	Electronic health records help me accessing my citizens' medication doses														
	Electronic health records help me accessing my citizens' laboratory test results														
	Electronic health records help me to share my citizens' information with my colleagues														
	Electronic health records help me in contacting my citizens														
	Electronic health records help me updating my citizens' records														
	I have difficulties checking my citizens' health records any time I need														

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		Mean	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
	I'm not able to maintain my citizens' medications list														
	I have difficulties contacting my citizens														
	I have difficulties contacting my colleagues														
	I have difficulties sharing citizen's information with my colleagues														
	Healthcare centres are far away from where I live														
	There is a need to use electronic health records in Saudi Arabia														

- **Human Barriers**

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		Mean	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
Negative believes	I prefer doing my work manually rather than using a computer														
	I'm not motivated to use electronic health records														
	Electronic health records can create technical problems														
	Electronic health records can create legal problems														
	Electronic health records can create administrative problems														
	Electronic health records are beneficial for citizens but not for the healthcare professionals														
	Implementation of electronic health records can decrease my productivity at work														
Lack of trust	Electronic health records can lose my data														
	My citizens' electronic health records can be out of date														
	Using electronic health records can be complicated														
	Electronic health records can give incorrect medication information														
	Electronic health records can give me incorrect medical appointments dates														
	Electronic health records can give me incorrect laboratory test results														
	Using electronic health records allows unauthorised people to access my citizens' information														

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
Resistance to change	Changing from traditional health to e-health requires long time to be accomplished														
	Changing to e-health needs special training in how to use them														
	Implementing health information system can reduce job opportunities														
	Working with electronic health records consumes more time than traditional health														
	Working with electronic health records requires more workload than traditional health														
	Using electronic health records affects the relationship with citizens														
	Using electronic health records imposes me to do tasks I'm not responsible for such as inserting citizens' information to the system														
	Using electronic health records will reduce the importance of physicians														

- **Cultural Barriers**

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
Physical interaction	I prefer meeting with my citizens to give information about the medication they need														
	I prefer paper based medical records more than electronic health records														
	Decisions made by electronic health records system are less detailed than traditional health decisions														

- **Medication Safety**

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
Communication gap	I'm able to maintain a list of medications electronically for citizens who are visiting from other healthcare institutions														
	Community pharmacies are able to view citizens' medication history from governmental pharmacies														

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
	Community pharmacies are able to update citizens' medication history from governmental pharmacies														
	I'm able to grant access electronically to other authorised pharmacists to my citizens' electronic medication information														
	Governmental pharmacies are able to view citizens' medication history from community pharmacies														
	Governmental pharmacies are able to update citizens' medication history from community pharmacies														
Limited use of technology	I always use a Computerised Provider Order Entry (CPOE) for prescription a medication														

- **Financial Barrier**

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
Very costly to adopt IT in healthcare	The expenditure spent on adopting IT in health should be spent on building new hospitals														
	The expenditure spent on adopting IT in health should be spent to provide more employment opportunities														

- **Security and Privacy**

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
Easy to access citizens medical records	My citizens' electronic health records are accessed without my permission														
	My citizens' electronic health records are disseminated without my permission														
	My citizens' electronic health records are updated without my permission														
	I'm not able to control the access of others to my citizens' electronic health records														
	I'm not able to determine who should see my citizens' electronic health records														

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
	I'm not informed of people who have access to my citizens' electronic health records														
	My citizens' electronic health records were corrupted														
	I had access to other citizen's electronic health records I'm not authorised to														
	I had the ability to control other citizen's health records														
	My citizens' electronic health records are missing														

A.5.3. IT specialists

- **Connectivity of Information systems**

Sub-barriers	Statements	Yes		No		I'm not sure		Mean	Total number of Participants
		R	%	R	%	R	%		
Absence of national healthcare systems	Electronic health records systems are used in more than one hospital in Saudi Arabia								

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
Absence of national healthcare systems	Citizens' health records are electronically sharable with other healthcare institutions in Saudi Arabia when necessary														
	Citizens' electronic health records in one hospital are accessible in other healthcare institutions when exchanged														
	Electronic health records in one hospital can be updated electronically by other healthcare institutions when exchanged														
	Electronic health records in Saudi Arabia are built by using structure standards (i.e. to standardise field length, data type and contents).														
	Vocabulary standards are used to ensure consistency of exchanged citizen's records between practitioners														
	Exchanged information can be understandable by other electronic health systems														
	Exchange of information can be processed by other electronic health systems														
	The electronic health records system integrates electronic health records from outside the immediate healthcare institution														
	Electronic health records support national health strategies (i.e. disease preventive programs).														

Sub-barriers	Statements	Yes		No		I'm not sure		Mean	Total number of Participants
		R	%	R	%	R	%		
Absence of national healthcare systems	IT infrastructure in the healthcare institutions in Saudi Arabia is ready to have national electronic health records system								

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
Absence of national healthcare systems	PCs in healthcare institutions are out of date														
	Computer networks in healthcare institutions are out of date														
	Storage capacity in healthcare institutions is insufficient														
	Servers in healthcare institutions are old														
	Routers in healthcare institutions are old														
	Backup systems in healthcare institutions are inefficient														
	Lack of development of nationally-based standards														

- **Technical Expertise and Computer Skills**

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
Poor maintenance	PCs in hospitals are equipped with adequate processor to ensure reliability to electronic health records														
	The minimum Internet connection speed in hospitals is adequate														
	Software maintenance was provided to all computers of professionals periodically														
	Hardware maintenance was provided to all computers of professionals periodically														
	Computer networks are well maintained periodically														
	Data in electronic health records system is daily backed up														
	Notifications are generated when maintenance is needed														
Po or int	The electronic health records are difficult to use														

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
	The electronic health records use difficult terminologies														
	The information in the electronic health records are inaccurate														
No guidelines	Guidelines were provided for using electronic health records														
Lack of experience in computer	Working with electronic health records requires IT skills in computer applications														
Insufficient access	PCs are provided sufficiently to ensure access to all users of electronic health records														
	The provided PCs are prepared to handle electronic health records applications														

- **Adoption of Health Information Services (HIT)**

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
Planning	A strong leadership team is essential for adopting electronic health records successfully														
	Vision is necessary for adoption of electronic health records successfully														
	There are clear benefits in adoption of electronic health records														
	Clear strategic plan is known when adoption electronic health records														
	Electronic health records are adopted in partnership with healthcare professionals														
	Electronic health records are adopted in partnership with citizens														
	Adoption of electronic health records caters for differing needs of end users														
	Goals for adoption electronic health records are clearly identified														
	Cost needed for adoption electronic health records was clearly identified														
	Time needed for adoption electronic health records was clearly identified														

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
	Perceived users are trained to have the skills needed to use electronic health records														
Technical support	Work stations were identified before adoption electronic health records														
	Hardware components needed were identified before adoption electronic health records														
	Software design was identified before adoption electronic health records														
	Backup system was set up before adoption electronic health records														
	Electronic health records applications are well maintained for healthcare professionals periodically														
	Electronic health records applications are well maintained for citizens periodically														
	Technical support is available during adoption of electronic health records														
	Technical support is available after adoption electronic health records														
Running over time/cost	The adoption of electronic health records has been accomplished within the perceived cost														
	The adoption of electronic health records has been accomplished on time														

- **Medication Safety**

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
Communication gap	Healthcare professionals are able to share medication information with authorised citizens electronically														
	Healthcare professionals are able to share medication information with authorised people within the hospital electronically														
	Healthcare professionals are able to share medication information with authorised people in other hospitals electronically														
	Medication history of a citizen is communicable with authorised community pharmacies electronically														
	Disseminated medication history is updateable electronically														

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
	Citizens can request prescription refill through their electronic health records														
Limited use of technology	Computerised Provider Order Entry (CPOE) is implemented as part of the electronic health records system														
	Electronic health records include decision support tools to perform medication administration (i.e. the right medication, the right dose and the right time to the right citizen)														
	Electronic health records reduce prescription errors														

- **Financial Barriers**

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
Very costly to adopt IT in healthcare	Adopting e-health applications requires high expenditure														
	The adoption of electronic health records experiences funding difficulties														

- **Security and Privacy**

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
Easy to access citizens medical records	Security standards are used to ensure citizens' health records are confidential and protected														
	Citizens have the right to determine who should see their information														
	Development of electronic health records is subject to privacy agreement between users														
	Disseminated citizens' information through electronic health records is encrypted														
	Citizens are able to know the purpose for granting access to healthcare professionals														

Sub-barriers	Statements	Strongly Agree		Moderately Agree		Neutral		Moderately Disagree		Strongly Disagree		I don't know		**Mean**	Total Number of Participants
		R	%	R	%	R	%	R	%	R	%	R	%		
	Access to the electronic health records system is limited to those who are authorised to obtain information														
	Role base access control is implemented by electronic health records to control what information to be viewed to whom														
	Audit trails were used to know who accessed what information														
	Stored data in citizens' electronic health records are encrypted														
	Electronic signature is used to ensure safe access to citizens' electronic health records														

A.6. Arabic Questionnaire

في هذا الجزء من الدراسة سوف يطلب منك اعطاء بعض المعلومات الإحصائية عن نفسك. الرجاء اختيار أجابة واحدة لكل سؤال.

الرجاء تحديد جنسك
ذكر
انثى

الرجاء تحديد المرحلة العمرية التي تنتمي لها
١٨ ـ ٣٠
٣١ ـ ٤٠
٤١ ـ ٥٠
٥١ ـ ٦٠
اكثر من ٦٠

الرجاء تحديد مستواك التعليمي
الشهادة الثانوية
بكلوريوس
ماجستير
دكتوراه

الرجاء تحديد مهاراتك في استخدام الحاسب الألي
متدنية (لا أستخدم الحاسب الألي او اي أجهزة الكترونية أخرى)
متوسطة (أستخدم تطبيقات الحاسب الأساسية. مثل مايكروسوفت اوفيس، البريد الإلكتروني، او متصفحات الإنترنت)
متقدمة (أقوم بصيانة المكونات المادية للحاسب كما أستخدم برامج متخصصة مثل برامج قواعد البيانات وبرامج الشبكات)

الرجاء نحديد دورك في مؤسسات الرعاية الصحية بالمملكة العربية السعودية
مريض
متخصص في الرعاية الصحية (طبيب – ممرض – صيدلي – فني مختبرات طبية)
متخصص تقنية معلومات

أسئلة خاصة بالمرضى

يحتوي هذا الجزء من الدراسة على عبارات تتعلق بعوائق تطبيق الصحة الإلكترونية في المملكة العربية السعودية. الرجاء قراءة كل جملة واختيار الإجابة التي تعتقد انها الأنسب. يرجى التفكير بكل عبارة جيدا قبل اختيار الأجابة. لا يوجد هناك اجابة صحيحة او اجابة خاطئة.

	الاستبيان	نعم	لا	لا أعلم
١	أنا أستخدم السجلات الصحية الإلكترونية في حال الإجابة بلا، اذهب الى العبارة رقم ٢١			
٢	أستخدم السجلات لاصحية الإلكترونية في اكثر من مستشفى في المملكة العربية السعودية			
٣	أستطيع الوصول الى سجلاتي الصحية الإلكترونية من أي مستشفى في المملكة العربية السعودية			

	الاستبيان	أوافق بشدة	أوافق	محايد	لا أوافق	لا أوافق مطلقاً	لا اعلم
٤	السجلات الصحية الإلكترونية التي أستخدمها صعبة الإستخدام						
٥	السجلات الصحية الإلكترونية التي أستخدمها تستخدم مصطلحات صعبة						
٦	المعلومات في في السجلات الصحية الإلكترونية غير دقيقة						
٧	أنا غير قادر على تعديل معلوماتي الشخصية						
٨	التعامل مع السجلات الصحية الإلكترونية تتطلب مهارات أساسية في إستخدام تطبيقات الحاسب الألي						
٩	يتوفر دليل أرشادي في كيفية إستخدام سجلاتي الصحية الإلكترونية						
١٠	تم تدريبي على كيفية إستخدام السجلات الصحية الإلكترونية						
١١	سجلاتي الصحية الإلكترونية تم الإطلاع عليها بدون إذن مني						
١٢	سجلاتي الصحية الإلكترونية تم نشرها بدون إذن مني						
١٣	سجلاتي الصحية الإلكترونية تم تحديثها بدون إذن مني						
١٤	أنا غير قادر على التحكم بإمكانية الإطلاع على سجلاتي الصحية الإلكترونية من قبل أخرين						
١٥	إنا غير قادر على تحديد من يجب عليه الإطلاع على سجلاتي الصحية الإلكترونية						
١٦	لم يتم إعلامي حول الإشخاص الذي تحصلوا على امكانية الإطلاع على سجلاتي الصحية الإلكترونية						
١٧	تم إتلاف سجلاتي الصحية الإلكترونية						
١٨	انا غير قادر على الوصول الى سجلاتي الصحية الإلكترونية من خارج المملكة						

١٩	أستطيع الوصول الى سجلات صحية إلكترونية لمرضى أخرين						
٢٠	سجلاتي الصحية الإلكرتونية مفقودة						
٢١	أستخدم الحاسب الألي لإطلاع على بريدي الإلكتروني						
٢٢	أستخدم الحاسب الألي في تصفح الإنترنت						
٢٣	أستخدم الحاسب الألي في إنجاز مهام العمل						
٢٤	أقوم بتنزيل التطبيقات على جهاز الحاسب الألي الخاص بي بمهارة						
٢٥	أملك امكانية إستخدام الحاسب الألي بشكل دائم وذلك للإطلاع على لابريد الإلكرتوني الخاص بي						
٢٦	لدي امكانية الوصول الى حاسب ألي وذلك لتصفح الإنترنت						
٢٧	سرعة الحاسب الألي الذي استخدمه كافية						
٢٨	سرعة إتصال الإنترنت الذي استخدمه كافية						
٢٩	الحاسب الألي الذي أستخدمة يتم صيانته جيداَ بصورة دورية						
٣٠	اتصال الإنترنت الذي أستخدمة يتم صيانته جيدا بصورة دورية						
٣١	يمكن للسجلات الصحية الإلكترونية أن تخلق مشكلات تقنية						
٣٢	يمكن للسجلات لاصحية الإلكترونية أن تخلق مشكلات قانونية						
٣٣	يمكن للجسلات الصحية الإلكترونية أن تخلق مشكلات إدارية						
٣٤	السجلات الصحية الإلكترونية مفيدة للمتخصصين في تقديم الرعاية الصحية وليست مفيدة للمرضى						
٣٥	تطبيق السجلات الصحية الإلكرتونية يمكن أن يقلل من إنتاجية المتخصصين في تقديم الرعاية الصحية						
٣٦	يمكن لسجلاتي الصحية الإلكرتونية أن تكون غير حديثة						
٣٧	يمكن لسجلاتي الصحية الإلكترونية أن تفقد بياناتي						
٣٨	إستخدام السجلات الصحية الإلكترونية يمكن أن يكون معقد						
٣٩	يمكن للسجلات الصحية الإلكترونية أن تقدم معلومات أدوية غير صحيحة						
٤٠	يمكن للسجلات الصحية الإلكترونية أن تعطيني تواريخ مواعيد طبية غير صحيحة						
٤١	يمكن للسجلات الصحية الإلكترونية أن تعطيني نتائج إختبارات مخبرية غير صحيحة						

٤٢	يمكن للسجلات الصحية الإلكترونية أن تسمح للأشخاص الغير مصرح بالهم الوصول الى معلوماتي						
٤٣	إتمام التحول من الخدمات الصحية التقليدية إلى الصحة الإلكترونية يتطلب وقت طويل						
٤٤	التحول إلى الصحة الإلكترونية يحتاج إلى تدريب المرضى في كيفية إستخدام وسائل الصحة الإلكترونية						
٤٥	أعتقد أن تطبيق نظم المعلومات الصحية قد يساهم في تقليل الفرص الوظيفية في مجال الرعاية الصحية						
٤٦	إستخدام السجلات الصحية الإلكترونية يؤثر على علاقتي مع طبيبي المعالج						
٤٧	أفضل الإلتقاء بالطبيب في حال أردت الحصول على معلومات دوائية						
٤٨	أفضل إستخدام السجلات الصحية الورقية عن السجلات الصحية الإلكترونية						
٤٩	السجلات الصحية الإلكترونية تحتوي على معلومات أقل تفصيلاً من السجلات الصحية التقليدية						
٥٠	الإنفاق الذي تم صرفة في سبيل تطبيق تقنية المعلومات في المجال الصحة من الأفضل إستغلاله في بناء مستشفيات جديدة						
٥١	الإنفاق الذي تم صرفة في سبيل تطبيق تقنية المعلومات في المجال الصحة من الأفضل إستغلاله في توفير فرص وظيفية جديدة						

أسئلة خاصة بمتخصصي الرعاية الصحية

يحتوي هذا الجزء من الدراسة على عبارات تتعلق بعوائق تطبيق الصحة الإلكترونية في المملكة العربية السعودية. الرجاء قراءة كل جملة واختيار الإجابة التي تعتقد انها الأنسب. يرجى التفكير بكل عبارة جيدا قبل اختيار الأجابة. لا يوجد هناك اجابة صحيحة او اجابة خاطئة

	الإستبيان	**نعم**	**لا**	**لا أعلم**
1	انا أستخدم السجلات الصحية الإلكترونية للمرضى (في حال الاجابة **بنعم**، أجب على الاسئلة من رقم 2 الى رقم 80 . في حال الاجابة **بلا او لا أعلم**، أجب على الاسئلة من رقم 32 وحتى رقم 87.)			

	الإستبيان	**أوافق بشدة**	**أوافق**	**محايد**	**لا أوافق**	**لا أوافق مطلقاَ**	**لا أعلم**
2	استخدم السجلات الصحية الاكترونية في أكثر من مستشفى.						
3	انا قادر على عرض السجلات الصحية الالكترونية لمرضاي في المؤسسات الصحية الاخرى بالمملكة العربية السعودية.						
4	استطيع تحديث نتائج الاختبارات المخبرية بشكل الكتروني للمرضى الزائرين من مستشفيات أخرئ بالمملكة.						
5	انا قادر على نشر السجلات الصحية الالكترونية لمرضاي بشكل الكتروني الى المؤسسات الصحية الاخرئ بالمملكة في حال الحاجة الى ذلك.						
6	التقارير الصحية الالكترونية التي استخدمها صعبة الاستخدام.						
7	التقارير الصحية الالكترونية التي اقوم باستخدامها تستخدم مصطلحات صعبة.						
8	التقارير الصحية الالكترونية غير دقيقة.						
9	العمل مع التقارير الصحية الالكترونية يتطلب مهارات خاصة في استخدام تطبيقات الحاسب الالي.						
10	يتوفر دليل ارشادي لإستخدام السجلات الصحية الالكترونية في المؤسسة الصحية التي أعمل بها.						
11	تم تدريبي على كيفية استخدام السجلات الصحية الالكترونية في المؤسسة الصحية التي أعمل بها.						
12	نظام السجلات الصحية الإلكترونية الذي أقوم باستخدامه يستجيب ببطئ.						
13	نظام السجلات الصحية الالكترونية الذي أقوم بإستخدامة غير قادر على عرض تطور حالة مرضاي.						

						الدعم الفني لنظام السجلات الصحية الإلكترونية متوفر دائما.	14
						السجلات الصحية الإلكترونية تدعم سير العمل للمتخصصين في الرعاية الصحية.	15
						السجلات الصحية الإلكترونية تساعدني في الحصول على المواعيد الطبية لمرضاي.	16
						السجلات الصحية الإلكترونية تساعدني في معرفة جرعات الدواء لمرضاي.	17
						السجلات الصحية الإلكترونية تساعدني في الحصول على نتائج الأختبارات المخبرية لمرضاي.	18
						السجلات الصحية الالكترونية تسهل نشر معلومات مرضاي مع زملائ العمل.	19
						السجلات الصحية الالكترونية تساعدني في التواصل مع مرضاي.	20
						السجلات الصحية الالكترونية تساعدني في تحديث سجلات مرضاي.	21
						السجلات الصحية الالكترونية الخاصة بمرضاي يتم الوصول اليها بدون اذن مني.	22
						السجلات الصحية الالكترونية الخاصة بمرضاي يتم نشرها بدون اذن مني.	23
						السجلات الصحية الالكترونية الخاصة بمرضاي يتم تحديثها بدون اذن مني.	24
						لايمكنني التحكم بامكانية الوصول من قبل الآخرين الى السجلات الصحية الخاصة بمرضاي.	25
						انا غير قادء على تحديد من ينبغي عليه رؤية السجلات الصحية الالكترونية الخاصة بمرضاي.	26
						لا يتم اعلامي بالاشخاص الذين يتحصلون على امكانية الوصول الي السجلات الصحية الالكترونية الخاصة بمرضاي.	27
						السجلات الصحية الالكترونية الخاصه بمرضاي تم اتلافها.	28
						سبق وتحصلت على امكانية الوصول لسجلات صحية الكترونية غير مخول لي بالوصول اليها.	29
						لدي امكانية التحكم بسجلات صحية الكترونية خاصة بمرضى اخرين.	30
						السجلات الصحية الالكترونية الخاصة بمرضاي مفقودة.	31
						اسنخدم الحاسب الآلي لمطالعة بريدي الالكتروني.	32
						استخدم الحاسب الألي لتصفح الانترنت.	33

						استخدم الحاسب الألي لانجاز مهمات العمل في مقر عملي.	34
						اقوم بتحميل التطبيقات بجهاز الحاسب الآلي الخاص بي بإتقان.	35
						لدي امكانية الوصول الى حاسب الي لتفحص البريد الالكتروني الخاص بي.	36
						لدي امكانية الوصول الى حاسب ألي لتصفح الانترنت.	37
						يتوفر عدد كاف من الحواسيب الألية في مقر عملي.	38
						الحاسب الألي الذي اقوم باسنخدامه يعمل بسرعة مناسبة.	39
						سرعة اتصال الانترنت الذي اقوم باستخدامه مناسبة.	40
						يتم صيانة الحاسب الألي الذي اقوم باستخدامه بشكل جيد دوريا.	41
						يتم صيانة شبكة الانترنت التي اقوم باستخدامها بشكل جيد دوريا.	42
						افضل القيام بأعمالي يدويا بدلا من القيام بها باستخدام الحاسب الألي.	43
						ليس لدي الدافع لاستخدام السجلات الصحية الالكترونية.	44
						السجلات الصحية الالكترونية يمكن ان تخلق مشاكل تقنية.	45
						السجلات الصحية الالكترونية يمكن ان تخلق مشاكل قانونية.	46
						السجلات الصحية الالكترونية يمكن ان تخلق مشاكل ادارية.	47
						السجلات الصحية الالكترونية مفيدة للمرضى وليس لأخصائيي الرعاية الصحية.	48
						تنفيذ السجلات الصحية الالكترونية يمكن ان يقلل من انتاجيتي في العمل.	49
						السجلات الصحية الالكترونية يمكن ان تفقد البيانات الخاصة بي.	50
						السجلات الصحية الإلكترونية الخاصة بمرضاي قد تكون غير محدثة.	51
						استخدام السجلات الصحية الالكترونية يمكن ان يكون معقد.	52
						يمكن للسجلات الصحية الالكترونية اعطاء معلومات دواء خاطئه.	53
						يمكن للسجلات الصحية الالكترونية ان تعطيني تواريخ مواعيد طبية بشكل خاطئ.	54

						يمكن للسجلات الصحية الالكترونية ان تعطي نتائج فحوصات مخبرية خاطئة.	55
						استخدام السجلات الصحية الالكترونية يسمح للاشخاص الغير مخول لهم بالوصول الى المعلومات الخاصة بمرضاي.	56
						التحول من الخدمات الصحية التقليدية الى الصحة الاكترونية يتطلب وقت طوي لأنجازه.	57
						التحول الى الصحة الالكترونية يحتاج الى تدريب خاص في كيفية استخدامها.	58
						تطبيق الانظمة الصحية الالكترونية يقلص فرص العمل.	59
						العمل باسنخدام السجلات الصحية الالكترونية يستهلك وقتاَ اطول من العمل بالطريقة التقليدية.	60
						العمل باستخدام السجلات الصحية الالكترونية يزيد من اعباء العمل عما كانت علية بالطريقة التقليدية.	61
						اسنخدام السجلات الصحية الالكترونية يؤثر سلباَ على علاقة الطبيب بالمريض.	62
						السجلات الصحية الالكترونية تفرض علي القيام بمهمات ليست من اختصاصي كادخال معلومات المرضى الى النظام.	63
						اسنخدام السجلات الصحية الالكترونية يقلل من اهمية الأطباء.	64
						افضل الالتقاء بمرضاي وجها لوجه لاعطائهم المعلومات حول الادوية التي يحتاجونها.	65
						افضل السجلات الطبية الورقية اكثر من السجلات الصحية الالكترونية.	66
						القرارات المتخذه عن طريق السجلات الصحية الالكترونية تحتوي على تفاصيل اقل من القرارات المتخذة عن طريق الصحة التقليدية.	67
						أستطيع إلكترونيا التحصل على قائمة بالأدوية التي يتناولها المريض الزائر من مستشفى أخر.	68
						تستطيع صيدليات المجتمع الإطلاع على التاريخ الدوائي للمريض والذي تحصل عليه من خلال الصيدليات الحكومية.	69
						تستطيع صيدليات المجتمع تحديث التاريخ الدوائي للمريض والذي تحصل عليه من خلال الصيدليات الحكومية.	70
						تستطيع الصيدليات الجكومية الإطلاع على التاريخ الدوائي للمريض والذي تحصل عليه من خلال صيدليات المجتمع.	71

						تستطيع الصيدليات الجكومية تحديث التاريخ الدوائي للمريض والذي تحصل عليه من خلال صيدليات المجتمع.	72
						بإمكاني إلكترونياً السماح للصيدليين المخول لهم بالوصول الى المعلومات الدوائية الإلكرتونية لمرضاي.	73
						دائما ما أستخدم تطبيق مزود الطلب الموحد Computerised Provider Order Entry) ((CPOE) في وصف الأدوية.	74
						الإنفاق الذي تم صرفة في سبيل تطبيق تقنية المعلومات في المجال الصحة من الأفضل إستغلاله في بناء مستشفيات جديدة	75
						الإنفاق الذي تم صرفة في سبيل تطبيق تقنية المعلومات في المجال الصحة من الأفضل إستغلاله في توفير فرص وظيفية جديدة.	76
						أجد صعوبة في الأطلاع على السجلات الصحية لمرضاي في أي وقت أريد.	77
						لست قادر على التحصل على قائمة الادوية الخاصة بمرضاي.	78
						أجد صعوبة في الإتصال بمرضاي.	79
						أجد صعوبة في الإتصال بزملاء العمل.	80
						أواجه صعوبة في مشاركة المعلومات الخاصة بالمرضى مع زملائي في العمل.	81
						مراكز الرعاية الصحية بعيدة عن المكان الذي أقيم فيه.	82
						هناك حاجة ملحة لإستخدام السجلات الصحية الإلكترونية في المملكة العربية السعوية.	83

أسئلة خاصة بمتخصصي تقنية المعلومات

يحتوي هذا الجزء من الدراسة على عبارات تتعلق بعوائق تطبيق الصحة الإلكترونية في المملكة العربية السعودية. الرجاء قراءة كل جملة واختيار الإجابة التي تعتقد انها الأنسب. يرجى التفكير بكل عبارة جيدا قبل اختيار الأجابة. لا يوجد هناك اجابة صحيحة او اجابة خاطئة

	الاستبيان	نعم	لا	لا أعلم
١	يتم إستخدام السجلات الصحية الإلكترونية في أكثر من مستشفى في المملكة العربية السعودية حالياً			

أجب على العبارات من ٢ الى ١٤ في حال كانت إجابتك على العبارة رقم ١ نعم فقط

	الاستبيان	أوافق بشدة	أوافق	محايد	لا أوافق	لا أوافق مطلقاً	لا أعلم
٢	يمكن مشاركة السجلات الصحية الإلكترونية للمرضى إلكترونيا مع المؤسسات الصحية الأخرى بالمملكة عند الحاجة لذلك						
٣	السجلات الصحية الإلكترونية للمرضى في مستشفى واحد يمكن الإطلاع عليها من قبل المؤسسات الصحية الأخرى بعد تبدالها معها						
٤	السجلات الصحية الإلكترونية في مستشفى واحد يمكن تحديثها إلكترونيا من قبل المؤسسات الصحية أخرى بعد تبادلها معها						
٥	تم بناء السجلات الصحية الإلكترونية في المملكة باستخدام معايير هيكلية (لتوحيد امتداد الحقول، نوع البيانات و المحتوى)						
٦	يتم إستخدام معايير المفردات لضمان توافق سجلات المرضى التي تم تبادلها بين المستخدمين						
٧	المعلومات التي تم تبادلها يمكن أن تكون مفهومة من قبل الأنظمة الصحية الإلكترونية الأخرى						
٨	المعلومات المُتبادلة يمكن التعامل معها من قبل الأنظمة الصحية الإلكترونية الأخرى						
٩	نظم السجلات الصحية الإلكترونية تدمج السجلات الصحية الإلكترونية من خارج المؤسسة الصحية الفورية						
١٠	السجلات الصحية الإلكترونية تدعم الإستراتيجيات الصحية الوطنية (مثل برامج مكافحة الأمراض)						
١١	السجلات الصحية الإلكترونية صعبة الإستخدام						
١٢	السجلات الصحية الإلكترونية تستخدم مصطلحات صعبة						
١٣	السجلات الصحية الإلكترونية تحتوي على معلومات غير دقيقة						
١٤	يتوفر دليل أرشادي في كيفية إستخدام السجلات الصحية الإلكترونية						

	الاستبيان	نعم	لا	لا أعلم
١٥	البنية التحتية لتقنية المعلومات في المؤسسات الصحية بالمملكة معدة لتطبيق نظم سجلات صحية الكترونية على الصعيد الوطني			

أجب على العبارات من ١٥.١ الى ١٥.٧ في حال كانت إجابتك على العبارة رقم ١٥ لا فقط

	الاستبيان	أوافق بشدة	أوافق	محايد	لا أوافق	لا أوافق مطلقاً	لا أعلم
١٥.١	أجهزة الحاسب الألي في المؤسسات الصحية قديمة						
١٥.٢	شبكات الحاسب الألي في المؤسسات الصحية قديمة						
١٥.٣	سعة التخزين في المؤسسات الصحية غير كافية						
١٥.٤	الخوادم في المؤسسات الصحية قديمة						
١٥.٥	أجهزة التوجية في المؤسسات الصحية قديمة						
١٥.٦	انظمة النسخ الإحتياطي في المؤسسات الصحية غير فعالة						
١٥.٧	هناك نقص في تطوير معايير قائمة على الصعيد الوطني						

أجب على العبارات من ١٦ إلى ٢٢ في حال كانت لإابتك على العبارة رقم ١٥ لا أو لا أعلم فقط

	الاستبيان	أوافق بشدة	أوافق	محايد	لا أوافق	لا أوافق مطلقاً	لا أعلم
١٦	أجهزة الحاسب الألي في المستشفيات مجهزة بمعالجات مناسبة لضمان إمكانية تشغيل السجلات الصحية الإلكترونية						
١٧	سرعة اتصال الإنترنت في المستشفات مناسبة						
١٨	تم توفير صيانة البرمجيات لجميع حواسيب المتخصصين بشكل دوري						
١٩	تم توفير صيانة أجهزة الحاسب الألي لجميع حواسيب المتخصصين بشكل دوري						
٢٠	يتم صيانة شبكات الحاسب الألي جيدا بشكل دوري						
٢١	يتم نسخ بيانات السجلات الصحية الإلكترونية احتياطياً بشكل دوري						
٢٢	يتم إنشاء أخطارات عند الحاجة الى صيانة						

٢٣	يتطلب العمل باستخدام السجلات الصحية الإلكترونية مهارات تقنية المعلومات						
٢٤	أجهزة الحاسب الألي موَفرة بشكل كافي لضمان وصول جميع المستخدمين إلى السجلات الصحية الإلكترونية						
٢٥	الحواسيب المتوفرة مجهزة للتعامل مع تطبيقات السجلات الصحية الإلكترونية						

٢٦	تواجد فريق قيادي قوي يعتبر أمر ضروري لنجاح تبني السجلات الصحية الإلكترونية						
٢٧	الرؤية الواضحة عنصر مهم لنجاح تبني السجلات الصحية الإلكترونية						
٢٨	هناك فوائد واضحة ترتب على تبني السجلات الصحية الإلكرتونية						
٢٩	تم التعرف على خطة إستراتيجية واضحة عند تبني السجلات الصحية الإلكرتونية						
٣٠	تم تبني السجلات الصحية الإلكرتونية بالشراكة مع متخصصي الرعاية الصحية						
٣١	تم تبني السجلات الصحية الإلكرتونية بالشراكة مع المرضى						
٣٢	تبني السجلات الصحية الإلكترونية تم بمراعاة الإحتياجات المختلفة للمستخدمين						
٣٣	الأهداف من تبني السجلات الصحية الإلكترونية محددة بوضوح						
٣٤	تم تحديد التكلفة اللازمة لاعتماد السجلات الصحية الإلكترونية بشكل واضح						
٣٥	تم تحديد الزمن اللازم لاعتماد السجلات الصحية الإلكترونية بشكل واضح						
٣٦	تم تدريب المستخدمين المنظورين ليتحصلوا على المهارات الضرورية لاستخدام السجلات الصحية الإلكترونية						
٣٧	تم تحديد محطات العمل قبل البدء بتبني السجلات الصحية الإلكترونية						
٣٨	تم تحديد الأجهزة المادية اللازمة قبل البدء بتبني السجلات الصحية الإلكترونية						
٣٩	تم تحديد تصميم البرمجيات قبل البدء بتبني السجلات الصحية الإلكترونية						
٤٠	تم تأسيس نظام النسخ الإحتياطي قبل البدء بتبني السجلات الصحية الإلكترونية						
٤١	تتم صيانة تطبيقات السجلات الصحية الإلكترونية لمتخصصي الرعاية الصحية بشكل جيد دوريا						
٤٢	تتم صيانة تطبيقات السجلات الصحية الإلكترونية للمرضى بشكل جيد دوريا						
٤٣	الدعم الفني متاح خلال فترة تبني السجلات الصحية الإلكترونية						
٤٤	الدم الفني متاح بعد الإنتهاء من تبني السجلات الصحية الإلكترونية						
٤٥	تم إنجاز تبني السجلات الصحية الإلكترونية ضمن التكلفة المحددة						
٤٦	تم إنجاز تبني السجلات الصحية الإلكترونية في الوقت المحدد						

٤٧	باستطاعة متخصصي الرعاية الصحية مشاركة معلومات الأدوية إلكترونياَ مع المرضى المخول لهم						
٤٨	باستطاعة متخصصي الرعاية الصحية مشاركة معلومات الأدوية إلكترونياَ مع الأشخاص المخول لهم في نفس المستشفى						
٤٩	باستطاعة متخصصي الرعاية الصحية مشاركة معلومات الأدوية إلكترونياَ مع الأشخاص المخول لهم في مستشفيات أخرى						
٥٠	يمكن مشاركة التاريخ الدوائي للمرضى الكترونياَ مع صيدليات المجتمع المخول لها						
٥١	التاريخ الدوائي الذي تم مشاركتة قابل للتحديث إلكترونياَ						
٥٢	بإمكان المرضى طلب إعادة تعبئة الدواء من خلال السجلات الصحية الإلكترونية الخاصة بهم						
٥٣	تطبيق مزود الطلب الموحد (Computerised Provider Order entry (CPOE)) مُنفذ كجزء في نظام السجلات الصحية الإلكترونية						
٥٤	تتضمن السجلات الصحية الإلكترونية أدوات دعم القرار الخاصة بإدارة الأدوية (مثل معرفة الدواء المناسب والجرعة المناسبة والوقت المناسب للمريض المناسب)						
٥٥	تساهم السجلات الصحية الإلكترونية في تقليل أخطاء الوصفات الطبية						
٥٦	يتطلب إعتماد تطبيقات الصحية الإلكترونية إنفاق عالي						
٥٧	يواجة تبني السجلات الصحية الإلكترونية صعوبات في التمويل المالي						
٥٨	تستخدم السجلات الصحية الإلكترونية معايير أمنية لضمان سرية وحماية السجلات الصحية للمرضى						
٥٩	يملك المرضى أحقية تحديد من بإمكانة الأطلاع على معلوماتهم						
٦٠	يخضع إنشاء السجلات الصحية الإلكترونية لاتفاق الخصوصية بين المستخدمين						
٦١	يتم تشفير المعلومات التي يتم نشرها إلكترونياَ عن طريق السجلات الصحية الإلكترونية						
٦٢	بإمكان المرضى معرفة الهدف وراء اعطائهم متخصصي الرعاية الصحية امكانية الوصول الى بياناتهم						
٦٣	امكانية الوصول إلى انظمة السجلات الصحية الإلكترونية محدودة بالأشخاص المخول لهم الحصول على معلومات						
٦٤	تطبق السجلات الصحية الإلكترونية منهج (التحكم في الوصول استناداً على الدور) للتحكم بماهية المعلومات التي يجب عرضها لمن						
٦٥	تستخدم السجلات الصحية الإلكترونية مسارات التدقيق لمعرفة هوية كل شخص تمكن من الوصول الى معلومات						

	وماهي المعلومات التي اطلع عليها						
٦٦	يتم تشفير البيانات المخزنة في السجلات الصحية الإلكترونية للمرضى						
٦٧	تستخدم السجلات الصحية الإلكترونية التوقيع الإلكتروني لضمان سلامة الوصول الى سجلات المرضى						

Appendix B: Data Mining Study

B.1. Ethical approval for the DM Study

RESEARCH ETHICS
Proportionate Review Form

The Proportionate Review process may be used where the proposed research raises only minimal ethical risk. This research must: focus on minimally sensitive topics; entail minimal intrusion or disruption to others; and involve participants who would not be considered vulnerable in the context of the research.

PART A: TO BE COMPLETED BY RESEARCHER

Name of Researcher:	SALEH ALMUAYQIL

Student/Course Details (If Applicable)			
Student ID Number:		12031451	
Name of Supervisor(s)/Module Tutor:		PROF. ANTHONY S ATKINS	
PhD/MPhil project:	☒		
Taught Postgraduate Project/Assignment:	☐	Award Title:	
Undergraduate Project/Assignment:	☐	Module Title:	

Project Title:	Integrated Framework of Knowledge Management and Knowledge Discovery for E-health in Saudi Arabia: Supporting Citizens with Diabetes Mellitus		
Project Outline:	The aim of the research is to develop a framework by integrating Knowledge Management (KM) and Knowledge Discovery (KD) to support the e-healthcare of diabetes mellitus citizens and health professionals in the Kingdom of Saudi Arabia.		
Give a brief description of participants and procedure (methods, tests etc.)	A QUESTIONS OF 19 MULTIPLE CHICE QUESTIONS AND ONE OPEN ENDDED QUESTIONS. PARTICIPANTS WILL BE A SAUDI ARABIAN CITIZENS WHO MAY HAVE ENCOUNTERED NON-HEALTH RELATED COMPLICATIONS OF DIABETES MELLITUS. THE RESPONSES OF THE QUESTIONNAIRE WILL BE ANALYSED THEOUGH A DATA MINING TECHNIQUE TO VALIDATE OUR INTEGRATED FRAMEWORK.		
Expected Start Date:	1/5/2016	Expected End Date:	1/2/2017

Relevant professional body ethical guidelines should be consulted when completing this form.

Please seek guidance from the Chair of your Faculty Research Ethics Committee if you are uncertain about any ethical issues arising from this application.

There is an obligation on the researcher and supervisor (where applicable) to bring to the attention of the Faculty Ethics Committee any issues with ethical implications not identified by this form.

Researcher Declaration

I consider that this project has no significant ethical implications requiring full ethical review by the Faculty Research Ethics Committee.	☒

I confirm that:		
1.	The research will **NOT** involve members of vulnerable groups.	☒
	Vulnerable groups include but are not limited to: children and young people (under 18 years of age), those with a learning disability or cognitive impairment, patients, people in custody, people engaged in illegal activities (e.g. drug taking), or individuals in a dependent or unequal relationship.	
2.	The research will **NOT** involve sensitive topics. Sensitive topics include, but are not limited to: participants' sexual behaviour, their illegal or political behaviour, their experience of violence, their abuse or exploitation, their mental health, their gender or ethnic status. The research must not involve groups where permission of a gatekeeper is normally required for initial access to members, for example, ethnic or cultural groups, native peoples or indigenous communities.	☒
3.	The research will **NOT** deliberately mislead participants in any way.	☒
4.	The research will **NOT** involve access to records of personal or confidential information, including genetic or other biological information, concerning identifiable individuals.	☒
5.	The research will **NOT** induce psychological stress, anxiety or humiliation, cause more than minimal pain, or involve intrusive interventions. This includes, but is not limited to: the administration of drugs or other substances, vigorous physical exercise, or techniques such as hypnotherapy which may cause participants to reveal information which could cause concern, in the course of their everyday life.	☒
6.	The research **WILL** be conducted with participants' full and informed consent at the time the study is carried out: • The main procedure will be explained to participants in advance, so that they are informed about what to expect. ☒ • Participants will be told their involvement in the research is voluntary. ☒ • Written consent will be obtained from participants. *(This is not required for self-completion questionnaires as submission of the completed questionnaire implies consent to participate).* ☒ • Participants will be informed about how they may withdraw from the research at any time and for any reason. ☒ • For questionnaires and interviews: Participants will be given the option of omitting questions they do not want to answer. ☒ • Participants will be told that their data will be treated with full confidentiality and that, if published, every effort will be made to ensure it will not be identifiable as theirs. ☒ • Participants will be given the opportunity to be debriefed i.e. to find out more about the study and its results. ☒	☒ N/A ☐

If you are unable to confirm any of the above statements, please complete a **Full Ethical Review Form**. If the research will include participants that are **patients**, please complete the independent Peer Review process.

Supporting Documentation

All key documents e.g. consent form, information sheet, questionnaire/interview schedule are appended to this application.	☒

Signature of Researcher:	[signature]	Date:	24/5/2016

Proportionate Review

NB: If the research departs from the protocol which provides the basis for this proportionate review, then further review will be required and the applicant and supervisor(s) should consider whether or not the proportionate review remains appropriate. If it is no longer appropriate a full ethical review form **MUST** be submitted for consideration by the Faculty Research Ethics Committee.

Next Step:
STUDENTS: Please submit this form (and supporting documentation) for consideration by your Supervisor/ Module Tutor.
STAFF: Please forward this form to the Chair of Faculty Research Ethics Committee who will arrange for it to be considered by an independent member of the Faculty Research Ethics Committee.

PART B: TO BE COMPLETED BY SUPERVISOR/MODULE TUTOR (If Applicable)

I consider that this project has no significant ethical implications requiring full ethical review by the Faculty Research Ethics Committee.	☑
I have checked and approved the key documents required for this proposal (e.g. consent form, information sheet, questionnaire, interview schedule).	☑

Signature of Supervisor:	A S Atkins	Date:	24 My 2016

Next Step: Please forward this form to the Chair of Faculty Research Ethics Committee who will arrange for it to be considered by an independent member of the Faculty Research Ethics Committee, having no direct connection with the researcher or his/her programme of study.

PART C: TO BE COMPLETED BY FACULTY RESEARCH ETHICS COMMITTEE MEMBER

This research proposal has been considered using agreed University Procedures and is now approved. Or This research proposal has not been approved due to the reasons given below.	☒ ☐

Proportionate Review

Name of Reviewer:	Dr Clare Stanier	Date:	12 Sept 2016
Signature:	[signature]		

B.2. Valid association rules

B.2.1. Valid rules from the Female dataset

Associations between diabetes non-health related complications encountered by female diabetic citizens in Saudi Arabia and their profile information

No	Valid associations in D_{Female}		Support	Confidence
	Complications	Profile information		
1	Identifying the right medication amount in Ramadan	Single Type1	0.2	0.94
2	Identifying the diet appropriate to the health condition	High school or below Type1 Not employed	0.2	0.92
3	Coexisting with aspects of diabetes lifestyle	High school or below Type1 Not employed	0.2	0.92
4	Identifying the right medication amount in Ramadan	Single Not employed Type1	0.2	0.92
5	Identifying the right medication time in Ramadan	High school or below Type1 Not employed	0.2	0.91
6	Identifying right medication amount in Ramadan	High school or below Not employed	0.2	0.91
7	Identifying the right diet in Ramadan.	High school or below Type1 Not employed	0.2	0.91

B.2.2. Valid rules from the Male dataset

Associations between diabetes non-health-related complications encountered by male diabetic citizens in Saudi Arabia and their profile information

No	Valid associations in D_{Male}		Support	Confidence
	Complications	Profile information		
1	Identifying the right medication dosage	Employed Type2 Married	0.2	0.98
2	Undertaking any physical activity	Employed Type2 Married	0.2	0.97
3	Remembering when to take medication	Type2 Married	0.2	0.97
4	Identifying the right medication dosage	Employed married	0.2	0.96
5	Undertaking any physical activity	Bachelor degree Employed Married	0.2	0.95
6	Identifying the right medication	Employed Married	0.2	0.95
7	Identifying the right medication	Employed Type2 Married	0.2	0.95
8	Remembering when to take medication	Employed Married	0.2	0.95
9	Identifying the right medication dosage	Type2 Married	0.2	0.94
10	Identifying the right medication amount in Ramadan	Bachelor degree Employed Married	0.2	0.94
11	Identifying the right medication	Bachelor degree Employed Married	0.2	0.93
12	Identifying the right medication amount in Ramadan	Employed Type2 Married	0.2	0.93
13	Identifying the right medication amount in Ramadan	Employed Married	0.2	0.93
14	Identifying the diet appropriate to the health condition	Employed Type2 Married	0.2	0.92
15	Undertaking any physical activity	Type2 Married	0.2	0.92
16	Identifying the right medication	Type2 Married	0.2	0.92
17	Identifying the right medication amount in Ramadan	Type2 Married	0.2	0.91
18	Identifying the right medication	Bachelor degree Married	0.2	0.90

Appendix C: Framework Validation and Web Portal Evaluation

C.1. Framework Validation

C.1.1. Consent Form

Participant ID:

Please tick when appropriate:

1	The framework and its goals were described to me in a presentation session.	
2	Functionality of the framework is illustrated.	
3	I had the opportunity to ask questions related to the framework.	
4	I understand that my participation is voluntary.	
5	I understand that I can withdraw from this study at any time.	
6	I agree to participate in this validation.	

Signature of participant:

Date:

C.1.2. Participants Profile Information

Please chose the appropriate answers:

<table>
<tr><td>1</td><td>Role in healthcare</td><td colspan="2">Citizen</td><td colspan="3">Healthcare professional</td><td colspan="2">IT specialist</td></tr>
<tr><td>2</td><td>Years of experience</td><td>Less than one year</td><td>1-5 years</td><td>6-10 years</td><td>11- 15 years</td><td>16-20 years</td><td>21-25 years</td><td>Over 25 years</td></tr>
</table>

C.1.3. Validation Form

1. Multiple-choice statements:

layer	Statement	Strongly disagree	Moderately disagree	Neutral	Moderately agree	Strongly agree
1st Layer	The framework outlines different e-health barriers.					
	The framework addresses relevant diseases in Saudi Arabia.					
	The framework addresses appropriate issues related to diabetes mellitus					
2nd Layer	The framework allow the capturing of new knowledge related to diabetes mellitus.					
3rd Layer	Guidelines, best practices, policies, strategies and governance are able to assist diabetic citizens with non-health related complications of diabetes mellitus.					
	The framework provides mechanism to share knowledge among diabetic citizens and healthcare professionals.					
	The framework facilitates sharing of tacit strategies in relation to measuring glucose level among different individuals.					
	The framework provides useful approaches with regard to converting tacit guidelines related to identifying appropriate medication into explicit.					
	The framework facilitates sharing of explicit policies with regard to diabetes prevention and management among different individuals.					
	The framework provides useful approach with regard to converting explicit best practices to appropriate diet and physical activities into tacit.					

2. Open ended questions:

1. Is there anything you wish to suggest to improve the framework?
2. Is there anything you wish to add that may hinders you from using the framework?

C.2. DSMKSA Evaluation

Diabetes **S**elf-**M**anagement in the **K**ingdom of **S**audi **A**rabia (DSMKSA) is a web portal designed to assist diabetic citizens and healthcare professionals in the kingdom of Saudi Arabia to self-manage diabetes mellitus through the creation and dissemination of variety of diabetes self-management and educational policies, strategies, guidelines, best practices and governance.

C.2.1. Consent Form

Participant ID:

Please tick when appropriate:

1	The web portal and its goals were described to me in a presentation session.	
2	Functionality of the web portal is illustrated.	
3	I had the opportunity to ask questions related to the web portal.	
4	I understand that my participation is voluntary.	
5	I understand that I can withdraw from this study at any time.	
6	I agree to participate in this evaluation.	

Signature of participant:

Date:

C.2.2. Participants Profile Information

Please chose the appropriate answers:

<table>
<tr><td>1</td><td>Role in healthcare</td><td colspan="2">Citizen</td><td colspan="3">Healthcare professional</td><td colspan="2">IT specialist</td></tr>
<tr><td>2</td><td>Years of experience</td><td>Less than one year</td><td>1-5 years</td><td>6-10 years</td><td>11- 15 years</td><td>16-20 years</td><td>21-25 years</td><td>Over 25 years</td></tr>
</table>

C.2.3. Evaluation Form

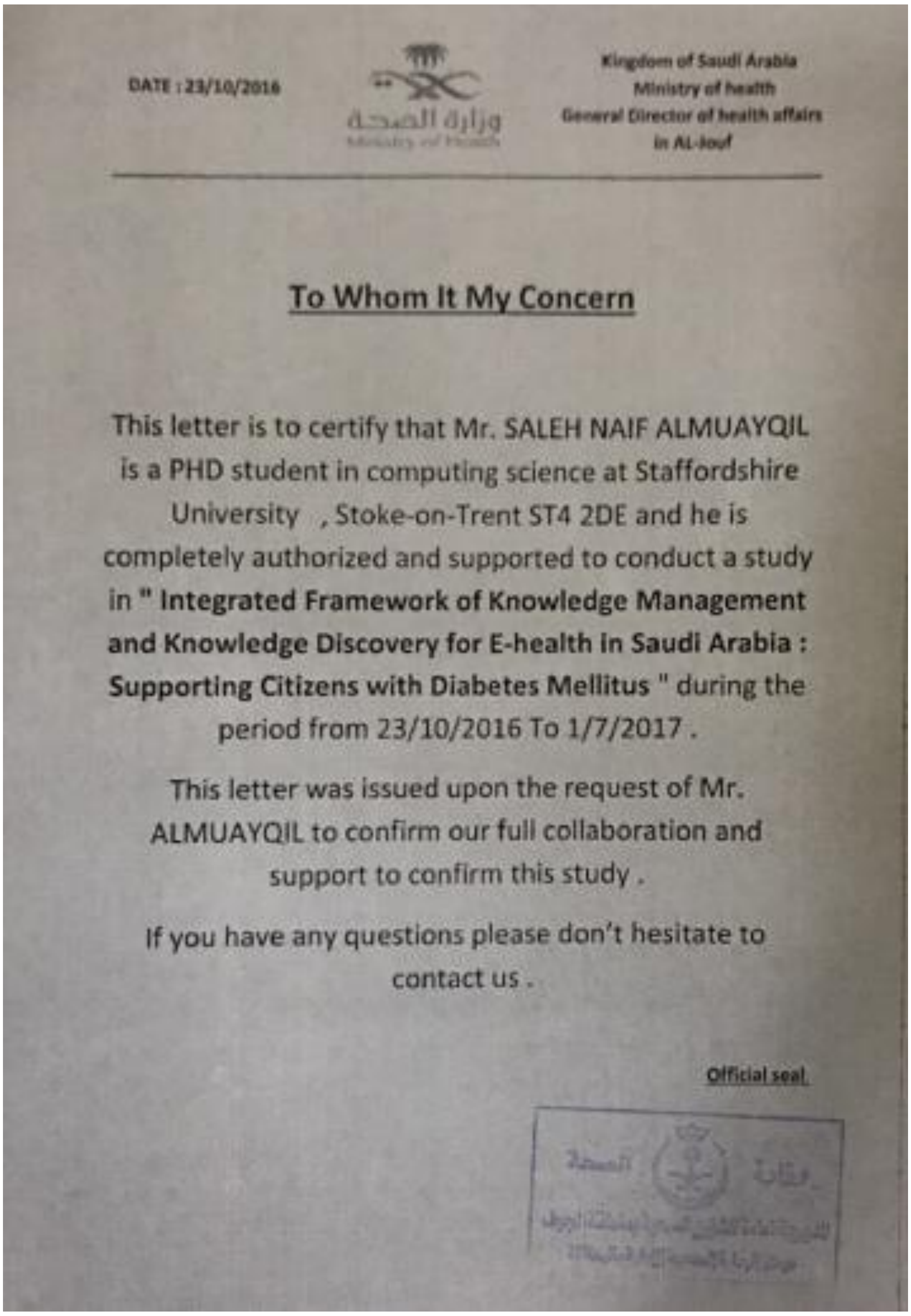
1. Multiple-choice statements.

Verification part	Statement	Strongly disagree	Moderately disagree	Neutral	Moderately agree	Strongly agree
Socialisation	Forums are effective of socialisation in relation to diabetes self-management and education in DSMKSA.					
	Community of practices are effective of socialisation in relation to diabetes self-management and education in DSMKSA.					
	Social media are effective of socialisation in relation to diabetes self-management and education in DSMKSA.					
Externalisation	Blogs are an effective in externalisation in relation to diabetes self-management and education in DSMKSA.					
	wikis are an effective in externalisation in relation to diabetes self-management and education in DSMKSA.					
	Social media are an effective in externalisation in relation to diabetes self-management and education in DSMKSA.					
	Diabetes Q&A page is an effective in externalisation in relation to diabetes self-management and education in DSMKSA.					
Combination	The official documents page is effective in integrating different explicit knowledge related to diabetes self-management and education in DSMKSA.					
	Wikis are effective in integrating different explicit knowledge related to diabetes self-management and education in DSMKSA					
	Blogs are effective in integrating different explicit knowledge related to diabetes self-management and education in DSMKSA					
Internalisation	Community of practices are effective in acquiring and internalising explicit knowledge related to diabetes self-management and education in DSMKSA.					
	Wikis are effective in acquiring and internalising explicit knowledge related to diabetes self-management and education in DSMKSA.					

2. Open ended statement:

If you have any suggestions to improve the web portal, please add in the space below.

C.3. Collaboration agreement from a PHC in Saudi Arabia



DATE : 23/10/2016

وزارة الصحة

Kingdom of Saudi Arabia
Ministry of health
General Director of health affairs
in AL-Jouf

To Whom It My Concern

This letter is to certify that Mr. SALEH NAIF ALMUAYQIL is a PHD student in computing science at Staffordshire University , Stoke-on-Trent ST4 2DE and he is completely authorized and supported to conduct a study in " **Integrated Framework of Knowledge Management and Knowledge Discovery for E-health in Saudi Arabia : Supporting Citizens with Diabetes Mellitus** " during the period from 23/10/2016 To 1/7/2017 .

This letter was issued upon the request of Mr. ALMUAYQIL to confirm our full collaboration and support to confirm this study .

If you have any questions please don't hesitate to contact us .

Official seal