Telecare for Managing Diabetes In Saudi Arabia

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A Thesis Submitted for the Degree of Philosophy Doctor (PhD)

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DECLARATION

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ABSTRACT

Saudi Arabia is struggling to provide quality healthcare services in light of the growing population, rapid spread of chronic diseases, and limited resources available. In addition to these obstacles, the Saudi society is a highly conservative one, and certain traditions may sometimes limit how healthcare services can be offered.

This work examines the impact of a Telecare solution on the healthcare system at the National Guard Health Affairs (NGHA). It focuses on diabetes, and the challenges faced by both the healthcare officials at NGHA, and the patients. These challenges also include social factors that may pose at obstacle in delivering healthcare services.

The 'Telecare for Managing Diabetes – TeMaD' system is designed and developed using the Soft Systems Methodology. It was then integrated into the hospital information systems at King Abdulaziz Medical City in the Central Region, and consisted of 52 participating patients, and four involved Diabetic Educators. HbA1c levels of all patients were recorded prior to commencement of the study. Patients were required to use TeMaD for a 3-month period, then, had their HbA1c levels recorded again after completion of the study. Overall observation of the results showed a reduction in the HbA1c levels of 83% of the patients.

Participating patients expressed their acceptance of the system, indicating that TeMaD allowed them to overcome some obstacles such as lack of transportation. It also assisted the majority of participants to better manage their diabetes and ease communication with their diabetic educators. Most patients requested that the system be offered permanently at the clinic. Diabetic educators were in favour of integrating TeMaD into the current healthcare system at NGHA, and they were enthusiastic about its numerous benefits.

Telecare solutions can be used to enhance the quality of healthcare services, meet current demands, and address obstacles faced by the healthcare system in Saudi Arabia, including social factors that are unique. They can be adopted by neighbouring Gulf States which share common obstacles in healthcare.

CHAPTER 1: INTRODUCTION

1.1 Background and Motivation

The lifestyles of people everywhere are changing rapidly due to urbanisation, technology, and associated habits. People are exerting less physical activity, eating unhealthy food, and adopting bad habits such as smoking. Such factors are quickly leading to obesity and related diseases.

One of the most rapidly spreading diseases today is diabetes, with millions of people around the globe suffering from it. According to the World Health Organisation (WHO), an estimated 3.4 million people died from diabetes in 2004. WHO expects deaths to double between 2005and 2030 unless urgent action is taken [1].

Due to various factors, women are more affected by this disease. This is especially evident in developing countries, where women might be deprived of receiving the necessary healthcare services.

This, sometimes fatal, disease is continuing to spread so fast, that governments are struggling to keep up with associated costs. Most governments are investing heavily in campaigns to raise the awareness of diabetes as a measure of both disease management and prevention. They are also trying desperately to manage the situation by improving the quality of healthcare services and finding new alternative solutions. But this, in itself, presents a huge dilemma in countries with limited healthcare and financial resources, and rapidly growing populations.

Although governments are allocating huge budgets to their healthcare sectors, the associated costs of chronic diseases are on the rise and continue to pose a burden on the economies.

It is essentially important to explore alternative methods of delivering healthcare. Although medical knowledge about diabetes, its onsets, associated complications, and treatment are somewhat similar globally, the methods in how healthcare services are offered to treat, prevent, and manage it can greatly differ from one country to another. In addition, the manner in how healthcare services are offered can depend heavily on social, cultural, and religious constraints. This is especially true when dealing with female patients, who usually are more affected by these constraints than male patients.

The research presented here is a novel approach which will identify this difference in practices and attempt to bridge the gap. It will highlight areas that pose as major obstacles in the Saudi healthcare system. Some of these areas are unique to Saudi and may not exist in other countries. This research will adopt the use of technology to offer healthcare services in a different manner, with the goal to overcome the differences in medical practices and bring them to the same level for all patients.

This research leads to the design of a Telecare model using the Soft Systems Methodology, and finally a Telecare system is developed for diabetic patients and their healthcare givers at the King Abdulaziz Medical City – Central Region (KAMC-CR). In order to produce a practical solution, the development of the Telecare solution focused on organizational collaboration throughout the NGHA medical cities in Riyadh and Jeddah, identified a shared vision and concentrated on raising Telecare awareness among the stakeholders.

The system has been designed and developed to achieve maximum user satisfaction for both patients and their healthcare givers. In order to achieve this, all participants were involved in the development process consisting of a clear gathering of requirements, system component testing, user feedback and training sessions.

1.2 Hypothesis

This research will assess the current healthcare system in Saudi Arabia, and examine the obstacles being faced by both the healthcare givers and their patients. It will focus on specific factors related to the conservative Saudi society which may often limit how healthcare services are being offered.

Due to the prevalence of diabetes in Saudi, a Telecare system for NGHA is designed and developed to assist in the management of this disease. This system is offered as an alternative method of delivering healthcare services using simple and available technology.

The work presented here will examine the impact of a Telecare solution on healthcare services currently being offered at NGHA for diabetic patients. It will investigate if Telecare can address and possibly overcome social, cultural, and religious factors of a conservative society, that currently present constraints on how healthcare services are offered. It will particularly focus on the impact this solution may have on female patients who are most affected by these social and cultural factors in Saudi Arabia.

Since the Telecare system was modelled using a Soft Systems Methodology, will it be able to effectively address human behavioural aspects related to religion, culture and tradition? Can a Telecare system positively impact diabetes management at the Saudi National Guard Health Affairs? Can the use of Telecare solutions improve the quality of services offered, reduce the operational cost and help healthcare officials in managing hospital resources more efficiently? Can Telecare strengthen the communication channels between the stakeholders? Will Telecare solutions be accepted by conservative Saudi patients as an alternative method of healthcare services? And finally, can a Telecare solution built for Saudi Arabia be suitable for application in the healthcare system of neighbouring Gulf States, which share the same religion and have common traditions?

1.3 Aims

The primary aim of this project is to produce new technology that can enable healthcare givers at NGHA to provide better healthcare services, to assist patients in managing their disease more effectively, and facilitate strong communication channels between them. To this effect, a number of goals have been identified as follows:

1. Identify obstacles being faced by the healthcare system in Saudi.

2. Focus on unique social and cultural factors impacting healthcare services in Saudi.

3. Develop a healthcare system for diabetes, to assist in disease management and prevention.

4. Motivate diabetics to adhere to treatment strategies.

5. Strengthen communication channels between patients and clinicians.

6. Grant patients more independence from the hospital.

7. Raise patient awareness about diabetes.

8. Raise awareness of NGHA healthcare officials of the practicality of Telecare and its benefits.

9. Reduce NGHA operational costs in relation to diabetes management.

1.4 Objectives

In order to achieve the project aims, a set of objectives have been identified as follows:

1. Analysis of current diabetes management tools and techniques.

2. Examination of available technology to assist in diabetes management.

3. Devise a model to be used for Telecare implementations at the National Guard Health Affairs (NGHA) using a methodological approach.

4. Develop a Telecare solution for diabetes management.

5. Implementation of the Telecare solution and integration into existing NGHA Hospital Information Systems (HIS)'s.

6. Measure the impact of the Telecare solution on the NGHA healthcare system.

7. Determine level of acceptance of Telecare among healthcare professionals and patients at NGHA.

8. Identify healthcare services at NGHA that can most benefit from Telecare solutions.

1.5 Organisation of Thesis

Chapter 2 presents a literature view of the status of diabetes in developing countries, with a reference to needs assessment. It discusses the research area we are targeting, and examines how Telecare solutions have been adopted in

developing countries with a focus on the situation in the Gulf Cooperation Council (GCC) States.

The healthcare system infrastructure is examined in Chapter 3, with a close look at influencing factors and obstacles. The status of eHealth directions and initiatives is discussed, in particular, initiatives taken by the Saudi Association for Health Informatics (SAHI) [2].

Chapter 4 reviews the prevalence of diabetes in Saudi Arabia, then looks at contributing factors within the society. It then discusses the growing costs of diabetes management, and the impact on the Saudi economy. Finally, it proposes the use of technology to assist in the management of this disease.

The adoption of a methodological approach is presented in Chapter 5. The Soft Systems Methodology (SSM) is used to design a Telecare model to help manage diabetes at KAMC-CR. Here, a SSM structure is followed step-by-step with illustrations describing how the methodology would apply at NGHA. It concludes with a devised model for a Telecare solution.

The devised model is then used as the basis to develop a Telecare solution, 'Telecare for Managing Diabetes TeMaD', for patients at NGHA Clinic 104. Chapter 6 presents the development stages involving the selection of the Software Development Life Cycle, standardization of development, the engineering of the software, and interfacing and integration steps.

Chapter 7 then presents a technical evaluation of the Telecare solution, both formative and summative. The evaluation meticulously examines the functionality, the smooth integration with existing hospital information systems, and examines the user-friendliness of the system. In this Chapter, the steps taken prior to launching the system are described. This includes completing all NGHA official processes necessary prior to launching.

A complete evaluation of the data gathered from the TeMaD study is presented in Chapter 8. This includes the evaluation of data gathered from the TeMaD system, and also that gathered from the 'TeMaD completion questionnaires' submitted by both participating patients and Diabetic Educators at NGHA Clinic 104.

In Chapter 9, a discussion of the research is presented. We examine how the Telecare solution impacted the healthcare services offered at the clinic. We also discuss if this approach has been successful in improving the healthcare services. Most importantly, we examine if this solution has been able to assist in overcoming social and cultural barriers that may pose as obstacles in delivering healthcare. This Chapter then weighs the level of success of this work by verifying whether or not the

research goals identified at the beginning of the research have been met at the end. Finally, it concludes by discussing how this work can be continued in the future.

The final Chapter offers what this research has contributed to the field. It indicates how a number of factors covered by this research are unique to Saudi Arabia, and have not yet been examined by other researchers.

CHAPTER 2: PRELIMINARY RESEARCH

2.1 Introduction

The healthcare and education sectors are primarily the two most important areas in the development of a country. Healthcare in particular, is a strong indicator of the level of development achieved. However, in many countries, healthcare is facing huge obstacles, affecting quality of healthcare services and quality of life. In order to take a step forward, we first need to examine the current situation of healthcare sectors, the type of obstacles that exist, and how governments are coping with these factors.

Struggling healthcare sectors need to assess how current services are offered, how technology can help overcome obstacles, and if such approaches can prove to be effective. To answer these questions, it is essential that we examine the needs in developing countries. This examination requires a close look at the current situation of diabetes and how it is being managed. In addition, we need to examine how current technologies are being adopted in healthcare, and how they are being introduced, developed, and integrated into healthcare systems.

Although we talk about developing countries, we are going to narrow our target to the GCC States and particularly focus on Saudi Arabia, and the impact this research can have on the healthcare system at the Saudi National Guard Health Affairs.

2.2 Needs Assessment in Developing Countries

In order to get a clear understanding of the situation, we need to assess the need for Telecare solutions in the healthcare industry in developing countries. We examine associated factors in such countries and assess current approaches. Such factors include the current situation of diabetes management, how technologies are utilised for healthcare delivery, and the use of scientific methodologies to develop Telecare.

2.2.1 Current Situation of Diabetes Management

Diabetes is rapidly spreading in many developing countries. The Gulf States have recorded record high levels of diabetes in recent years. Figures published by the International Diabetes Federation (IDF) in 2009 indicate that five states, which are members of the GCC, are among the top ten globally with the highest prevalence of diabetes [3], with approximately 6.5 million residents of the GCC suffering from diabetes [4].

A study published by the WHO shows this prevalence in the Gulf region (figure 2.1) and neighbouring developing countries in the Middle East.

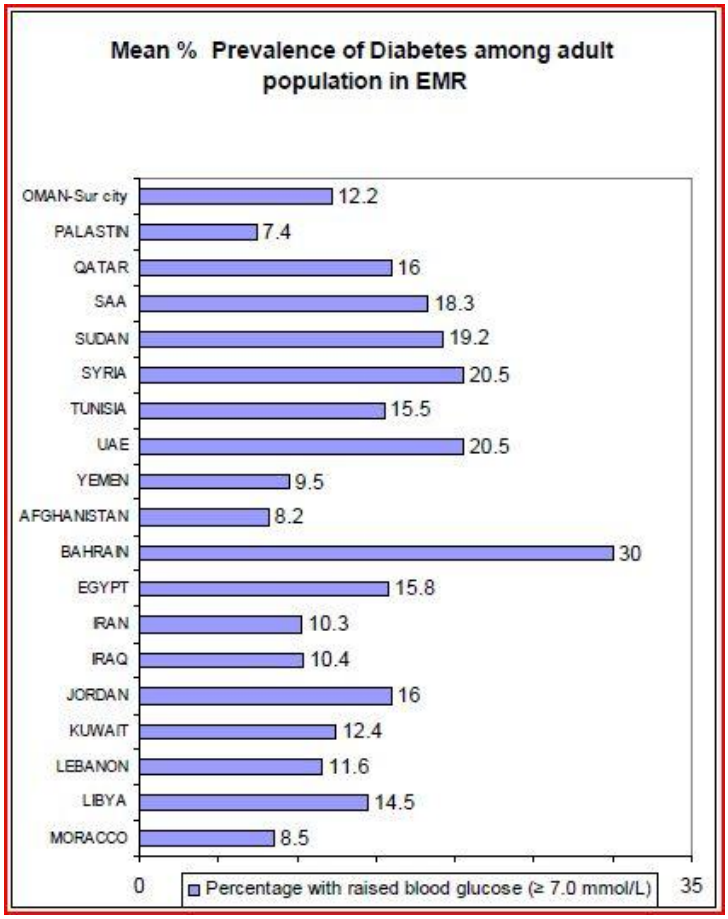


Figure 2.1: Prevalence of diabetes in the Middle-East & North Africa

Unfortunately, by 2025, the number of people with diabetes is expected to be more than double in Africa, the Eastern Mediterranean and South-East Asia regions [5].

This is giving rise to concerns on how to contain the spread of diabetes, and how to manage the financial burden of healthcare costs on the governments of these developing countries.

Based on an article published by *Business Intelligence – Middle East* in 2009, the treatment of diabetes in the United Arab Emirates (UAE) and Saudi Arabia is "highly fragmented and sub-optimal in a number of areas" [4]. The article discusses the fact that critical treatments are either 'inaccessible' or simply 'not being prescribed'. Medics in Saudi Arabia have complained about not having access to the best treatments [4].

This obviously affects the quality of life for diabetics, and demonstrates the inefficiency of current practices in the region. If anything, it highlights the urgent necessity of alternative healthcare delivery methods.

2.2.2 Economic Burden of Diabetes on Developing Countries

The prevalence of diabetes among a population imposes a large economic burden on the individual, the government, and the healthcare system. It leads to lower productivity, decreased income for families, and higher health costs. This is especially the case when the majority of the population is young, as is the situation with the populations of the GCC countries.

Furthermore, governments are burdened by the high cost of diabetes management, and the high cost of treatment of associated health problems such as kidney failure, heart disease [4], vision impairment, and obesity.

The IDF estimated that the US economy lost approximately $58 billion in 2007 as a result of "*lost work days, restricted activity days, lower productivity at work, mortality, and permanent disabilities*" caused by diabetes [3]. Recent indicators given by the American Diabetes Association (ADA) state that diabetes will cost the US $174 billion in expenses in 2010, and this number will most likely triple in the next 25 years [6].

As for developing countries, some studies have measured the economic burden of diabetes on their economies. For example, in India, we find that the economic burden on urban families is rising, and the total direct cost has doubled from 1998 to 2005 [7].

An IDF MENA regional meeting which took place in Egypt 2009, hosted discussions on how to facilitate the National Diabetes Programmes (NDPs) for the prevention, treatment and care of diabetes across the Middle East and Northern Africa. Discussions included actions necessary to prioritise diabetes within a national healthcare framework. This includes the move to demand a commitment to financial investment in diabetes [8] in order to cope with associated growing costs.

2.2.3 Use of Technologies for Healthcare

Our need for improving healthcare services is growing rapidly. In this day and age, ignorance of available technologies and how they can impact healthcare services is a cost many cannot afford.

Richard Klausner, managing partner of The Column Group, stated in *The Global Campaign for the Health Millennium Development Goals 2011 report*, issued by the U.N. that "*We are at a transformational time in global development. Dramatic changes in the economic outlook for many parts of the developing world and the resulting changes in poverty rates are forcing us to reconsider long-held assumptions*

about the challenges, even hopelessness, of development". He went on to add that "*democratising technology has spearheaded an explosion of connectivity; of redefining who is on and who is off the great grid of true development*" [9].

Current leaps in development that have been welcomed in the healthcare sector involve technologies that are relatively low in cost, available to the masses, and reliable. This is especially important when dealing with patients in developing countries, with low incomes and limited access to technologies.

Arguably, the more popular technology for remote delivery of healthcare services is communication technologies used to remotely deliver medical advice, treatment, follow-ups, and reminders to out-patients. The program CELLPHONES4HIV sends bulk SMS messages as a preventive measure for HIV mothers in South Africa [9]. Remarkable results have been achieved in this program using simple mobile technology.

Other more advanced technologies in the field of medical imaging informatics and biomedical technologies have proven to be extremely effective [10].

The field of eHealth is continuously examining the suitability of the latest technology to be used to introduce new methods of delivering healthcare and improving current health infrastructures.

Governments are searching for means to deliver healthcare more efficiently to save time, and with low costs in order to meet growing demands. Many projects have adopted simple technologies to achieve these goals. A successful project is the D-Tree International, used by health officials dealing with malnutrition of children in Tanzania. It provides the healthcare giver with a simple tool which runs on a mobile phone. The tool assists healthcare workers to access patient medical records and easily assess patient data. It provides simple screening, examination, counselling, and treatment tools. The project has improved the quality of the healthcare service, and saved both time and money. It has also reduced the impact of severe malnutrition on child and infant mortality [9]. It is predicted that the decreasing cost of mobile phones will encourage more healthcare givers to use this system.

Many have faith that with the emergence of new technologies, better healthcare services can be delivered to more people, with a reduction in cost and time. However, more commitment is required from governments and healthcare officials in developing countries to support such approaches.

2.2.4 Use of SSM Methodologies

The SSM focuses on dealing with problems that may not be clearly defined and involve 'messy situations'. Such situations involve human behaviour, social factors, and even traditions that may impact how a solution can be presented. Its strength lies in instances when goals and objectives cannot be clearly defined. Such attributes may lead to variations in what might be an acceptable solution to a problem. These variations depend on a person's personal perception of what is acceptable. Using SSM allows developers and designers to incorporate behavioural aspects expected from humans, resulting in higher acceptance levels of developed systems, and less resistance of new solutions being presented.

Accordingly, SSM is being used frequently to develop systems in the healthcare field. It allows us to understand the healthcare needs (i.e., growing costs, increasing demands, limited resources), and also effectively address the needs of patients (i.e., demand for more healthcare services, resistance to new solutions).

SSM also has a 'participative nature' which usually leads to high acceptance levels by the users and lower resistance to new solutions being offered. SSM has been successfully used to develop models in many healthcare related projects, such as:

1- Simulation of out-patient services [11].
2- Assist in the design and development of solutions for knowledge management problems in a healthcare setup [12].
3- A viable approach to develop Integrated Digital Health Systems (IDHSs) with high interoperability [13].

The SSM methodology is increasingly being used to address ill-structured situations in the healthcare sector, offering flexibility and practicality of the systems being built.

2.2.5 Current Telecare Solutions

Western countries have conducted tremendous amounts of work in the field of Telecare. Much of the research, studies, and trials have led to positive results. Their stable national infrastructures allow Telecare solutions to be a feasible and practical option. However, when we look at the situation in developing countries that lack basic national infrastructures, such as reliable telecommunication systems, adequate roads, and stable municipal power, we find that Telecare faces huge obstacles. These

countries usually lack the capability to offer higher education and improved health services, especially when the resources are limited.

And although we are discussing Telecare solutions in developing countries, we will only focus on research carried out on the Gulf States, which all enjoy a 'somewhat' stable national infrastructure. These states share common characteristics in their economies, infrastructures, and social setup.

In the Gulf States, the national annual income of a family is considered high, and the majority of the population have access to basic technologies (i.e., Internet, mobile), which makes these countries excellent environments for Telecare applications.

Despite huge budgets allocated by the governments for the healthcare sectors, healthcare officials continue to face obstacles such as growing demands for quality healthcare and limited resources. They realise that there is an urgent need to explore alternative methods of delivering health services.

With the support of their governments, healthcare officials are examining Telecare as a tool to provide healthcare services to remote rural regions, such as the case in Saudi Arabia which has a vast area spanning over two million km and more than half of this area is desert terrain. Telecare is also being considered by Saudi healthcare officials as an effective way to offer preventative services. Telecare has been successful in developing countries in providing prenatal and neonatal education to parents in order to reduce infant mortality [14].

More importantly, for Telecare to succeed in developing countries, it is essential that the basic technologies be available to the masses, in a stable and reliable setup. In Kuwait, the ratios of Internet users to the population size are quite high. According to the World Bank, 39.4% of the population used the Internet in 2009 [15].

Furthermore, the Gulf States have high mobile penetration rates measured in 2010, with Saudi Arabia at 130%, Bahrain 177%, Kuwait 107%, Oman 126%, and the UAE at 210% [16].

Some countries have realised the benefits of Telecare and are starting to invest in this direction. Other than initiatives taken in Saudi Arabia, as will be discussed in Chapter 3, one of the UAE's leading health insurance companies, Daman, is now offering its clients a tele-medical Population Health Management Programme for diabetic type-2 patients. Their objective is to encourage patients to adopt healthier lifestyles, allow patients to self-manage their chronic condition and reduce costs in the long run [17]. As of 2010, approximately 1,300 patients were enrolled in the program. Results indicated that the service was able to reduce HbA1c levels and Body Mass Index (BMI) levels for participating patients.

Another initiative has been taken in Qatar, where in February 2011, an article published in *Telecare Aware* indicated that Qatar Telecom (Qtel), the national telecommunications company, has partnered with Mobile Health Company to offer mHealth services. These services are interactive and healthcare officials will be able to provide patients with health information such as that related to diet, obesity, and physical activity [18].

With the growing demands on quality healthcare services, Telecare solutions are expected to become a more common method of delivering healthcare, especially to those with chronic conditions and patients who live in rural areas.

2.3 Target of Research (Bridging the Gap)

The research conducted here aims to explore an alternative method of delivering healthcare services in Saudi Arabia. It suggests the use of Telecare solutions to target patients with chronic diseases. It selects diabetes due to its high prevalence in Saudi Arabia, and the extremely high costs associated with diabetes management and treatment.

Although Telecare is most commonly used as a means to target 'elderly' and 'physically less able' patients in order to grant them more 'independence' in their homes, this research attempts to alter this view. In our opinion, Telecare approaches can be used to target yet another group of patients, those who might be restricted from receiving quality healthcare services due to social and cultural factors. In addition, we propose targeting younger patients who might be uncommitted to necessary management and treatment regiments due to the chronic nature of their disease and the constant interference it may cause to their lives on a daily basis.

Finally, the research presented here addresses factors related to Telecare applications, which are unique to Saudi Arabia, and have not been previously addressed as shown in figure 2.2. The examination of these factors may open the door for further research in other developing countries with similar obstacles such as Pakistan, India, and Arab countries in the Middle East.

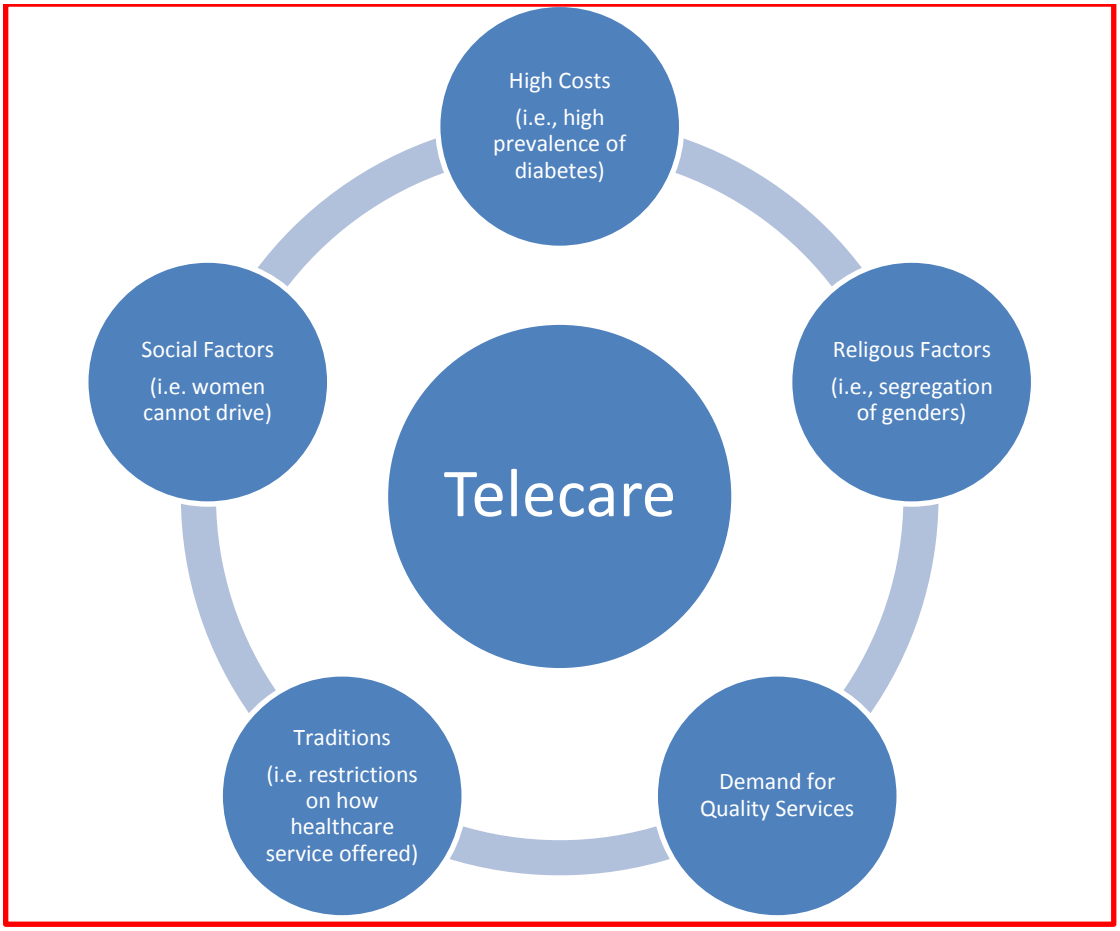


Figure 2.2: Factors associated with Telecare in Saudi Arabia

Our primary task is to design a Telecare model using the Soft Systems Methodology, then develop a Telecare application which is integrated into the existing NGHA infrastructure. This solution will attempt to offer an alternative method for diabetes management and achieve a number of set goals. We will conclude by assessing if the Telecare solution was able to achieve similar results to those reached through traditional healthcare services, or if Telecare is able to exceed such services by achieving better results.

2.4 Why Use Telecare for Diabetes Management in Saudi?

This section discusses whether there is an actual need for Telecare solutions in Saudi Arabia, and if such solutions can be used to manage diabetes.

2.4.1 Is it Needed?

Saudi Arabia is facing huge challenges in the healthcare sector. These challenges will be discussed in detail in Chapter 3, and involve limited resources, high costs, and associated social and cultural factors. In addition, there is an alarming prevalence of diabetes, claiming approximately one-third of the population in Saudi Arabia. Statistics are offered in Chapter 4 with a more detailed look.

Given this setup, it is essential that an alternative method of delivering quality healthcare be examined. Telecare seems to be a suitable approach, with considerable research being conducted in Europe and North America. Telecare may be able cut costs, manage resources more efficiently, offer patients more independence, raise disease awareness, and promote healthy lifestyles.

Saudi Arabia should invest in such approaches and examine the possible impact on the healthcare system and on social and cultural factors.

2.4.2 Is it a Suitable Solution?

Telecare primarily uses technology to offer remote services to patients. This use of technology can help maintain a higher level of privacy for patients, which will most probably be highly welcomed due to the conservative nature of the Saudi society.

Remote monitoring is also useful in a country with a vast area, mostly categorised as desert terrain. It is often difficult to provide patients in these areas with specialised healthcare services due to lack of specialised medical expertise. Telecare will enable the delivery of quality healthcare services to patients in rural and remote areas.

Finally, the stable telecommunications infrastructure in Saudi Arabia, will allow immediate development and deployment of Telecare solutions in a reliable and efficient manner.

2.4.3 Can it Help?

Research published in many Telecare and Telemedicine journals has indicated that Telecare has achieved reasonable results in Europe and North America, with more work being conducted on further implementations, new technologies to be incorporated, and identification of medical fields and diseases as promising areas for Telecare implementations.

But can Telecare solutions succeed in Saudi Arabia? Will the conservative Saudi society resist Telecare services? How will religious views and traditions influence the acceptance of Telecare solutions?

This research involves a trial study that offered diabetic patients at NGHA a Telecare solution to manage their disease. The findings will be discussed in detail in Chapters 7, 8, and 9. However, the implementation of the Telecare solution was able to address most problems faced by the healthcare institution and, more importantly, was successful in overcoming a number of obstacles, achieving high levels of patients and healthcare giver satisfactions levels, and improving the health of patients.

Adopting a Telecare approach is promising, and there is much work to do in this field which can benefit the Saudi healthcare system.

2.5 Summary

There are many obstacles being faced by the healthcare sectors in developing countries. By focusing on GCC States, we find an alarming spread of chronic diseases, in particular diabetes. There is a growing demand for quality healthcare services, yet limited resources.

Although technology is being adopted by healthcare sectors to overcome obstacles and provide better healthcare services in Europe and North America, the case is different in developing countries. We need to assess if such an approach is suitable, especially in the Gulf Region, which might share common obstacles with other countries, but also be characterised as facing other obstacles that are unique.

This research indicates that governments in developing countries need to invest more in the field of eHealth and offer services such as Telecare and telemedicine in order to cope with growing demands.

CHAPTER 3: THE SAUDI HEALTHCARE SYSTEM: INFLUENCING FACTORS AND CHALLENGES

3.1 Introduction

The development of the healthcare sector in any country can be a true reflection of the development of the country itself. During the past three decades Saudi Arabia has been investing in its healthcare sector for two primary reasons: to improve healthcare services in order to reduce dependency on foreign expertise hence cutting costs, and to also cope with the rapidly growing population which has increased dramatically since the 1970's.

Based on the Population Reference Bureau, statistics taken in 2010 indicate that Saudi Arabia has an extremely young population. Out of the total population of approximately 29 million people, an estimated 38% are under the age of 15 as indicated by the Population Reference Bureau (PRB) in 2010 [19]. A more recent report published in 2011 by PRB estimated the population growth in Saudi to reach 36 million in 2025 and up to a staggering 44.6m in 2050 [20].

In light of this high increase in population growth, Saudi is under tremendous pressure to provide quality healthcare services. At this day and time, Saudi is a country in most need of healthcare researchers to address many issues at hand and to offer information, data, and statistics that can in turn highlight areas of weakness in the healthcare sector and help in assessing the overall healthcare efficiency in providing services.

This in turn has led to tremendous budgets being allocated to support the healthcare sector. The government announced the country's largest budget in its history December 20th, 2010, indicating a GDP growth by 3.8%, with state spending of SR580 billion (approximately GBP96 billion), an increase of SR40 billion (approximately GBP6.6 billion) on the previous year, with more than half the figure going to new projects [21].

A statement issued by the Ministry of Finance, indicated that the Kingdom's gross domestic product (GDP) for the current year 2010 would reach an estimated SR1.63 trillion (approximately GBP 272 billion), an increase of 16.6% on 2009 due to the 25% growth of the oil sector. GDP for the non-oil sector (government and private) is expected to show growth of 9.2% [22].

Out of this budget, the Health and Social Affairs Sector received SR68.7 billion (approximately GP 11.5 billion), the second largest after the Education Sector.

As published in *Al-Watan Newspaper* [23], December 21st, 2010, the budget allocated by the Saudi government for each sector is clearly shown in figure 3.1, indicating the health sector having been allocated 12%, the second largest budget after the education sector.

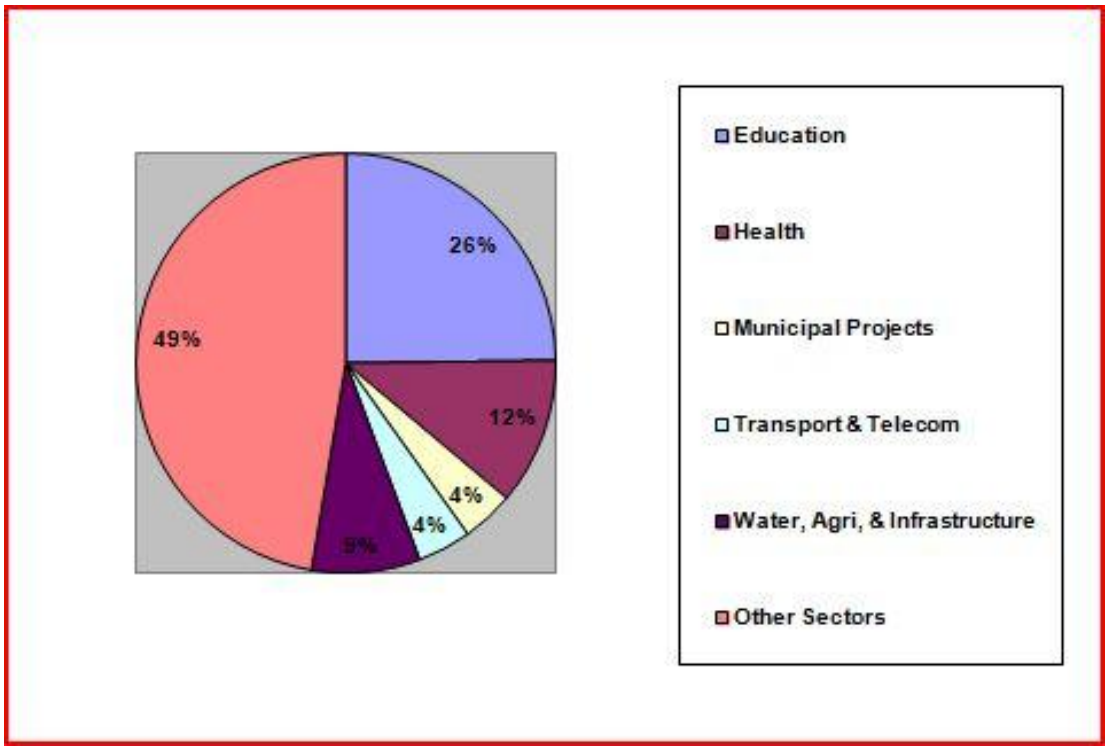


Figure 3.1: Saudi GDP Budget Allocations per Sector 2010

This strategic direction by the Saudi government is in response to the fundamental change healthcare demand in Saudi is currently facing. With the rapidly growing population and analysis of the demographics, which indicate that the number of people over age 65 will increase more than sevenfold during the next 25 years [24], Saudi will face a huge rise in demand for health care over the next two decades.

The challenge is that the current Saudi healthcare system is not prepared for a rapidly growing and aging population, nor are they prepared for the expected rise in chronic diseases such as diabetes [24]. Based on the McKinsey Analysis report, conducted in 2006, this is due to three main factors:

1. Population growth: where the population in 2025 is expected to be twice its current size today,

2. Aging population: over the next 25 years, the number of people over 65 years will increase more than sevenfold,

3. Health risk factors: there are clear risk factors; most prominent is the prevalence of Diabetes type-2 and obesity due to life styles and aging population.

Another challenge is the unique cultural setup in Saudi Arabia. This setup sometimes presents the healthcare system with constraints which can impact the quality of healthcare services being offered. For example, Saudi Arabia is the only country in the world that prohibits females from driving. This factor, combined with the fact that there is an inadequate transportation system, has had a huge impact on female patients receiving the required care.

Furthermore, cultural and traditional factors can restrict how healthcare services are offered. Many patients insist on receiving care from same-sex health officials. With limited healthcare resources, this can be a huge obstacle. The Saudi Ministry of Health (MOH) recognizes these social and cultural factors, and indicates in its published mission that its goal is to provide healthcare in line with Islamic principles [25].

The Saudi government is therefore dedicated towards offering the support required in light of the challenges and obstacles being faced by the healthcare sector.

This support has led to movements in many areas: the establishment of healthcare educational institutions to increase the number of healthcare professionals, adoption of the latest technologies to support healthcare services, and opening the door to research and analysis to establish a national database of medical information and national trends, such as the National Diabetes Center, established under King Saud University [26]. In addition, much effort has been dedicated towards the

examination of new methods of delivering quality healthcare services, such as Telecare.

Telecare solutions have many areas of specialty and cover numerous sides of healthcare services such as Tele-Medicine with its many applications such as Video-Consulting and Tele-Radiology which have matured to become essential healthcare services. Others such as Tele-Pathology are still undergoing much research. Telecare solutions also involve distance nursing and community support [27].

Saudi Arabia is currently in need of researchers to examine the possibility of applying Telecare solutions, the acceptance of such an approach by the Saudi population, and the impact this will have on the Saudi healthcare system involving both healthcare professionals and patients. The benefits of these solutions will be more evident when applying them to a particular group of patients sharing a common disease. Due to the rapidly increasing number of diabetics in Saudi, this would be a suitable platform to work from.

3.2 Demographics

The Saudi Ministry of Planning and Economy published a report early 2010 which indicates that the population of Saudi Arabia has more than tripled over the past 34 years. The report showed Saudi Arabia to have one of the highest paces of population growth in the world. During the period of 1975-2009, the population has risen by 333%. [28].

Figure 3.2 shows this growth during the past five decades [29], indicating a rapid increase starting around the 1980's.

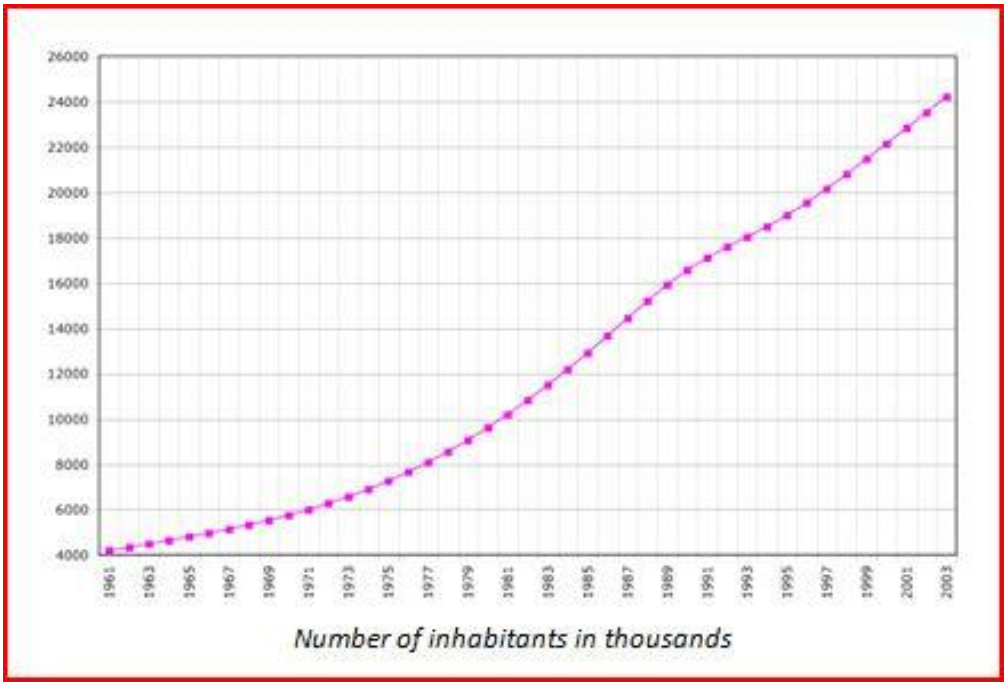


Figure 3.2: Saudi Demographics

Table 3.1 focuses on the Saudi population growth rate in the past ten years, as indicated by the Central Intelligence Agency (CIA) World Factbook [30].

Year	Population growth rate (%)
2000	3.28
2001	3.27
2002	3.27
2003	3.27
2004	2.44
2005	2.31
2006	2.18
2007	2.06
2008	1.954
2009	1.848

Table 3.1: Saudi population growth rate

Another main characteristic of the Saudi population is the fact that there is a high ratio of youths, where approximately 70% are under 34 years of age [28], and the median age is 24.9 years [30].

Accordingly, a study carried out by the Gulf Cooperation Council for Healthcare [24] indicated that the number of people over 65 will increase more than sevenfold during the next 25 years. This huge increase in the number of elderly residents will result in an increase in the number of people requiring care. In turn this will put an even higher demand on quality healthcare services in the future.

3.3 Social Setup

To understand the Saudi society, we must first begin by discussing Islam. Not only is Islam the only religion in Saudi, but it was also founded in the country, which hosts the two holy mosques in Makkah and Medina held sacred by all Muslims. Saudi Arabian law defines the country as Muslim and requires all citizens to be Muslim.

Saudi law is derived from Islamic teachings called 'Shareea', and a great deal of the Saudi culture is based on religion. In addition, the majority of Saudis belong to the Sunni branch of Islam, most following the teachings of the Hanbali School, which is considered the strictest.

Is it important to stress on how intricately religion is woven into the fabric of society, and how Islam plays a major role in peoples' everyday lives. How it has shaped the society, and its culture. These facts result in a religious and conservative society, which closely follows the teachings of Islam.

Another factor worth examining is literacy rates. Between 2000 and 2004, the literacy rate for females between 15-24years was 92%, and for males 95%, however, only 18% of females aged 15 and older were economically active [20]. This, in part, can be attributed to the primary role of a woman assumed by the society, to first care for her family at home.

Although most issues discussed in this section present constraints for Saudi women, perhaps the most debilitating, is the fact that Saudi Arabia is the only country in the world that prohibits women from driving. Together with an inadequate transportation system, this factor has and continues to present women with obstacles on many fronts such as working, receiving healthcare services, and other essential matters.

3.4 Healthcare System Infrastructure

Based on the report published by the Saudi Ministry of Health 'Directory of Work Processes at the Public Administration of Health Agencies and Health Offices abroad' [31], the Higher Healthcare Agencies in Saudi Arabia are made up of the following:

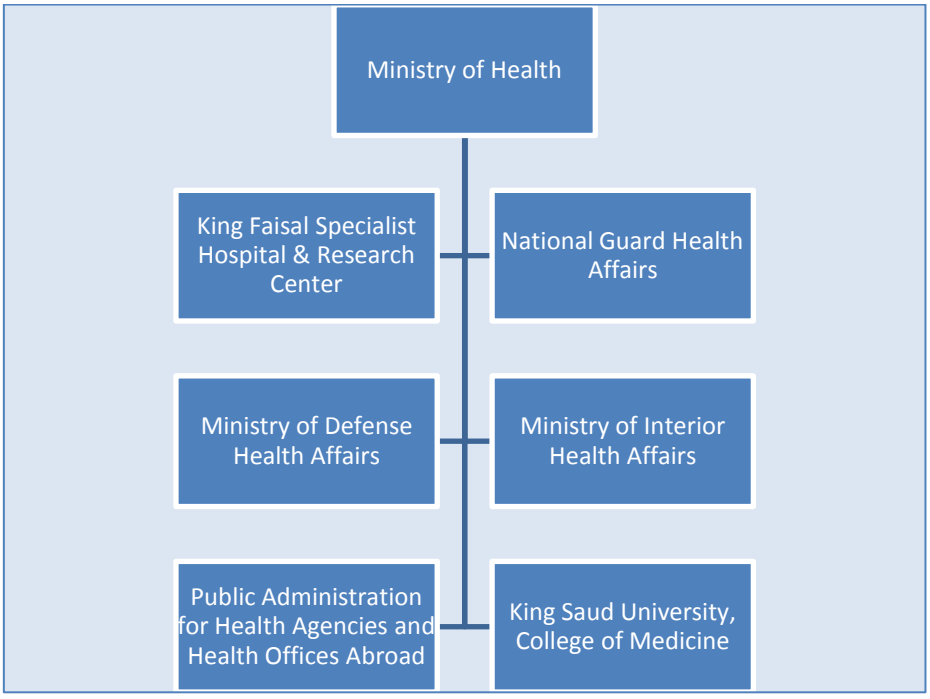


Figure 3.3: Saudi Higher Healthcare Agencies

These agencies are considered either fully or partially owned by the government, and represent the major Health Affairs Infrastructure in Saudi Arabia, their interaction with one another, and with the Minister of Health.

In order to get a more general view of the Healthcare System in Saudi Arabia, we can divide the Healthcare Sector into four main areas:

1. Government Sector
2. Private Sector
3. Medical Insurance
4. Other entities supporting the Healthcare System

3.4.1 Government Sector

1. **Government Civil Hospitals**

The Ministry of Health (MOH) supervises all civil governmental hospitals in the Kingdom of Saudi Arabia [32]. It is the responsibility of MOH to provide staffing for these hospitals and finance their operations and projects. These hospitals offer healthcare services to their personnel and their dependants. In addition, the MOH also supervises a large number of medical centres and clinics available in all regions of Saudi Arabia.

2. **Government Military Hospitals**

These hospitals fall under the Health Affairs division of the Military Sector they serve. Each military sector is responsible for financing the health affairs entity belonging to them.

The National Guard Medical Cities, hospitals, and clinics fall under the authority and control of the Saudi National Guard, who in turn is responsible for all related finances. They primarily provide healthcare services to the National Guard personnel, and their dependants [33].

The Ministry of Defence also has a number of hospitals and clinics scattered around the Kingdom offering their healthcare services to the Ministry of Defence personnel and their dependants.

Another main military entity is the Saudi Arabian Armed Forces, who have a number of medical centres, hospitals, and clinics providing health services to their personnel and their dependants.

3. **Government Educational Hospitals**

King Saud University (KSU) was founded in 1957 as the Kingdom's first university. It's comprised of 19 colleges and specialized institutions. The College of Medicine is considered one of the most prominent medical colleges in the Kingdom. King Khalid University Hospital (KKUH) in Riyadh is affiliated with KSU and is considered an excellent teaching hospital, training medical students from the College of Medicine. King Abdulaziz University Hospital (KAUH) in Jeddah, is another prestigious teaching hospital affiliated with the College of Medicine at King Abdulaziz University. These two hospitals are considered the training ground for all medical professionals. KKUH and KAUH offer students a real life experience in the healthcare sector where they

interact with patients and learn to work with the latest medical technologies and equipment.

3.4.2 Private Sector

In the past two decades there has been a huge demand on providing more healthcare services to the ever growing population. This demand has opened the door for the private sector to actively participate in the Healthcare Sector with the encouragement of the government. Today, the numerous private hospitals all over the Kingdom have alleviated the pressure from the governmental healthcare sector, offering their services to many residents, most not eligible for treatment at governmental hospitals and clinics, including expatriates.

3.4.3 Medical Insurance

Due to the growing population in Saudi Arabia, the growth of the private sector, the quick pace of industrialization, and a high per-capita medical expenditure, there has been an increasing demand on expanding the healthcare services and providing health insurance for both Saudi citizens and expatriates. In the midst of this demand, the private sector started investing and participating in expanding the healthcare system with the encouragement of the Government.

In July 2003, the Saudi government passed the Control Law for Cooperative Insurance Companies that opened the sector for foreign investment [34]. The law has been implemented gradually and requires employers to pay for insurance coverage of foreign workers and dependant family members. More than 200 hospitals across the Kingdom have taken part in the cooperative health insurance program.

Today, there are many national companies currently operating in Saudi Arabia's insurance market along with over 100 insurance agencies.

3.4.4 Entities Providing eHealth Solutions and Platforms

The Healthcare Sector has realised the urgent need to adopt the latest methods of delivering Health services in order to cope with the high demand while maintaining

the highest levels of quality healthcare. The Healthcare Sector is thirsty for innovative solutions and high-end technology to assist them in achieving their goals.

1. Sultan bin Abdulaziz Medical & Educational Telecommunications Program (MeduNet)

The Sultan bin Abdulaziz Medical & Educational Telecommunications Program (MeduNet) was established in 1997. It is a leading and unique program that offers specialised services in Telecommunications and Information Technology for the health and educational sectors in the Kingdom of Saudi Arabia. Its goal is to link the organisations in these sectors via a state-of-the-art network that connects them with advanced international medical and educational centres. It provides end-to-end telemedicine solutions to private and public healthcare centres [35].

MeduNet currently offers the Health Sector, both governmental and private, a variety of services and solutions such as Telemedicine, Video-Conferencing, Health Information System, Distance Learning & CME, in addition to many other services.

2. King Abdulaziz City for Science & Technology (KACST)

King Abdulaziz City for Science & Technology (KACST) is an independent scientific organisation of the Saudi Arabian government, established in 1977. Its mission is the promotion of science & technology in the Kingdom by coordinating and cooperating with various universities, agencies and institutions concerned with research and technology [36].

Among its other roles, KACST is responsible for providing Internet services in the Kingdom of Saudi Arabia, in cooperation with the Saudi Telecommunication Company (STC), the Communications and Information Technology Commission (CITC) and a number of Internet Service Providers (ISPs) from the private sector. KACST also governs a number of policies such as Web Filtering [36].

Figure 3.4 illustrates the Internet Topography in Saudi Arabia and the different technologies available [37].

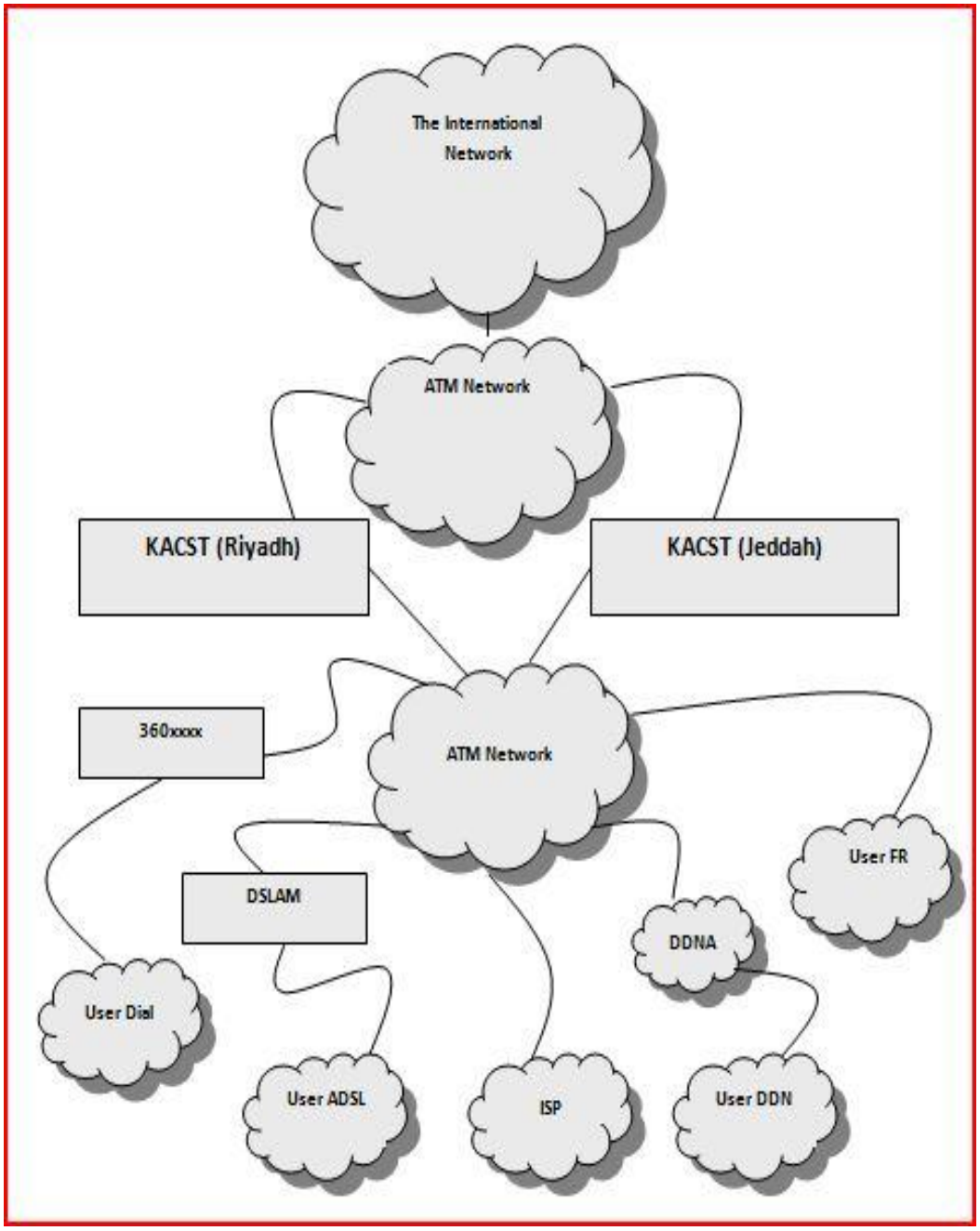


Figure 3.4: Saudi Internet Topography

Given the setup described in figure 3.4, it is essential to indicate that the Internet infrastructure is rapidly being upgraded. The information presented in figure 3.4 gives a description of the technology used in 2003. However, latest technologies are being incorporated to offer a more available and reliable setup with fast Internet speeds and high bandwidths using fibre optics and wireless technologies.

Current technologies include Satellite Internet setups using broadband technology, in addition to DSL lines with higher bandwidths and lower prices, now affordable for many.

3.5 Obstacles

In Section 3.3 we discussed the social setup in Saudi Arabia, and briefly mentioned some aspects of the society that have proven to have an impact on healthcare services offered.

3.5.1 Strict Religious Adherence

Strict religious adherence, in some instances, can be considered a constraint when the delivery of healthcare services to patients is closely examined. For instance, female patients may refuse healthcare services offered by male healthcare givers, and vice versa. This is not an uncommon situation, is being faced by many healthcare centres, and can restrict healthcare services being offered when only limited resources are available. This is especially evident when examining primary health clinics situated in rural areas. Usually, these centres are low on resources and therefore find it difficult to accommodate patient requests.

An article published in the *Arab News*, indicated that a campaign was launched on the social networking website Facebook, by a Saudi woman, demanding hospitals exclusively for women [38]. This campaign has been gathering much support from the public including both female patients and female healthcare givers.

Most conservative Saudi families do not wish to have their female family member exposed to unrelated males even in the capacity of a patient-healthcare giver setup. One woman who posted her reasons for supporting this movement is to 'provide a clean, healthy and Shareea-compliant environment for women working in the health sector and increase job opportunities for them'.

The women said when such hospitals are established, this would help put an end to the "negative social image" about women medical professionals, which have prevented many young men from marrying nurses [38].

The Saudis who share these views believe that women-only hospitals are an excellent option whether as a potential place of employment or where their female relative can receive medical care without fear of exposure.

3.5.2 Culture

Another important factor that is viewed by many healthcare officials as an obstacle is the nature of the Saudi culture. Segregation is common within the society, and mixing of genders is discouraged on many fronts, even when it comes to health.

Many hospitals in Saudi Arabia use a reminder system to remind patients of upcoming appointments through a phone-call to the patients' registered contact number. This practice minimizes 'no-shows' and allows appointment divisions to better manage appointment slots. Many patients have expressed that these phone calls can be inconvenient, especially when a male health official is calling a female patient as a reminder to an appointment. In compliance with culture and tradition in Saudi, the KAMC has overcome this problem by automating the reminder system. Now, all reminders are sent to patients via SMS through an SMS server linked to the appointments module. Patients receive an SMS reminder five days prior to the appointment, and then another SMS reminder 24 hours prior to the appointment. The SMS has also been utilised to raise patient awareness. In addition to the appointment date and time, related advice is also sent [39].

Other incidences within the society demonstrate how the culture can present obstacles and restrictions when the goal is to provide quality healthcare services.

3.5.3 Females Prohibited from Driving

Saudi law prohibits women from driving in public. This law dates back to 1932 when the state was established. Society at that period was an extremely conservative and tribal one. Although Saudi people have come a long way since then, they are still very much conservative. Only in the past two decades, we have witnessed publicly opened discussions about lifting the ban, taking place between the public, religious scholars, and law regulators. Despite this, the ban is still in place and has a huge impact on the everyday lives of Saudi residents. Healthcare is not exempt from this negative impact. What compounds the issue is that Saudi Arabia does not have an adequate transportation system. No underground, no trains within the city, and no reliable cab system is available. The present cab system is resisted by many females and their families due to its unreliability, lack of supervision of vehicle safety, weak driving laws enforced on violating drivers, no clearly marked pickup locations, and other factors, making this an unlikely option for many.

3.6 eHealth in Saudi Arabia

The past few sections discuss some of the major obstacles being faced by the Saudi healthcare system. In light of the growing population, rapidly spreading diseases, a conservative and religious society, there is an urgent need to examine alternative methods of delivering healthcare in order to maintain quality services.

During the past ten years, a number of healthcare institutions have taken initiatives towards raising awareness of eHealth, establishing eHealth policies, and presenting eHealth solutions. The following list presents institutions in Saudi that are currently concerned with eHealth and provide solutions.

3.6.1 National Guard Health Affairs (NGHA)

The National Guard's Health Affairs four medical cities in Riyadh, Jeddah, Dammam, and Ihsaa, are considered among the leading healthcare institutions in Saudi Arabia. They primarily provide healthcare services to National Guard personnel and their dependants, free of charge. High demand in recent years has led to the establishment of the NGHA Business Center which extends healthcare services to private patients.

There is a growing demand on NGHA officials to provide quality care for patients. Faced with obstacles previously discussed, this objective is becoming more and more difficult to achieve and maintain.

With a state-of-the-art Wide Area Network (WAN) between medical cities kingdom-wide and Local Area Networks (LAN) within each medical city, involving ATM and Fast Ethernet speeds, fibre optics connectivity, leased lines, and a fully reliable and highly available system, NGHA has an ideal platform.

During the past decade, NGHA healthcare officials have been exploring the opportunities of eHealth and searching for alternatives to traditional healthcare services, through the utilisation of the available network infrastructure. Such alternatives should be able to overcome existing obstacles and achieve high satisfaction levels among patients and healthcare givers. Initiatives have been taken towards the solutions eHealth can offer, and investments have been made accordingly.

The NGHA is a leader in the specialised field of Siamese twin separation surgeries, with cases referred from the Middle East and Europe. Although the track record began February 1992, it wasn't until January 2002 during the separation surgery of

the Sudanese twins Najlaa and Naseebah [40], that the use of technology was utilised for educational purposes. The NGHA IT team led the project, which consisted of a live broadcast of the surgery over the Internet, with periodic updates about the surgery stage and progress.

Statistics from Web servers later indicated that the live feed was viewed by numerous universities and medical centres in the Middle East, Europe and North America. Due to the successful attempt, there was an ambition to utilise technology even further. The following separation surgery for the Malaysian twins, Ahmad and Mohammed carried out September 2002, was an excellent opportunity.

The IT department used the existing NGHA WAN link (leased line) that connects the hospitals in the central and western regions to allow consultants needed as a support team for the surgery, to witness and participate in the surgery events remotely. They were able to remotely present their consultations and successfully take part in the surgery.

Once again, medical institutions and universities viewed the live broadcast and followed the accurate update of the surgery events online. In return, the NGHA IT team received over 1,000 emails from Internet followers acknowledging such efforts [41].

The organisation had a clear vision and strategy on how necessary it is to incorporate the latest technologies into existing healthcare services. Serious commitments were made supporting the investment in a structured approach towards eHealth opportunities. The NGHA IT department established committees and teams of specialised personnel to invest in numerous Hospital Information Systems (HIS).

The Clinical Information Management System (CIMS) was launched in 2004 with the goal to optimise the provision of care, coordinate patient care activities and key clinical documentation through National Guard Facilities, support decision making in healthcare delivery, and manage healthcare services. This system was fully integrated into existing HISs with interfaces to systems at the Laboratory, Pharmacy, Nursing, Patient Administration, Radiology, Scheduling, and Medical Records. The most recent addition has been the successful implementation of the Computerised Physician Order Entry (CPOE).

A number of other projects also proved to be successful such as the launching of the Picture Archiving & Communication System (PACS) and the Enterprise Resource Planning (ERP) systems.

In 2006, an initiative was taken to establish the College of Public Health and Health Informatics which offers the first postgraduate course in Health Informatics by the NGHA affiliated university, King Saud bin Abdulaziz University for Health Sciences.

The NGHA also invested heavily in eHealth solutions, which led to much success and international recognition, one being awarded Excellence in Electronic Health Records by the Arab Health Exhibition in 2010.

3.6.2 Saudi Association for Health Informatics (SAHI)

The strong drive that healthcare officials at NGHA have towards the field of health informatics eventually led to the establishment of the Saudi Association for Health Informatics (SAHI) organisation in 2005. SAHI works under the direct supervision of KSAU-HS, with the aims to "*practice public activities, develop theoretical and applicable knowledge, and provide scientific and applicable studies and consultation, private and public, as per the provisions included in these rules"* [42].

The primary objectives of SAHI are to "develop and activate the scientific knowledge in the field of health informatics", and to also provide a platform for scientific consultation in this field. SAHI also strives to "facilitate the exchange of scientific outcome and thoughts in the fields of interest of the association with other respective committees and establishments inside and outside the Kingdom", and finally to define codes of ethics and practice in the field of health informatics [42].

SAHI provides healthcare practitioners an environment in which they can work together to more effectively and efficiently utilise the applications of health informatics.

3.6.3 King Faisal Specialist Hospital and Research Center

Saudi Arabia has a good track record as the leader in health informatics in the Middle East. King Faisal Specialist Hospital and Research Center (KFSH&RC) was the first to implement a Hospital Information System (HIS) in the early 1970's. This was such a major advancement at that time that the hospital was referred to as the 'first automatic hospital'. KFSH&RC continues to actively participate in the field of informatics, with expertise and services.

3.6.4 Ministry of Health (MOH)

The Ministry of Health provides 60% of the healthcare services. However, due to the rapidly growing population and limited resources available, there can be a compromise in the quality of services being offered.

The MOH is taking new initiatives towards the field of health informatics. In 2010, it announced a five year plan to establish a national framework for health services, which involves unifying standards with other governmental healthcare providers and the private sector [43].

3.6.5 King Saud bin Abdulaziz University for Health Sciences (KSAU-HS)

The International Medical Informatics Association (IMIA) has taken major steps to promote the field of health informatics education world-wide. IMIA suggests that proper education of healthcare professionals is necessary to meet the demands of health informatics [44]. Based on these recommendations, the Master of Health Informatics degree program was introduced in 2005 at KSAU-HS as the first of its kind in the region.

It aims to prepare health informatics specialists to actively participate in research and advancements in the field of health informatics. It provides graduates with the necessary set of skills required to meet the demands on technology use in the healthcare sector [42].

3.7 Summary

Saudi Arabia consists mostly of desert terrain, making it sometimes difficult to offer quality healthcare services to everyone. In addition, it has a rapidly growing population and the demand for healthcare services is rising. Also, there are numerous social and traditional factors that may restrict how healthcare services can be offered.

The MOH provides healthcare services to almost 60% of the population, while the remainder is covered by other governmental institutions and the private sector. This variation in healthcare providers has resulted in diversity of how healthcare services are administered and managed. More importantly, we find variations in the

approach towards the utilisation of technology in the health sector, with different policies, visions, and outcomes.

Although Saudi Arabia is investing heavily in the healthcare sector, and healthcare officials are shifting towards solutions offered through health informatics, these efforts are neither unified nor standardized. A prime example is the current status of health records, that are redundant and usually not up-to date.

In order for these efforts to achieve maximum success, the Saudi healthcare system needs to work together under the same umbrella. Hopefully, the new directives of the MOH and the establishment of SAHI will pave the road for a more unified and structured approach towards health informatics.

CHAPTER 4: DIABETES MANAGEMENT IN SAUDI ARABIA

4.1 Introduction

Chronic diseases, based on the definition stated by the World Health Organisation (WHO), are diseases of long duration and are usually slow in their progression. Examples of such diseases are strokes, diabetes, hypertension, heart disease, and cancer. Chronic diseases have been identified as the leading cause of mortality in the world accounting for almost 60% of all deaths, and 43% of the global burden of disease [45]. By 2020, these figures are expected to rise to 73% of all deaths and 60% of the global burden of disease [45]. Based on estimates by WHO, the highest increase in deaths will occur in Africa by 27% followed by the Middle Eastern region by (25%) [46].

In Saudi Arabia, chronic diseases alone were the cause of 69% of all deaths in 2002 (figure 4.1). Based on WHO statistics [47] during 2002, the total deaths in Saudi are 97,000, where 67,000 were directly linked to chronic diseases.

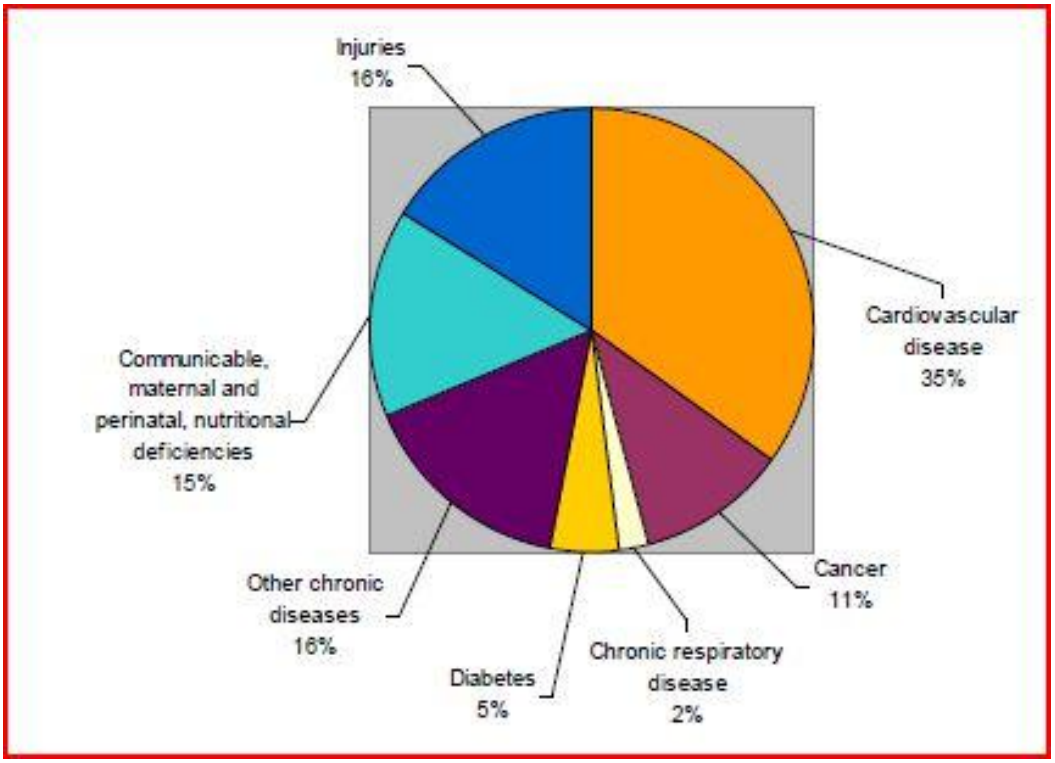


Figure 4.1: Deaths by cause, all ages, Saudi Arabia, 2002, WHO

These chronic diseases are linked to risk factors that are either related to lifestyles, such as lack of physical activity, smoking, and low fruit and vegetable intake, or related to biological factors such as obesity and hypertension [48].

The high increase in the number of chronic disease patients in the Region is also attributed to additional factors mentioned in Chapter 3, such as having an aging population and the rapid population growth.

The McKinsey study [24] predicts that **by 2025** the Gulf Cooperation Council (GCC) countries, consisting of Saudi Arabia, Kuwait, Oman, Qatar, Bahrain, and UAE, will face the following demands:

- **Treatment Demand**

  Treatment demand will rise in GCC by 240%, in particular, cardiovascular disease up by 419%, and diabetes up by 323%.

- **Hospital Beds**

Demand for hospital beds will more than double, in particular, in Saudi Arabia and the United Arab Emirates (UAE).

- **Cost**

Healthcare delivery in the GCC will reach about GP30 billion, increasing fivefold from today's cost.

Another alarming figure is the rapidly increasing number of diabetes in Saudi Arabia. In 2005, the number of diabetes was estimated at 25% of the population, indicating that one in every four Saudis is diabetic. Since then, the number has risen to indicate that almost 28% are diabetic. This figure has raised a red flag for MOH and other healthcare officials, showing that diabetes is dangerously approaching epidemic levels [49] (where any disease affecting 30% of the total population is considered an epidemic).

The Saudi government has acknowledged that swift reaction is needed in order to deal with these issues. Actions such as the investments into the private healthcare industry and changes to improve healthcare policies are being made.

Capitalising on the region being mostly Muslim has resulted in campaigns showing that tobacco use is undesirable in Islam. During 2002, Hajj was made tobacco-free. The average number of pilgrims during Hajj is estimated at two million. Also, the encouragement of physical activity for women is being more acceptable. National research is also being funded by the Government such as that investigating the increased incidence of cancer in the region and its possible association with depleted uranium after the Gulf Wars in 1991 and 2003 [50].

This Chapter will present information about diabetes as a rapidly growing chronic disease in Saudi. It will then continue by presenting the primary contributing factors related to the prevalence of diabetes, and associated costs. Finally, it will examine the potential impact of technologies on the management of diabetes. How they can affect primary issues and obstacles currently being faced, such as hospitals increasing operational costs, improving quality of healthcare services being offered,

raising public awareness about certain diseases, dealing with limited human resources and medical equipment, and other major obstacles.

4.2 Prevalence of Diabetes

Diabetes is spreading in the world at an alarming pace. Based on a report issued by WHO, the prevalence of diabetes in all age groups world-wide was estimated at 2.8% in 2000 and 4.4% in 2030. The total number of people with diabetes is expected to rise from 171 million in 2000 to 366 million in 2030 [51].

With these alarming world projections, it seems that the region of the Middle East, in particular, the Gulf States (Bahrain, Saudi Arabia, Kuwait, United Arab Emirates, Oman, Yemen, and Qatar), will be hit the hardest, due to a number of factors which will be discussed in the next section.

In December 2006, the United Nations General Assembly unanimously adopted Resolution 61/225: 'World Diabetes Day', which acknowledges the burden of diabetes on countries across the globe. All member states were encouraged to establish national healthcare policies regarding the prevention, care, and treatment of diabetes [52].

Accordingly, the Health Ministers for the Gulf States have responded to this resolution and pledged to place diabetes and other non-communicable diseases as a top priority on their health agenda.

"*I would like to emphasize the dedication of Health Ministers' in the Gulf to control this epidemic, and take whatever necessary actions to help decrease the burden of disease and implement national strategies heading at reduction of risk factors of the diabetes mellitus*", said Dr. Tawfik Khoja, Director General, Executive Board, Council of Health Ministers for the GCC States [53].

Furthermore, a study by the International Diabetes Federation showed that out of the top 10 countries with the highest prevalence of diabetes, five are in the Gulf. In 2007, the diabetes prevalence rate was the highest in the United Arab Emirates at 19.5%, followed by Saudi Arabia at 15.7%, then Qatar and Bahrain both at 15.2%, and Kuwait at 14.4%, and finally Oman at 13.1% [54].

A closer look at common factors between these states, discussed in the following section, will shed some light on contributing factors that result in high prevalence of diabetes in the Gulf region.

Saudi Arabia, in particular, has an alarming increase in the number of diabetics. The president of the Saudi Diabetes and Endocrine Association, Dr. Abdulaziz Alturki, stated in January 2010, that Diabetes has affected more than 28% of the Saudi population, cautioning that only an additional increase of 2% will officially categorise diabetes as an epidemic in Saudi Arabia [55].

In the Saudi capital of Riyadh alone, 78,000 diabetics were registered as patients at diabetic centres during the year 2009 [56].

We find diabetes particularly prevailing in specific groups, such as females, where 30% are estimated to have Diabetes type-2, and obesity levels exceeding 50% [57]. Another group with a high prevalence of Diabetes type-2 in Saudi Arabia, is among adolescents and children. A survey conducted by Alnoor Specialist Hospital in 2008, on schools in the Makkah region (covering the city of Makkah, and surrounding towns and villages), discovered 400 students with undiagnosed diabetes. These students were in elementary, middle school, and high school levels [58]. Medical records were accordingly issued for all diabetic students, appointments at the diabetic clinic were made, and awareness programs at schools were organised and conducted. These attempts are aimed to raise awareness and help prevent the increase of diabetes among Saudi youth.

4.3 Contributing Factors

In order to successfully manage any disease, we need to identify the contributing factors to its prevalence.

4.3.1 Lifestyle

The common lifestyle of a society has an immediate and direct link to a number of health factors of that particular population. Numerous studies have demonstrated a strong association between physical activity and health, and also between physical fitness and health. In addition, external factors, such as climate, economies, and the availability of public services also have an immense impact. Here, we examine the arguably three most dominant factors in Saudi Arabia, that have had a negative

impact on population health, and been repeatedly linked to the alarming increase in the numbers of diabetics.

- **Physical Inactivity:**

The lack of adequate physical activity has been strongly linked to the development of many chronic diseases. It is particularly linked to the increasing incidence of type-2 diabetes, along with an established link between diabetes and cardiovascular disease. These links have generated interest in the effects of physical activity on insulin sensitivity and glycemic control [59].

Physical inactivity is generally a result of modern lifestyles, the excessive use of household technologies, such as televisions and computers, which contribute to low fitness levels.

In Saudi Arabia, other external factors also play a role in leading to physical inactivity. Two primary factors are defined:

1. ***The Saudi Climate***: a desert climate with extreme weather conditions during both the summer and winter times on most of the region. In Riyadh, the capital, we find that during the months May through September, high temperatures exceed 40 degrees, and occasionally bypass 45 degrees, with usually low or no precipitation or wet days at all and extremely low humidity. This translates into outdoor activities, during these five months, being dangerous and possibly resulting in serious health problems, such as heat strokes, dehydration, and other serious health conditions. Moreover, during the months November through March, temperatures drop below 10 degrees, also with low precipitation and low number of wet days, making outdoor activities a health hazard that can potentially lead to hypothermia, and other serious health conditions. Graph 4.2 presents annual weather measurements in the city of Riyadh [60].

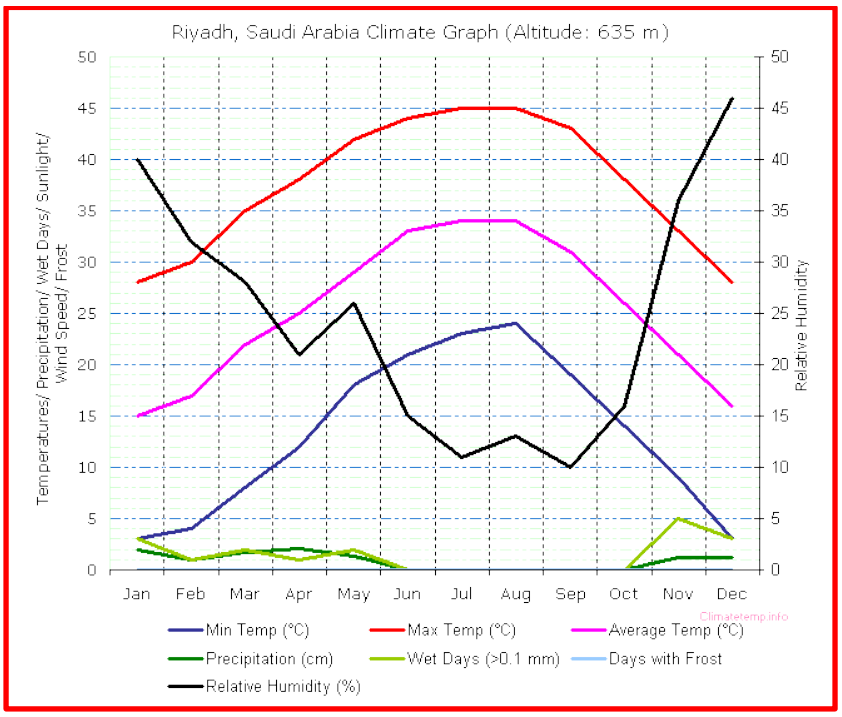


Figure 4.2: Annual weather measurements in Riyadh

These facts about the weather year-long can be viewed as major obstacles that restrict individuals from carrying out outdoor activities, limiting physical activities to be performing indoors only. This conclusion leads us to another matter: does Saudi Arabia offer residents indoor venues that can be utilised for this matter? In order to answer this question, let us examine the second factor playing a role in physical inactivity.

2. ***Social Factors***: a growing trend in Saudi Arabia in the past decade has led to higher awareness levels of the benefits of physical activity. Fitness centres are becoming more common, especially in large cities, attracting people from all age groups, with an increase in the numbers of youths. However, due to the culture of segregation, these centres are not for members from both genders. A large number of these fitness centres are for men only. Saudi society does not encourage physical activity for women, hence restricting any such activities in girls' schools. We therefore find only a handful of fitness centres for women, and even in these cases, memberships are usually costly, where an annual membership can cost an average of GBP 1,428 (SR10,000).

However, the Government is working towards raising the awareness of how physical activity can help prevent and manage chronic diseases. The Ministry of Health and a women's charity, Al-Nahda Philanthropic Society for Women, are spearheading campaigns to encourage Saudis to start moving [61].

Another social factor is the inadequate transportation system in Saudi. This factor mostly affects women, who are prohibited from driving, and youths, under the legal driving age, compounded with the fact that alternative means of transportation are not reliable.

- **Diet**

During recent decades, Saudi Arabia has experienced unprecedented social and economic development and growth. The Saudi population, blessed with an assured food supply, has become heavily accustomed to an affluent diet. Common eating habits are associated with high consumptions of energy dense foods of animal origin and, processed foods, and foods prepared with added fats, sugar, and salt [62].

The high consumption of such foods could be associated with the growing trends in the development of cardiovascular diseases, obesity, diabetes, and other chronic diseases as indicated by numerous health studies [63].

Although efforts by the Government have been made towards raising awareness regarding dietary plans and eating habits, the general population remains unconcerned about links between diet and disease. More efforts need to be exerted into the introduction of methods to correct dietary excesses by shifting national diets closer to the desirable dietary plans developed for the Saudi population [64].

- **Overweight and Obesity**

Trends of obesity and overweight among the Saudi population are alarmingly high. Based on Saudi press reports in 2006, about 52% of Saudi men and 66% of Saudi women are either obese or overweight. Among adolescents, the rate is 18% and in pre-schoolers over 15%.

A recent study carried out on 357 male students aged 18 – 24 years from Al-Qassim (north of Riyadh) indicated that 21.8% of the students

were overweight and 15%.7 were obese. The study showed that the most common eating habits included frequent snacking, fried food consumptions, and low intake of fruits and vegetables [65].

This, no doubt, is affected by lifestyles and diet, as previously discussed, but all efforts by the Government and interested organisations have had little success in preventing and even managing obesity and overweight. Almost daily, Saudi newspapers, which are mostly government guided, address these issues and discuss healthy lifestyles, national dietary plans, and encourage exercise. Sadly, these trends continue to increase, because, according to Y. Al-Tuwaijri, an epidemiologist who studies obesity at a leading Riyadh hospital, "*the whole environment doesn't support a change in lifestyle*" [66].

4.3.2 Aging Population

As previously discussed in Chapter 3, Saudi Arabia has a rapidly growing population. The current population count stands at 29 million, however, this number is estimated to grow to 35.7 million in 2025 and reach 49.8 million in 2050 [20].

Recent statistics taken in 2010 by the Population Reference Bureau indicate that a big portion of the population is youths. Out of the total 29 million people currently living in Saudi, an estimated 38% are under the age of 15 [20]. This indicates that very soon Saudi Arabia will be facing an aging population and will need to deal with associated health problems such as chronic diseases. Over the next 25 years, the number of people over 65 years will increase more than sevenfold [24], and evidence of an increasing rise in the prevalence of diabetes, hypertension, and cardiovascular disease have already been recorded.

The biggest concern of Saudi healthcare officials is that the country is not prepared for a growing population or for an aging one. New budgets allocated to the Ministry of Health are being wisely spent to help cope with future expectations of a high rise in chronic diseases, diabetes in particular. Healthcare projects are targeting the establishment of new hospitals and expanding existing ones to meet the growing demands of more beds. Teaching hospitals are expanding their training programs allowing for more physicians and nurses to get adequate training, in order to meet growing treatment demands.

4.3.3 Diabetes Awareness

Diabetes is the fourth cause of death, and 50% of diabetics are unaware of their condition, stated Dr. Khoja, Director General, Executive Board, Council of Health Ministers for Gulf Cooperation Council. He then stressed the importance of raising awareness about diabetes, since 80% of type-2 diabetes can be prevented with a well-balanced diet and regular exercise [67].

Diabetes continues to spread rapidly, with national statistics indicating that more than 28% of the population in Saudi is diabetic. Unless major efforts are made to raise awareness about diabetes, these numbers will continue to grow, and very soon this disease will be categorised as an epidemic in Saudi Arabia.

Healthcare officials also need to raise the awareness about the established links between diabetes and other related health risks patients may not be aware of.

For instance, many diabetics living in the hot climate of Saudi Arabia are not aware of the impact of hot weather on their disease. People with diabetes 'have an impaired ability to sweat, predisposing them to heat-related illnesses, as do uncontrolled high blood sugars', stated Dr. Adrienne Nassar, a researcher at Mayo Clinic [68]. A survey on heat awareness was taken by 152 diabetic patients at the diabetic clinic at Mayo Clinic, USA. Results indicated that 20% of patients did not take any precautions in the heat. And although nearly three-quarters of the patients acknowledged having been warned about heat and insulin, very few realised that heat posed a risk to their oral diabetes drugs (39%), glucose meters (41%), and glucose test strips (38%). Not only that, but the surveys revealed that on hot days, 37% of patients left their diabetes drugs and supplies at home, meaning they wouldn't be able to check their blood sugars of they felt faint. This could be one of the reasons that 'people with diabetes have higher rates of emergency room visits, hospitalisations, and deaths caused by heat illness during hot weather than during more temperate weather', as stated by Nassar [68].

A large number of diabetics are also unaware of the link between their disease and vision impairment. An article published November 2009 described how six out of ten people living with diabetes worldwide are unaware of the numerous visual complications associated with the disease [69]. Unfortunately, these complications can be prevented when patients are equipped with the required knowledge.

Finally, numerous studies have exposed the link between physical activity and the prevention of diabetes, and although many efforts have been dedicated towards raising the awareness, these messages have not reached the public, because physical

activity remains under-utilised in the management of diabetes. Also, most diabetic patients remain sedentary or do little exercise to improve their health or make any useful changes to their lifestyles.

4.4 Cost of Diabetes Management

Diabetes mellitus is a burden on any country's economy. It is considered to be the most costly medical disorder globally, mostly because of its chronic complications that can weigh heavily on a nation's healthcare expenditure.

In a number of countries, diabetes accounts for a large percentage of the total health expenses. In the USA, the latest statistics produced by the American Diabetes Association in January 2011 indicate that diabetes represents 11% of their total healthcare expenditure. Studies show that healthcare costs for a diabetic can reach up to 2.4 times that of a non-diabetic [70].

Costs can be categorised as 'Direct' and 'Indirect'. Direct costs consist of the healthcare resources that a population uses for the treatment of diabetes or related illnesses. Indirect costs include all potential resources that are lost as a result of diabetes mellitus including the morbidity, disability and premature mortality.

Medical complications associated with diabetes also add to the growing costs. Based on the USA Diabetes Fact Sheet [70] these complications include:

- **Heart disease and stroke:**

  Adults with diabetes have heart disease death rates about two to four times higher than non-diabetic adults, and their risk for stroke is two to four times higher, in addition to the fact that cardiovascular complications are the most costly, contributing to 19.2% of the total and direct and indirect costs associated with diabetes.

- **Hypertension:**

  Between 2005 and 2008, 67% of diabetics aged 20 years or older had high blood pressure or used prescription medication for hypertension.

- **Blindness and eye problems:**

  Diabetes is the leading cause of new cases of blindness among adults aged 20-74 years.

- **Kidney disease:**

  Diabetes is the leading cause of kidney failure accounting for 44% of all new cases recorded in 2008.

- **Nervous system disease:**

  Between 60% and 70% of diabetics suffer from mild to severe forms of nervous system damage, and 30% aged 40 years or older have impaired sensation in the feet, which can lead to amputation.

- **Amputations:**

  People with diabetes account for more than 60% of all non-traumatic lower-limb amputations.

- **Dental disease:**

  Young adults with diabetes are at twice the risk for gum disease than non diabetics, and about one-third of diabetics have severe gum disease consisting of loss of attachment of the gums to the teeth.

- **Complications of pregnancy:**

  Poorly controlled diabetes before conception and during the first trimester among women with type-1 diabetes can lead to major birth defects in 5% to 10% of pregnancies and spontaneous abortions in 15% to 20% of pregnancies. In the following trimesters, it can lead to excessively large babies, raising the complications for both the mother and child.

- **Other complications:**

  A number of complications are associated with diabetes, and they range from comas to depression.

In 2007, direct and indirect costs of diabetes in the USA estimated at approximately GBP 93 billion ($174 billion) [70]. More recent estimations in the UK indicate that in 2010 the NHS spent GBP 9 billion annually on treating diabetes and its complications, which accounts for about 10% of the NHS annual spending [71].

Studies in Saudi Arabia, where almost two-thirds of the population are diabetic, are being conducted by the King Saud University National Diabetes Centre, to measure the direct and indirect costs of diabetes. Dr. Khalid Al-Rubeaan states that preliminary results indicate that diabetes is exhausting 23% of healthcare expenditure and 17% of direct medical service [72].

The alarming growth in the numbers of diabetics in Saudi is overwhelming healthcare officials. Dr. Mohamed Al-Hamed, Director of Diabetes Centres at the Ministry of Health, indicated in 2008 that total annual expenditures on diabetes in Saudi has reached GBP 7 billion (SR 51 billion), with GBP 1.1 billion (SR 8 billion) being spent on direct costs, and GBP 6.1 billion (SR 43 billion) on indirect costs [73]. With the rapidly spreading disease, these costs are predicted to have risen dramatically in the past couple of years.

4.5 Using Technology for Diabetes Management

There are a number of reasons that dictate the importance of offering alternative methods of delivering healthcare services to deal with the increase of chronic diseases, in particular diabetes. Some needs are general and usually apply to many healthcare sectors around the world. Other reasons found seem to be more specific to the unique environment in Saudi Arabia, and also the region.

The use of technologies to support this cause is widely spreading due to its availability, reliability, accuracy, and efficiency. These technologies have especially proven to be effective in the management of chronic diseases. Diabetes management in particular, has had much focus from both the technology industry and the healthcare environment. Many successful studies and trials exist of introducing simple technologies to manage diabetes. These solutions have proven to be cost-effective, improve the quality of healthcare services, and most importantly assist in managing diabetes.

Let us examine the most common reasons for using technology to manage diabetes.

4.5.1 To Complement Traditional Methods of Care Service

- ***Cope with rapid spread of diabetes***

With the rapidly growing number of diabetics in Saudi and the limited healthcare resources, the demand for healthcare services is increasing. Healthcare officials in Saudi are realising that alternative methods of delivering healthcare services are crucial at this time. They are investing wisely in researching available technologies that can complement current healthcare services, be easily integrated into the current healthcare system, and gain acceptance from both the healthcare givers and the patients.

- ***To raise awareness***

Technology also has the advantage of allowing healthcare givers to reach a large number of patients with little effort and in a short period. Mobile technology, with the use of SMS, and other social networking sites enable healthcare givers to raise awareness about diabetes by quickly reaching their audience.

4.5.2 To Offer Better Quality of Care

- ***To maintain quality healthcare service***

A study carried out during 2003 focused on the factors influencing patient choice of hospitals in Riyadh. Out of six primary factors identified, the most important one affecting patient choice of hospital is 'Medical Services', accounting for 28% of the total variance [74]. Therefore, healthcare institutes in Saudi are focusing their efforts on improving their medical services, in order to maintain quality healthcare services.

- ***To encourage diabetics to be independent through self-management tools***

Patients diagnosed with diabetes are usually required to make changes to their lifestyles, such as increasing physical activity, adhering to suitable diets, monitoring of their disease, and intake of required medications. These responsibilities are periodically overseen by a healthcare giver. Computerized diabetic monitoring

systems used to monitor patient readings have proven to be an effective intervention tool [75]. Use of these technologies promotes enabling diabetics to be more independent which eventually leads to a more normal lifestyle with absolute minimal visitations to healthcare givers. In recent years, these technologies have proven to be effective.

- ***To improve healthcare services in rural areas***

Saudi Arabia is the largest country in the gulf region. Its health service plan consists of two tiers working together to meet health needs from preventive care through advanced surgery. The first tier is made up of a network of advanced hospitals and specialised medical facilities, which are located in major urban areas. The second tier consists of a network of primary health clinics throughout the country. These clinics provide preventive, prenatal, emergency, and basic services [76]. Finally, remote rural areas are reached through mobile clinics which provide limited healthcare services such as vaccinations and basic medical care. Saudi's desert terrain does present various obstacles in reaching such remote areas. Technology used through the mobile clinics can allow specialised medical services to these areas, and can therefore greatly enhance the level of medical services currently being offered in these areas.

4.5.3 To Assist in Resource Management

- ***Cope with increasing operational cost of hospitals***

Saudi healthcare institutes are finding it difficult to justify their rapidly increasing operational costs. A factor contributing to this issue is the lack of beds, as indicated during a press conference with NGHA officials [77]. The officials were clear in stating that this is a problem being faced by most healthcare institutes in Saudi.

Another factor is the extent of medication waste among Saudi Families. A study during 2002 revealed that families in Saudi Arabia and other Gulf countries spent a total of GP75 million on medications that were never used. This puts an unnecessary load on the budget of healthcare institutions [78].

Saudi Healthcare institutes are also facing the population's demand for healthcare services by an increase of human resources, specialised medical facilities, and medical equipment, amongst other expenses. These factors are obviously resulting in higher hospital operational costs.

Using technology as a means to efficiently manage healthcare resources has proven to be effective. Technology can assist healthcare officials in controlling hospital costs, managing health resources, whilst maintaining quality care levels. Healthcare information systems, such as Electronic Medical Records, Clinical Information Management Systems, Hospital Enterprise Resources Planning, and other systems have all had a positive impact on maintaining operational costs, when successfully implemented and integrated into existing hospital processes.

Furthermore, technologies used specifically to assist in the management of diabetes are growing to be extremely popular. Mobiles and hand-held devices are being used to closely monitor patient blood sugar readings. For diabetes clinics struggling with limited resources and budgets, these devices have been a major aid in managing the growing number of patients.

4.5.4 To Help Overcome Social, Religious, and Cultural Factors

- ***'Same-sex' healthcare givers and patients***

There is no doubt that the social, religious, and cultural factors can play a pivotal role in how healthcare services are delivered. For instance, many Muslim patients insist on only receiving healthcare services from the 'same-sex' healthcare giver. In some situations, the opposite setting also applies, where healthcare givers might prefer only dealing with patients of the same sex.

Physicians in the UK have been calling for Muslims to be given different treatment since 2000. A professor published an article in the *British Medical Journal*, requesting that the NHS be more accommodating to the needs of Muslims [79].

The majority of Saudis are conservative Muslims. Issues affecting healthcare delivery often involve religious aspects, such as patient acceptance or resistance of services offered from physicians or nurses of a different gender.
The use of technology may address these obstacles and present options of delivering quality healthcare services in a manner that is seen more acceptable by patients and takes into consideration religious aspects.

- ***To address sensitive cultural and traditional factors associated with some healthcare services***

Segregation can be seen in the Saudi society on many fronts, in schools, universities, most workplaces, and at almost all social events and gatherings. In addition, most Saudis are traditional and cherish their privacy. This identity can be disrupted when a patient is diagnosed with a chronic disease such as diabetes, which requires continuous monitoring from healthcare givers, and periodic information from the patient regarding daily and weekly diet plans, and activity rates.
Perhaps technology can reduce the amount of direct interaction between the patient and healthcare giver, and allow patients to manage their disease more independently and enable them to indirectly coordinate with healthcare givers whenever necessary.

- ***To address sensitive cultural and traditional factors associated with impact of diabetes on social obligations***

Based on discussions which took place during 2009 with healthcare givers and patients at the NGHA diabetic clinic, the social impact of this disease on the future of many younger patients has been realised.

With women: There is an enormous impact on marriage. Since most marriages in Saudi are arranged through families, we find that the 'health' factor of a woman considered for marriage is important. The reason being society's concern that she is fit to bear children, where child-bearing is considered a married woman's main role. In addition, the average size of a Saudi family is 6.1 in 2004, based on the national census data [80], and details of Saudi Arabia's 2010 census data are yet to be fully unveiled. This average might lead to questioning a diabetic woman's ability to meet this quota. In many cases, a woman between 20-30 years of age, who is diagnosed with diabetes, can find that her disease can pose a serious obstacle towards getting married.

With men: There is also an impact on getting married, however, not so drastic as that with women. Nonetheless, men with diabetes are viewed as disabled members of society. The general categorization given to a diabetic is 'unhealthy'. Families are concerned about symptoms diabetes can cause, such as 'depression', where the man can be seen as unfit to support a family and steadily hold a job.

4.6 Summary

This Chapter identifies the growing number of chronic disease patients in the world, and the rapid spread of these diseases among the Saudi population. The focus is then concentrated on diabetes as the most dangerously spreading disease, where Saudi Healthcare statistics indicate that today almost 28% of the population is diabetic. Healthcare officials have voiced their concern and fear that diabetes is now dangerously close to being categorised as an epidemic, unless swift measures are taken, and long-term solutions are presented and adopted.

The prevalence of diabetes in Saudi Arabia is alarming. Contributing factors such as lifestyles, an aging population, and dietary habits all add to the problem. Although the Saudi government allocates a huge budget to the healthcare sector, the cost of managing diabetes continues to grow.

The current situation mandates an immediate intervention by healthcare professionals in Saudi to efficiently manage this disease. The use of technology can prove to be effective in the management, treatment and prevention of diabetes in Saudi Arabia. Furthermore, solutions based on the use of technology might be able to successfully overcome social, cultural, and religious barriers, and gain a high acceptance from patients.

CHAPTER 5: APPLYING A METHODOLOGICAL APPROACH FOR A SAUDI TELECARE SOLUTION AT NGHA

5.1 Introduction

Specialized hospitals and advanced medical centres located in major urban areas in Saudi Arabia are equipped with necessary medical equipment, specialised healthcare givers, and efficient medical systems. These attributes permit the deliverance of quality healthcare services to patients. However, current challenges face the healthcare system, such as the growing population, rapid spread of chronic diseases such as diabetes, and restrictions in delivering health services due to the social, cultural, and religious setup of the Saudi society.

Unfortunately, the situation in many primary health clinics located in rural areas is different. Similar to primary health clinics in many other nations, those in Saudi Arabia are suffering and under enormous pressure to provide quality healthcare services. The demand for better medical services increases but inadequate resources are available.

Social, cultural, and religious factors also influence the quality of healthcare services. These factors have been discussed in Chapter 3, and presented challenges unique to the healthcare system in Saudi Arabia.

These issues have led healthcare officials to pursue alternative methods of delivering healthcare. To explore new means to cope with current struggles and to successfully maintain a high standard of healthcare services in Saudi. Studies carried out in a number of countries have implemented Telecare solutions to overcome challenges similar to those faced in Saudi Arabia. These implementations have mostly been successful in maintaining quality healthcare services. We believe that Telecare, in

addition to previous successes, can also address social, traditional and religious factors that might limit how healthcare services are offered in Saudi.

This Chapter will begin by defining our problem area, looking at any existing experience gained by Saudi healthcare institutions in the field of Telecare, then specifically defining our research target area. It will also examine the conservative cultural and traditional aspects of the society and the impact on healthcare services. In addition, it will focus on available technologies which will influence the design of a Telecare solution.

Problem-solving approaches to systems design are presented and the justification of selecting one is discussed. The adopted approach is applied to the healthcare system at NGHA, in particular, the diabetes clinic at KAMC-CR. This application requires an in-depth look at a number of processes followed by the clinic, and the interactions between healthcare givers and the patients.

Many interviews, questionnaires and meetings at KAMC-CR gave a clear look at the actual workings of this system, in addition to uncovering some of its weak points. Healthcare professionals and patients were given an opportunity to not only point at problem areas, but to also propose possible solutions. Many of them showed a generally positive attitude towards Telecare solutions and their suitability to current situations. They were excited about how the application of Telecare solutions can actually address problems being faced by both healthcare professionals and patients. Moreover, they expressed their confidence in the potential of these solutions to deliver better quality of service.

The final stage was to devise a Model illustrating how a Telecare solution can be applied to the Saudi healthcare system, showing all involved components. As indicated by Flood & Carson, when dealing with complexity, researchers may want to model, to identify a system to represent reality, for a number of reasons such as studying structures, processes, and behaviours [81]. This Model is devised specifically to study the process of applying Telecare solutions to suit the healthcare system at NGHA. The Model takes into consideration the option of customisation in the future to suit other Saudi healthcare institutes. Following Chapters will examine the implementation and integration of a Telecare solution at NGHA based on the devised Model.

To apply a Telecare solution, the infrastructure needed is in two parts: the *Organisational* and the *Technical* [82]. Chapter 3 examines aspects of the organisational part, while this Chapter examines the technical part.

We conclude by presenting the Model created to describe the application of Telecare solutions that manage patients with chronic diseases at NGHA, based on

both the technical and organisational setup there. In addition, we provide a description of the Methodology used to devise the Model, and a justification of using this particular methodology and its suitability to the research area at hand.

However, let us first identify the research methods to be used for data collection in various tasks described in this chapter throughout to Chapter 8.

The research presented here adopts a quantitative method, which allows us to conduct empirical investigations through "*statistical, mathematical or computational techniques*" [83].

These investigations take place through the observation of health services at the clinic, surveys to gain specific measurements, and interviews conducted with both healthcare-givers and patients to gain a more in-depth understanding of current obstacles.

This data and associated findings are incorporated into the stages of the SSM, which in turn leads to the development of the Telecare Model.

After the development of the Model, the implementation of the TeMaD system commences. Once again, the quantitative method is selected to analyse the data gathered from the TeMaD system. Statistics are generated with the aid of the software package SPSS, to produce meaningful results. This task mainly focuses on tracking the percentage of change in patient blood sugar levels. Based on these results, empirical relationships and associations with other patient-related factors (i.e. social, religious, etc) are identified and correlations are formed accordingly. A quantitative method was again used to capture user feedback after participating in the TeMaD study. This took place through the distribution of questionnaires, after commencement of trial to both participating patients and DE's. The objective is to capture user perception and attitude towards telecare system.

Finally, the sampling technique used to determine and establish our sample size for the TeMaD trial, is Quota Sampling, which is a non-probability sampling method. This method is used because of the criteria set for the sample size requiring that it reflects gender ratios and specific age groups. This method was also selected because it allows some 'targeting' when selecting the sample size, hence the tendency to select patients with some familiarity with the technologies used by the TeMaD system, and, from a practical perspective, patients that were literate. Although some might argue that this method may result in a biased sample size [84], it is essential to realise that TeMaD is not a system intended for use by all patients. It is a healthcare service that should be used alongside conventional healthcare services for patients that meet specific criteria.

5.2 Existing Telecare Solutions in Saudi Arabia

This section examines if any Telecare solutions have been applied at NGHA or other healthcare institutes in Saudi. If so, it looks at how these solutions have been implemented. It examines if any scientific methodologies were followed, or Models developed and implemented.

1. NGHA

Although we have discussed the limited Telecare solutions offered by NGHA, it is interesting to know that most were the products of a Prototype methodology. This design and development methodology has a number of advantages; the most luring to NGHA software design teams is the reduced cost and time required to complete the system. However, the use of Prototyping has the disadvantage of ending up with insufficient analysis. That said, we find some early Telecare initiatives at NGHA lacked the scientific methods of gathering requirements and needs, and the proper analysis required. They also lacked the proper documentation to Prototype modelling and implementation. This was the case with the numerous live Internet broadcasts of Siamese twins' separation surgeries, which took place for educational purposes over a period of five years. Similarly, the broadcast of certain surgeries in Riyadh over the NGHA network for consulting NGHA Physicians located in Jeddah. The NGHA also offered free medical consultancy over a live video-conferencing link, connecting Physicians at the Hospital in Riyadh with Patients located 40 Kilometres outside Riyadh. The project lasted for one week during the Janadriyah festival years 2000 and again 2001.This was also a project developed using a Prototype approach.

However, since 2005 NGHA has taken major steps to pave the road for a more scientific approach to eHealth implementations in general. The King Saud bin Abdulaziz University for Health Sciences was established, consisting of a number of specialised majors for postgraduate studies, including a Master's of Science course in Health Informatics.

In addition, major health informatics projects were launched starting in 2004, adopting scientific analysis and design approaches, and suitable development methodologies.

2. Other healthcare providers

There is actually little information that can be gathered from the limited number of healthcare institutes offering Telecare solutions in Saudi with regards to the approaches followed when developing and offering Telecare solutions. This is mainly due to the ad hoc implementation of such services in the past and lack of documentation.

A handful of leading hospitals have successfully offered patients Telecare solutions. King Faisal Specialist Hospital and Research Centre is considered a leader in eHealth offering outreach programs and medical services via Teleconferencing. Also, the Ministry of Health is now focusing on eHealth directions and strategies [85], as indicated in Chapter 4.

5.3 Research Target Area

Our research target area will be the application of a Telecare service for managing patients at NGHA with Diabetes. The research will involve the design and development of such an application, with an in-depth look at influencing factors from both the healthcare sector and the social aspects of the population. The Telecare service at hand will be developed in a manner that will allow its customization to accommodate other healthcare facilities in Saudi, and permit for smooth integration into existing systems.

The *Project Hypothesis* presented in Chapter 1, also raised questions of applying Telecare services within the healthcare system of neighbouring Gulf countries that share Saudi's social traditions, culture and religion. This will be briefly covered later in Chapter 8. However, this direction will most likely be an area to be researched independently.

5.4 Factors Influencing Design

Here we look at the different factors that will influence our view of the situation and how we approach it. These factors are essential when selecting a methodology and model to use for applying a Telecare service.

5.4.1 NGHA Resources

- NGHA has a high speed Wide-Area-Network connecting its four primary hospitals and its sixty plus primary health clinics kingdom-wide using high bandwidth Leased Lines or Satellite technology.

- It also has a high speed Ethernet Local Area Network within each of its Hospitals connected to an ATM (Asynchronous Transfer Mode) backbone providing high speeds of data transfer over a stable network.

- NGHA has implemented a Clinical Information Management System (CIMS), launched in 2003, and is now in the phase of implementing and integrating the Patient Electronic Medical Record.

- NGHA is also now in the process of implementing a PACS system, to be integrated into the existing NGHA HIS.

- All primary areas related to hospital operation are electronic using applications complying with universal health systems standards (Messaging system, Human Resources System, Clinical Information Management System (CIMS), Oracle databases 9i, Oracle ERP, SUN systems).

5.4.2 Social Factors

It is fair to say that Saudi is unique in its culture. Let us identify some of the factors that truly make it a unique place, requiring acceptable solutions.

- Saudi law prohibits females from driving. In addition, it lacks efficient public transportation. This is considered a huge obstacle for women affecting their mobility. A survey, as part of this research, carried out on 100 female patients at NGHA, found the most common obstacle facing women in reaching their appointments, is problems securing transportation from and to the hospital.

- Due to strict adherence to religious factors in Saudi, many patients request same-sex physicians. This can sometimes be difficult to satisfy, especially in small healthcare centres located in rural areas with only limited healthcare professionals.

5.4.3 Technology Available

Designers and developers often make the mistake of fitting the problem into the technology, rather than fitting the technology into the problem. For systems to achieve their objectives and gain acceptance by their users, we need to be realistic in selecting the technology that can deliver our set objectives. It is essential that technology used is common between our user-groups, easy to use, and available. Telecare services can be delivered through simple Mobile technology and Internet technology, which are both spreading widely in Saudi, easy to use, affordable and accessible.

The Saudi telecommunications industry consists of three mobile phone service companies: the Saudi Telecommunications Company (STC), Mobily, and Zain. Statistics released in October 2008 indicated that the total number of mobile phone clients with STC reached 18 million, with Mobily reached 12 million, and with Zain reached 1 million. This brings the total number of mobile phone users in Saudi by the end of 2008 to approximately 32 million, with a ratio of 123% to the population size [86]. The ratio exceeds 100% due to single subscribers owning more than one mobile line each.

With regards to Internet usage in Saudi, statistics provided by the International Telecommunications Union in 2010 showed that 9.8 million people in Saudi use the Internet. This indicates that 38.1% of the Saudi population uses this technology, with this number continuing to grow [87].

YEAR	Users	Population	% Pop.
2000	200,000	21,624,422	0.9 %
2003	1,500,000	21,771,609	6.9 %
2005	2,540,000	23,595,634	10.8 %
2007	4,700,000	24,069,943	19.5 %
2009	7,761,800	28,686,633	27.1 %
2010	9,800,000	25,731,776	38.1 %

Table 5.1: ITU statistics of Internet users in Saudi (2010)

5.5 Design of Telecare Model

Once our 'problem area' has been identified, examined, and assessed, the next step is to provide a suitable solution. For this, we need to examine the different 'problem-solving' approaches.

As stated by Flood and Carson, there are two popular views when examining a 'problem', one called *Hard* and the other called *Soft*. The Hard systems view looks at a problem as something difficult and hard to understand and requires a solution. The Soft systems view looks at a problem as "*that which arises in the everyday world of events and ideas, and may be perceived differently by different people*." [81].

Based on a review of these two views, performed by Flood and Carson [81], portraying their primary differences, strengths, and weaknesses, one was chosen to be applied to our problematic situation. The following sections will discuss the Soft Systems approach, and present a justification of why it was chosen. Next is a

description of how the approach was applied, and eventually led us to the development of a Model.

5.5.1 Methodology Selection and Justification

The problem-solving approach selected is the *Soft Systems Methodology*. The reason behind our selection is attributed to the following:

- the 'messy situation' this area of research is covering (i.e., obstacles faced by patients and patient/physician interaction)

- the social aspects in Saudi which play a major role in the success of implementing such solutions (i.e., cultural, religious and traditional)

- the 'subjective view of the social world' that the Soft School offers better suit the area of research at hand.

5.5.2 Application of Soft Systems Methodology (SSM) Stages

The SSM consists of a number of stages as indicated by Flood and Carson [81]. We will now apply these stages to our research area as follows:

- **Stages 1 & 2**

Our objective is to achieve a representation of the real world in as neutral a way as possible. The layout depicted in figure 5.1 represents the application of a Telecare solution within the Saudi National Guard Health Affairs Healthcare system. It uses a Rich Picture Diagram to express how a Telecare solution can be applied to the existing healthcare system at NGHA. A Rich Picture Diagram was chosen to simplify the complex structure at NGHA and to provide the reader with an easy interpretation of how a Telecare solution can be successfully applied within the NGHA healthcare system.

Figure 5.1 consists of a number of components interacting with one another through a series of steps that briefly define the relationships between them. A more detailed description of each step is listed below.

1. Steps

1. Patient takes his/her blood sugar level readings at home, then sends them to the Telecare website via SMS (Mobile Technology), or Email (Internet Technology) using the User Interface of the NGHA Telecare Website.

2. Healthcare giver periodically (i.e., daily) checks application for recent entries, and can be alerted via Pager or Email when a new patient entry has been submitted.

3. Healthcare giver checks patient readings by logging into NGHA Telecare Website using the Administrator Interface.

4. Based on readings, healthcare giver may list instructions/recommendations for patient, or simply add comments to Patient File.

5. Healthcare giver then performs an update of the Patient File on the website database to the Patient Medical Record on the NGHA Hospital Information System.

6. Patient is notified of healthcare giver entry via SMS or Email.

7. Patient reviews healthcare giver recommendations, and accordingly takes necessary action (i.e., take medication, schedule hospital appt, modify diet, etc…).

8. General patient data stored on a National Saudi Database. The objective of this national database is to monitor diseases, examine trends, and provide preventive measures on a national level.

9. Similar information from other healthcare institutions will be gathered, analysed, and then shared between concerned health institutions to derive national statistics and trends.

2. Rich Picture Diagram

Figure 5.1 shows the Rich Picture Diagram of applying a Telecare solution within the healthcare system at NGHA, and shows the different participants and components.

Based on the Rich Picture Diagram, the following themes or viewpoints were identified:

- System needs to be developed for Patient/Healthcare giver interaction
- System standardisation required between NGHA and other healthcare institutes in Saudi
- Lack of a fully integrated Saudi National Database
- Patient and healthcare giver resistance to any new system
- Integration of Telecare services with existing NGHA hospital information systems

From these, a number of relevant systems were identified:

- Interactive web-based system & SMS-Messaging system
- Patient feedback/satisfaction system
- Educational system
- Technical coordination system

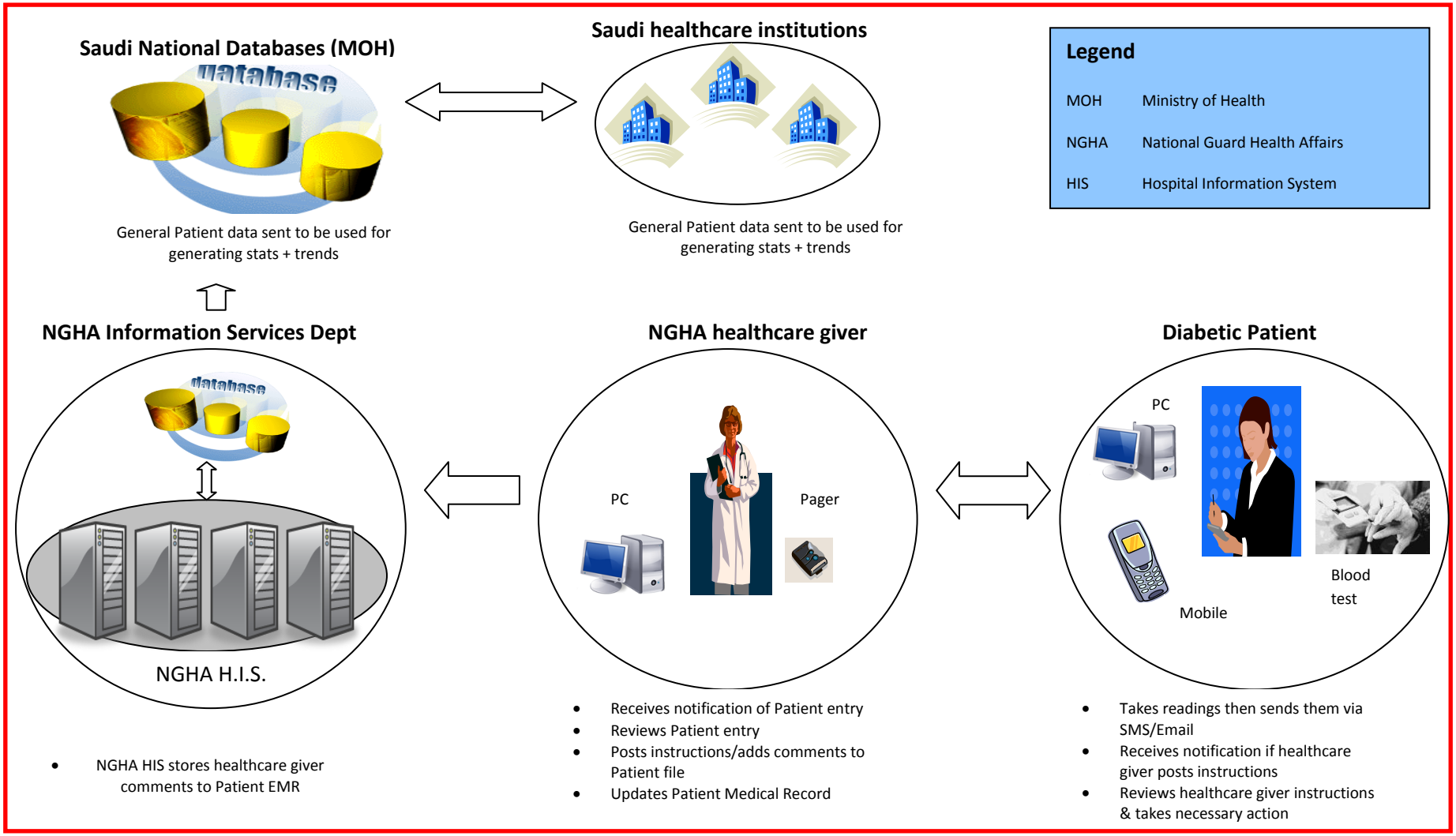


Figure 5.1: NGHA Rich Picture Diagram

- **Stages 3 & 4**

The next stages involve developing a root definition, then applying a CATWOE analysis, which will lead us to the development of a Conceptual Model of the problematic situation.

The research area currently being examined is how a Telecare service can be applied in the healthcare system at NGHA. A 'Root Definition' will be developed to assist us in determining factors relating to the structure and process of the system.

1. Root Definition

NGHA is a military healthcare institute that falls under the jurisdiction of the Saudi National Guard. Consisting of four major hospitals, over 60 primary healthcare centres, equipped with state of the art medical technologies, and specialised healthcare professionals kingdom-wide, it offers healthcare services to its patients (NGHA dependants and privately covered patients) with the objective of improving their quality of life.

2. C.A.T.W.O.E.

When C.A.T.W.O.E. is applied to the problem area being addressed at NGHA, we find:
(C)ustomer: Patients (diabetics)

(A)ctor: Healthcare givers

(T)ransformation: Limited healthcare services to better healthcare services which improves quality of life for patients.

(W)eltanschauung: It is beneficial to the Saudi Government that it controls spread of disease and is able to provide healthcare services to more patients.

(O)wner: Saudi Healthcare Institutions (Military, Government, and Private)

(E)nvironmental Constraints: Saudi conservative culture and societal setup

After examining the application of CATWOE to a problem area discussed by Flood and Carson [81], we can also apply this to our research area.

The following statements were used to describe the system, and have been assembled in a diagrammatic form (figure 5.2) to represent the conceptual model of applying a Telecare service in the NGHA healthcare system in Saudi Arabia:

- Identify social aspects of Saudi culture
- Identify NGHA missions and goals
- Identify NGHA resources
- Develop Telecare service
- Provide Telecare service
- Raise Public Awareness about Telecare solutions
- Use available NGHA Technology
- Operate Telecare Service in place of traditional method used
- Monitor understanding and knowledge
- Monitor Telecare service acceptance by Patients and Healthcare Professionals

3. Conceptual model – Applying Telecare service to NGHA health system

Figure 5.2 shows the Conceptual Model designed for the application of Telecare within the NGHA health system.

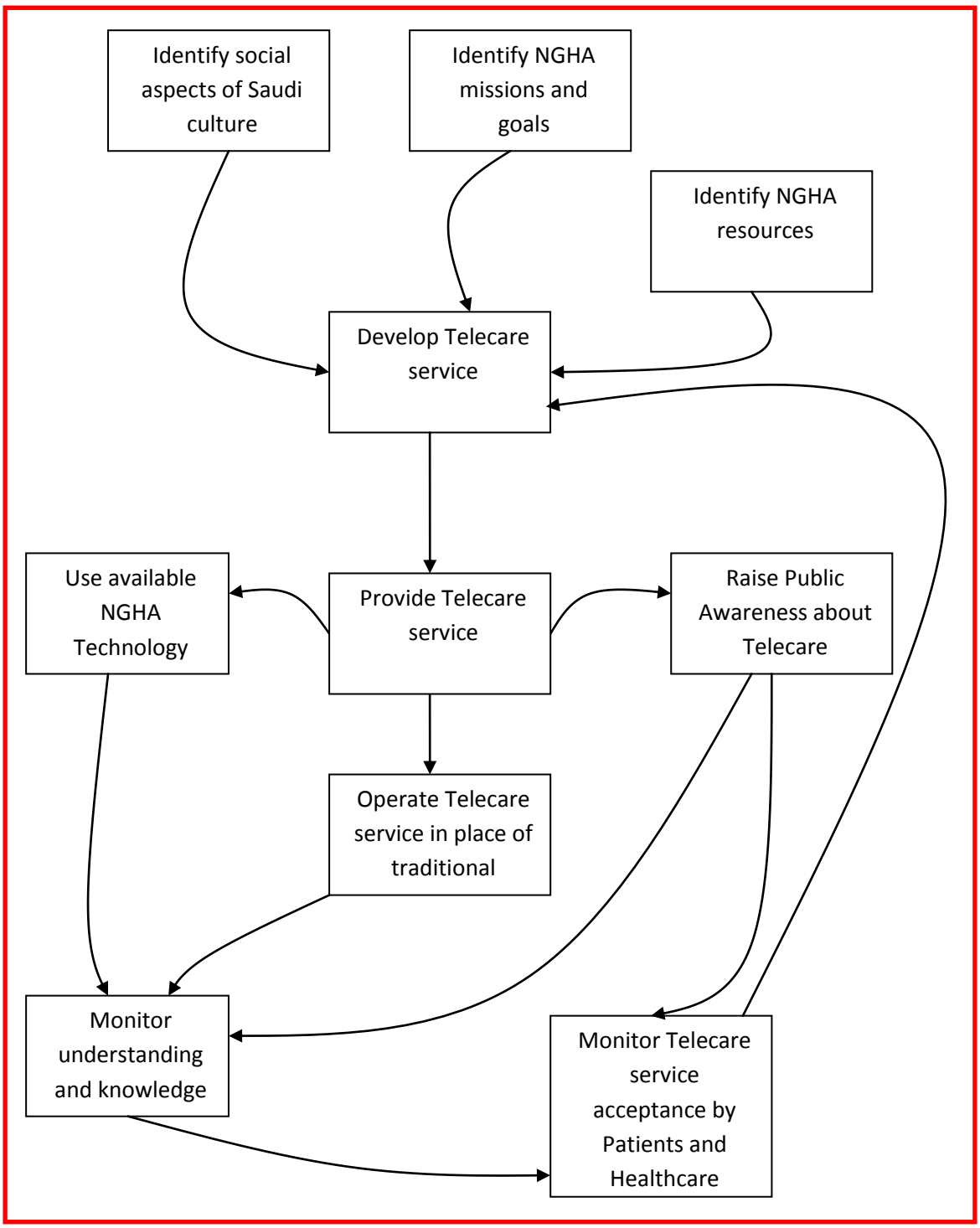


Figure 5.2: Conceptual Model – NGHA Telecare

- **Stage 5**

After getting an in-depth look at the problematic area, it is now necessary to compare the conceptual model with the real world. This can be tackled by constructing an agenda which compares the activities shown in the conceptual model with the situation in reality [81].

Conceptual model activities VS real world

Activity in conceptual model	Situation in real world	Comments
Identify social aspects of Saudi culture	Social aspects are identified	
Identify NGHA missions and goals	NGHA has a clear set of missions and goals	
Identify NGHA resources	NGHA resources have been identified	
Develop Telecare service	Initial Telecare service requirements gathered	Via meetings with healthcare officials and information gathered from patients via questionnaires
Provide Telecare service	No Telecare service at NGHA currently exists	Single instances of Telecare services have been offered at NGHA for limited time periods
Raise Public Awareness about Telecare solutions	Limited attempts, more needs to be done	A goal set by the newly established 'Saudi Association for Health Informatics (SAHI)'
Use available NGHA Technology	NGHA has required infrastructure and technologies to provide Telecare services	
Operate Telecare service in place of traditional method used	No Telecare services are currently available	This will be possible *after* a Telecare service has been developed
Monitor understanding and knowledge	Teams dedicated to this activity need to be identified from both Medical and IT departments	
Monitor Telecare service acceptance by Patients and Healthcare Professionals	Teams dedicated to this activity need to be identified from both Medical and IT departments	

Table 5.2: Conceptual model activities VS Real World

- **Stages 6 & 7**

At this point we are interested in the changes that are socially feasible and applicable to the system at hand. In particular, we focus on changes to the structures, procedures, or attitudes.

As Checkland indicated [88], discussions about desirable changes should be carried out with 'Concerned actors', to get a more accurate look at the effectiveness of the activities.

Identifying desirable changes

Table 5.3 presents some of the desirable changes in the three categories:

Area of Change	Desirable Changes
Changes to System Structure	• Changing the way current NGHA healthcare services are being offered • New patient pathways will be introduced • The integration of required technology • Introducing new participants to the structure and new teams • New skills required from participants • Ownership of new system needs to be determined (Risks, System components, etc)
Changes to System Procedures	• The nature of the Patient-Physician relationship will change • Patients and physicians will need training on new procedures
Changes to Attitudes	• Patient acceptance of Telecare services • Physician acceptance of healthcare policies and procedures • Patient/Physician willingness to participate in Telecare services • Raising public awareness of Patients and their families

Table 5.3: Desirable Changes

5.5.3 Model Selection and Justification

Working from the basis of results gathered through the implementation of SSM, we now move on to develop a Model, also using the Soft System Diagram approach. However, we have adopted the modified version of this Model, proposed by Checkland, using sentences broken down into phases [89].

The primary reasons behind selecting this approach to develop the Model are as follows:

- We are attempting to reflect social factors impacting on a system
- Our research area can be viewed as that involving 'purposeful human activity'
- The area of research can be categorized as a 'messy situation'

Based on these points, it seems that SSM is the most suitable methodology to apply to our area of research, especially that we are dealing with social and cultural issues. The SSM methodology is able to successfully deal with such issues in that it *"comes to grips with the plurality of viewpoints"* and is able to *"generate meaningful debate between a wide variety of participants"* with the ultimate objective to *"promote learning and understanding"*, as stated by Flood and Carson [81].

Furthermore, the soft systems diagram will use features adopted from a decision flow diagram (DFD) approach. The justification of this merge is because soft system diagrams deal with messy situations consisting of 'purposeful human activity', and DFDs are used when representing a situation where 'problem solving' activities are applied. DFDs are also used when an 'end' is known. In this case, the 'end' can be identified as our set of objectives.

5.5.4 Model Development

Prior to designing the Telecare model at hand, it is essential that we identify all the components related to the process and the relationships between them.

1. Components and Relationships

- Primary Components

    1. Patient
    2. Physician (Healthcare giver)
    3. Hospital Information System (HIS)
    4. Electronic Medical Record
    5. Website

- Future Components

    1. Saudi Healthcare Institutions
    2. Saudi National Database/Registry for Diabetes

- Relationships

    1. Patient takes his/her blood sugar level readings at home, then sends to the Telecare website via SMS (mobile technology) or Email (Internet technology) using the User Interface.
    2. Healthcare giver periodically (i.e., daily) checks application for recent entries, and can be alerted via Pager or Email when a new patient entry has been submitted.
    3. Healthcare giver checks patient readings by logging into NGHA Telecare website using the Administrator Interface.
    4. Based on readings, the healthcare giver may list instructions/recommendations for the patient, or simply add comments to Patient File.

5. Physician then performs an update of the Patient File on the website Database to the Patient Medical Record on the Hospital Information System.

6. Patient is notified of healthcare giver entry via SMS or email.

7. Patient reviews healthcare giver recommendations, and accordingly takes necessary action (i.e., take medication, schedule hospital visit, modify diet, etc…).

8. Patient general data is sent to a National Database for Diabetics in Saudi.

2. Model Representation

In the Model, all *primary components* will be represented by a solid rectangle and all relationships by a solid line. In addition, all *future components* and their *relationships* will be represented by a dotted rectangle and a dotted line. Each line will have an arrow depicting the direction of the relationship.

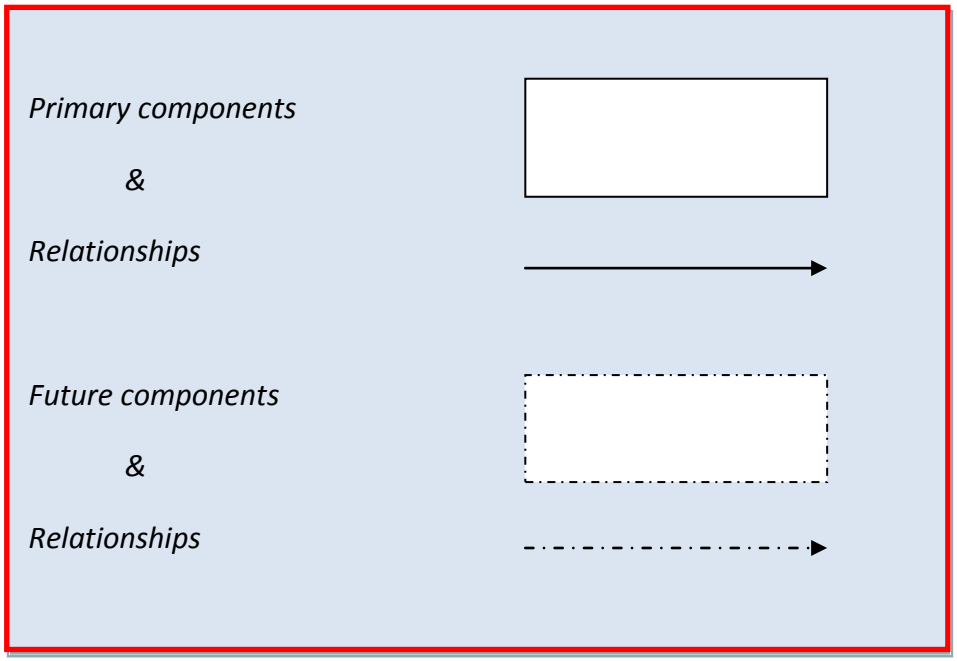


Figure 5.3: Model component representations

3. Technology Used to Deliver Telecare Solution

1. Mobile Technology (SMS), or
2. Internet (System accessible from the NGHA official website)
3. Existing NGHA Hospital Information System
4. Existing NGHA network infrastructure
5. Existing NGHA computer hardware and software

4. Telecare Model for Chronic Disease (Diabetes) Management in Saudi

At this point we are ready to develop the Model. Figure 5.4 shows the different components and the relationships between them based on the previous analysis. Although the proposed model is to be applied to the healthcare system at NGHA, it can also serve as a generic model to be adopted by other Saudi healthcare institutes.

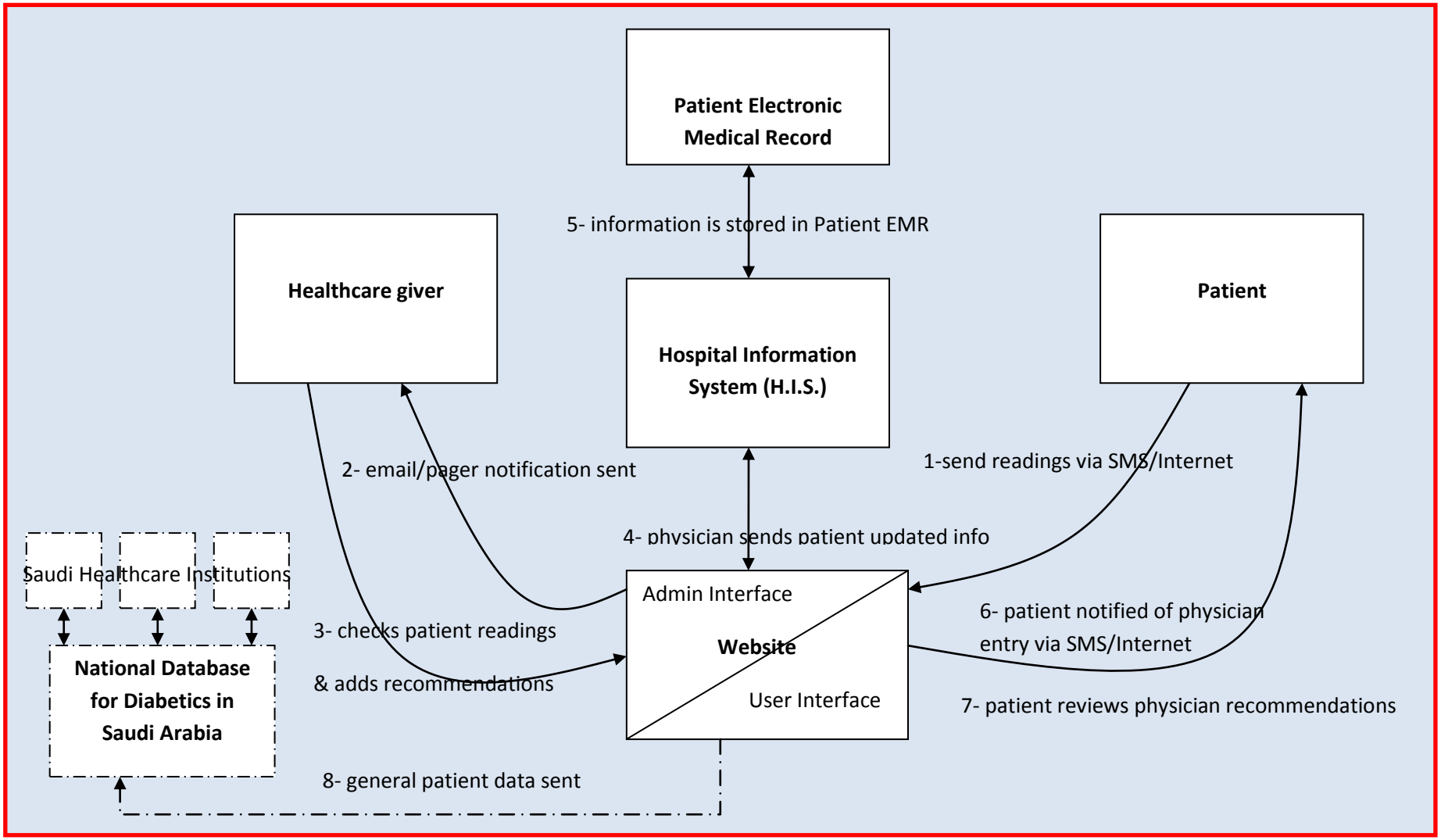


Figure 5.4: Telecare Model for Chronic Disease (Diabetes) Mgmt in Saudi

5. Revised Telecare Model for Chronic Disease (Diabetes) Management in Saudi – Involvement of Diabetic Educator

Recent research on Telecare applications implemented in the UK have shown that the involvement of nurses in the process taking place between the patient and healthcare officials within a Telecare solution can enhance the quality of healthcare service being offered [90]. The reason being that although technology can capture specific information from patients, depending on the characteristics of the technology being used, a Telecare solution incorporating more involvement from a secondary healthcare giver at the clinic, other than the physician, can result in better quality of healthcare service. Especially since secondary healthcare givers are usually the ones responsible for the continuous monitoring of diabetics' blood sugar levels, dietary plans, and physical activity regimens. These tasks require close communication channels between patients and the healthcare giver. The NGHA diabetic clinic relies on Diabetic Educators (DEs) to perform such routine tasks. Escalations to physician are only made by the DE when necessary.

In our previous model we rely on Internet and Mobile technology to send information through the Telecare solution between the patient and the healthcare official. However, based on the literature reviews conducted and stated earlier in this chapter, we find that more Saudis have access to Mobile technology than those with access to Internet. In this case, it would be highly recommended to involve the DEs, where our objective is to capture more information from the patient. The role of the DE would consist of:

- Gathering information from patient
- Get feedback
- Give instructions
- Assess if patients needs to come for appointment
- Escalate case to physician

This can be implemented through the assignment of a small number of DEs to the Telecare solution. The DEs would communicate with the patients and gather information. The DE will then determine the next course of action, to either give

appropriate advice or inform patient of a required visit to the hospital and escalate the situation to a physician via updating the patients' healthcare record.

In this case, let us revisit the model presented in figure 5.4, and make required adjustments. Modifications to the model are represented in **Pink**.

The model components and relationships will also be redefined based on the new modifications.

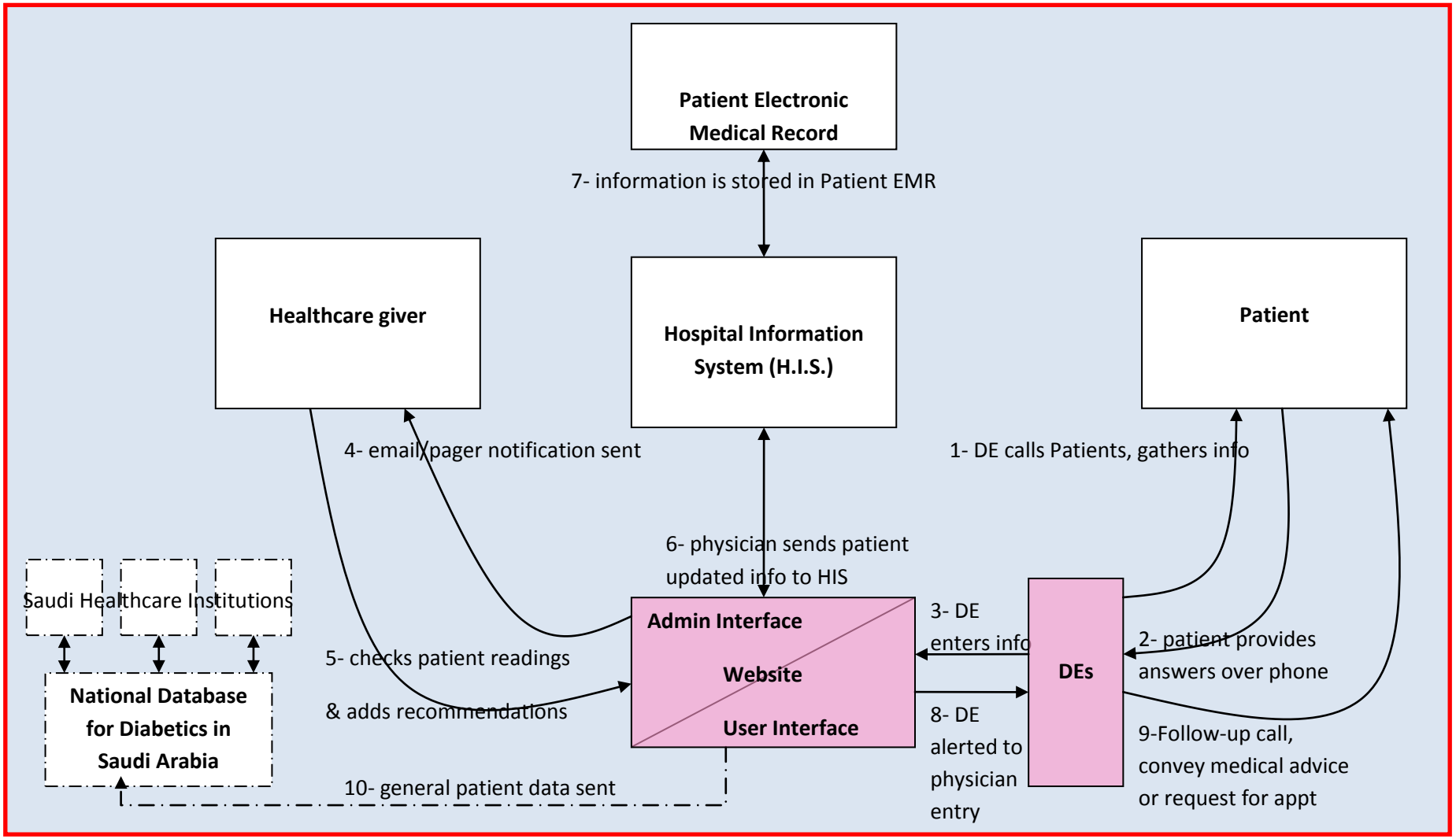


Figure 5.5: Revised Telecare Model for Chronic Disease (Diabetes) Mgmt in Saudi

6. Revised Components and Relationships

Primary Components

1. Patient
2. Physician (Healthcare Professional)
3. Diabetic Educator
4. Hospital Information System (HIS)
5. Electronic Medical Record
6. Website

Future Components

1. Saudi Healthcare Institutions
2. Saudi National Database/Registry for Diabetes

Relationships

1. DE communicates with patient over the telephone, and gathers information through a series of questions.
2. Patient provides answers over the phone.
3. DE enters information into website.
4. Physician is alerted via Pager or Email that a Patient entry has been submitted.
5. Physician assesses patient information through Administrator Interface of Telecare website then enters medical advice or request for appointment.

6. Physician then performs an update of the Patient File on the website Database to the Hospital Information System.

7. Information is stored in the Patient Electronic Medical Record.

8. DE alerted to Physician entry.

9. Follow-up call by DE to patient to convey medical advice, or to indicate that an appointment is required.

10. Patient general data is sent to a National Database for Diabetics in Saudi.

5.6 A Model That Covers Social and Cultural Factors

An important question to begin with is: does this model address social, cultural and religious aspects of the Saudi people?

In order to answer this question, let us examine the characteristics of the model in light of social aspects previously discussed in both Chapters 3 and 4.

Table 5.4 cross examines the characteristics of the model developed, against the social, cultural and religious factors.

Characteristic	Social, cultural and religious factors
The model allows patients to communicate their information directly by contacting the DE, or indirectly by using the online application.	• This addresses the sensitive issue of patients requesting 'same-sex' healthcare giver. • Accommodates segregation. • Limits face-to-face appointments.
The model offers patients at the diabetic clinic an alternative means of diabetes management which considerably reduces the number of hospital visits.	• Accommodating for patients (especially female) who face transportation problems. • Accommodating for elderly patients with physical disabilities.
The model offers patients at the diabetic clinic different methods of communicating with their healthcare givers.	• Less disruptive to patients' lives. • Offering patients more flexibility in communicating with healthcare giver.

Table 5.4: Model VS social, cultural and religious factors

5.7 Summary

In order to develop an appropriate Telecare solution for a specific organisation, we need to understand the healthcare system. This can be obtained by examining the organisational setup, entity processes, and relationships. In addition, it is important to understand the existing obstacles and influencing factors. We also need to assess the technical infrastructure. This information can be used to produce a model used as the basis of future development.

Once these elements at NGHA have been identified and addressed, the model is developed by following a methodological approach. The selection of the approach depends on the information that has been obtained, and in our case which involves variance in human behaviour, represented in the form of conservative traditions, it has been determined that the *Soft* approach would be the most suitable.

The Soft Systems approach was adopted and the implementation of its seven stages led to the development of a Rich Picture Diagram, establishing a Root Definition and the CATWOE, resulting in the Conceptual Model. Prior to proceeding to the next stage, the conceptual model was presented to NGHA officials to ensure that the information is correct. The activities in the conceptual model are compared to real-life activities in order to measure accuracy. This exercise led us to the identification of Desirable Changes in NGHA. The final stage concludes with devising a model, which consists of a number of components and their relationships.

Once more, the devised model has been presented to NGHA officials and discussed to ensure accuracy of systems depicted, and flow of information. This model will be adopted in the following Chapter as the basis for developing the Telecare solution and integrating it into the existing hospital information systems.

CHAPTER 6: DESIGN AND DEVELOPMENT OF A TELECARE SYSTEM FOR DIABETES

6.1 Introduction

System design is viewed as the process of designing software based on predefined requirements, and customer needs. Chapter 3 has discussed numerous challenges that face the healthcare system in Saudi. Chapter 4 then focuses on the high prevalence of diabetes in Saudi, and the impact this has on the quality of healthcare services.

The issues discussed in these two Chapters led us to develop a model in Chapter 5, for applying a Telecare system to assist diabetics in managing their disease. Our next task is to design and develop the system using an appropriate methodology. After a brief discussion with the Diabetic Educators at the NGHA clinic and systems developers at the IT department, it was decided to name the system TeMaD – *Telecare for Managing Diabetes*.

This Chapter describes the design and development process followed to build the TeMaD application. It starts by examining a number of Software Development Lifecycles (SDLC), followed by the selection of one methodology with a justification as to why it was chosen. It also gives an insight into the challenges, obstacles, supporting factors, and other issues that will influence the TeMaD application.

6.2 TeMaD System Objectives and Goals

TeMaD will offer NGHA diabetic patients an alternative method of receiving healthcare services through a Telecare solution. The nature of their disease requires that they are continuously in contact with their healthcare givers, which can often be intrusive to their lives especially in a conservative society that highly regards its privacy. This system gives them flexibility, reducing the need for patients to physically come to the hospital. It allows remote monitoring of their disease, maintaining, to an extent, a normal routine, with minimal disruptions to their lives.

In addition, it will assist patients in overcoming a number of obstacles such as the lack of transportation faced by many. The system will also allow patients to be more independent, granting them more control over their disease, and simple and efficient means of contacting their healthcare givers when needed.

The use of this application as an alternative method of managing Diabetes aims to achieve the following goals:

1- Decrease HbA1c level in diabetics by 5%.

2- Provide diabetics with an alternative method of managing their disease.

3- Raise patient awareness using appropriate technology.

4- Managing diabetics at home, and reducing hospital visits, unless necessary.

6.3 Glycosylated Haemoglobin (HbA1c)

This will primarily detect the impact of the system by measuring the HbA1c levels of participating patients before and after using the system.

The Haemoglobin A1c test is a simple one that allows healthcare providers to measure the average amount of sugar in the blood over the last two to three months [91]. Monitoring the HbA1c in type-1 diabetic patients, in particular, may improve treatment.

In the previous section, we identified the primary goals of this study. One of the most important is to examine if using Telecare can have a positive impact on monitoring and managing diabetes. And also, to examine if using Telecare can prove

to be an equally effective or possibly a more effective method than traditional healthcare solutions currently being offered at NGHA.

This can be determined by detecting whether or not the level of HbA1c of diabetic patients participating in the study has been reduced after using TeMaD. The reasonable decrease in HbA1c levels has been determined to be 5%.

This result will give us clear indicators of the impact a Telecare solution may have on diabetic patients.

6.4 Requirements Specification

Once the purpose of the system has been identified, as have the objectives and goals, it is essential to gather additional requirements from the end-users in order to have a complete scope. In this study, we will be dealing with two end-users: the Diabetic Educators that will act as a system administrator (sometimes referred to as D.E. or Administrator), and the participating diabetic patients.

We will begin by gathering the system requirements from the Diabetic Educators at NGHA Clinic 104, in order to get an understanding of how they feel this system can help them and what their expectations are.

After a number of meetings with the Diabetic Educators, a general understanding was attained about the various processes, and problems in the current system highlighted, leading to the identification of the following requirements.

6.4.1 System Requirements

The TeMaD system will primarily have three interfaces from which diabetic patients can send their information:

1. *Internet Interface*
2. *S.M.S.*
3. *Dedicated Landline*

1. Internet Interface

The main component of TeMaD is its Internet interface. This interface presents the patient with a user-friendly, simple and clear window, from which the patient enters his/her readings on a daily basis.

2. SMS

The SMS option is constructed of a simple syntax (described in the patient information booklet), which the patient follows when sending his/her readings. This information is sent to the NGHA Unified Messaging System (UMS) and stored in the SQL database. This information is then retrieved by TeMaD through the built interface.

SMS Syntax & Number

- TeMaD SMS Dial-in number (local Saudi number): **0500383686**

- TeMaD SMS Syntax:

Typeofservice(space)MRN*DDMMYY*Reading1*Reading2*Reading3*Reading4*Reading5*Reading6*Reading7

- Type of service: indicates this is a blood sugar reading. *This design attribute gives the system flexibility to be re-used in other healthcare areas.*

- MRN#: a numeric value (i.e., 123456)

- DD/MM/YYYY: 25/11/2008

- Readings#: is the value of blood sugar level taken at a given period

Reading intervals:

Reading 1: before breakfast

Reading 2: two hours after breakfast

Reading 3: before lunch

Reading 4: two hours after lunch

Reading 5: before dinner

Reading 6: two hours after dinner

Reading 7: other

3. Dedicated Landline

A dedicated extension has been situated at the Diabetic Clinic (Clinic 104) in the office of the Diabetic Educator. A diabetic educator will be assigned to receive phone calls during both the morning and afternoon sessions at the clinic. This extension number is displayed in the Information Booklet for patients to use when sending their readings.

6.4.2 Clinician Requirements

1. Consent forms need to be provided for the participants to sign. The consent forms will include the following sections: Application name, duration of study, study goals, patient selection criteria, refusal of participation, patient incentives, study steps, study side effects, confidentiality, and patient information if agrees to participate.

2. Information leaflet on how to use the three different modes of TeMaD should be distributed to all participating patients. The leaflet will contain a detailed description of how to use each mode, providing examples whenever possible.

Internet Mode:

1. Clear instructions need to be provided for the participants, in written format, on how to use the Internet option of TeMaD.

2. An online demonstration of how to use TeMaD needs to be posted on the NGHA website on the TeMaD webpage.

Mobile Mode:

1. Clear instructions need to be provided for the participants, in written format, on how to use their mobiles to send their readings via SMS to the TeMaD application, including the mobile number that will be used, and the proper format to follow in which the readings need to be sent.

Landline mode:

1. Clear instructions need to be provided for the participants, in written format, on how to send their readings over the telephone, including the number which will be used.

2. To minimize the time spent with each caller, patients should be instructed on how to prepare their readings prior to calling in, and to be prepared for the diabetic educators' questions (i.e., have you recently performed any physical activity?).

3. A dedicated number (extension needs to be set up) for patients using TeMaD, and situated in one of the diabetic educators offices.

6.4.3 Requirements from Existing NGHA HISs

The following information was gathered from the Diabetic Educators as the primary data fields required for TeMaD.

Data from MISYS:

Age, Gender, City, Physician, Tel, Mob, Education Level, Height, Weight

Data from Lab:

Investigation & Date → B/P, FBS, RBS, HbA1C, TC, LDL, HDL, TG, A\C Ratio, DEE, Foot Exam.

Data from Pharmacy:

Medications, Insulin

Data Entry:

1. Status →S,M,D,W
   Kids

2. Type→Typel,Type2, GDM, OS

3. Psychosocial →Lives alone, Family Care Giver
   Psych Score, Psych appt, Gulcagor → y ,n ex

4. Physical Activity, Intensity, Duration, Freq

5. Knowledge Score, Compliance Score, Group → y, n, scheduled

6. Foot care → Ulcer, Infection, Gangrene,
   Low risk, Medium Risk, High Risk

7. Diet Management → Last Diet, Next Dietician Appt

8. Readings → F, 2h p B, BL, 2h p L, B D, 2h PD, Other

6.5 Factors Supporting Development

The TeMaD system will be integrated into the hospital information systems at NGHA-CR. For smooth interfacing, we need to examine the existing applications.

6.5.1 Technical Factors

From a technical point of view, the following technology already exists at NGHA and will be utilised in the development of TeMaD:

- NGHA Internet website (www.ngha.med.sa): that provides us with the platform from which this application will be launched and hosted.

- Unified Messaging System (UMS): that consists of e-Fax, SMS/MMS, and IVR modules. This system is currently running at NGHA King Abdulaziz Medical City - Western Region hospital (KAMC-WR). It is being used in three main areas: Appointment inquiries, Medication refills, and Appointment requests. For the purpose of this study, we will only be using the SMS module for TeMaD.

- The SMS module will also be utilised in TeMaD as a Patient Awareness tool, allowing the Diabetic Educators to send their patients SMS messages to their mobile. These messages can contain advice based on patient readings reviewed, or simply educational tips, and nutritional recommendations.

- For the dedicated telephone line, there existed an option to use the Integrated Voice Response module of the UMS, however, due to hardware components not currently available at King Abdulaziz Medical City - Central Region (KAMC-CR) hospital, we had to abandon this option and rely on a simple landline solution. The Communication Department at KAMC-CR has been cooperative in assigning us a dedicated line situated within the diabetic clinic at the location we specified, to be used throughout the period of this study. A DE will be responsible for managing this landline during clinic working hours.

- The UMS consists of a feature allowing MMS messages to be sent/received to the hospital system. Although this feature is not part of our study, it can be incorporated in the future. It will be beneficial where patients can send pictures of infected areas (i.e., toe with gangrene) to their caregivers.

6.5.2 Environmental Factors

As for the healthcare system at the Diabetic Clinic, we find that:

- The senior Diabetic Clinic Educator has developed a general diabetes website (www.diabeticinfo.com.sa), allowing his patients to easily interact with him. This indicates that some of the diabetic patients at the clinic are familiar with the technology and may adapt quickly to the concept of data-entry through the Internet.

- The diabetic educators are supportive of this project and are eager to actively participate.

6.6 TeMaD Challenges

After discussions with the diabetic educators, and the Information Services Department developers, about the different modes of data entry available from TeMaD, the following challenges have been identified:

- SMS technology might present some obstacles due to the following reasons:

  - Entering information through SMS can be time-consuming and/or confusing for older patients.

  - More data-entry mistakes expected from SMS mode.

  - Many diabetics have low vision and might therefore prefer sending their readings using the Internet or landline options of TeMaD.

  - Data required from patients includes blood-sugar level, time of reading, date of reading, meal time, and confirmation of physical activity, resulting in a relatively long SMS.

- At the Diabetic Clinic, patients are given a Gluco-meter that can transfer readings via Infrared (IR), however, information can only be sent to the vendor website through a secure link, and not all mobile phone devices have IR technology.

6.7 Software Development Life Cycle (SDLC)

In order to develop our software, we need to adopt a software development life cycle (SDLC). According to Pressman, a SDLC is used to "*define a distinct set of activities, actions, tasks, milestones, and work products that are required to engineer high-quality software.*" [92].

A number of SDLCs are available, each providing the software engineer with a framework of activities to follow during development of the software. However, each one focuses on certain aspects of these activities and may accordingly offer workflows to invoke them differently.

6.7.1 SDLC Selection and Justification

The selection of a life cycle depends on a number of factors, such as the nature of the application, the environment it will be used in, the stakeholders, the resources available, and most importantly time and cost restraints.

The current situation implies the essential need for the SDLC to be flexible with 'iterative' steps allowing developers to build on basic structure and functionality, with the involvement of the diabetic educators at each stage. Based on this, it has been determined that the two most appropriate SDLC methodologies are the *Incremental Model*, and *Evolutionary Prototyping*. These two models are similar as both consist of iterative steps between their stages, allowing feedback from the user. This feedback usually impacts further development of the application.

However, Evolutionary Prototyping is used when the requirements are not clear, therefore allowing the user to test initial prototypes. The results of user testing gives developers the necessary feedback to further develop the system. This may sometimes lead to requests of additional requirements entailing added functions. On the other hand, the Incremental Model best suits situations in which initial software requirements are reasonably well-defined [92].

In our situation, the requirements are clear and the application goals and objectives are precise. Although the user will test initial versions of the application and possibly give feedback altering some functionality, no major changes will be made or new primary requirements added to those already agreed upon. Therefore, the Incremental Model better suits the development of TeMaD.

Another important reason the incremental model was found appropriate, is the fact that it allows developers to complete a set of functionalities and deliver to the customer within a specific time period, without having to wait until all system functionality has been completed. Once a set has been delivered, the developers can then start working on a new set (or new increment). This factor allows flexibility in delivering parts of the system over time. In our situation, the developers assigned to the task are working at the Information Services Department at KAMC-CR and KAMC-WR. These developers participate in IT projects for the National Guard Health Affairs kingdom-wide, and therefore have tight schedules. Their involvement in developing TeMaD requires there be flexibility in the deliverables. However this should not cause any gaps for the DEs while testing the functionality. Therefore, as each increment is delivered, the DEs will start testing the functionalities and we can move on to training, while other increments are being developed.

After the selection of our model based on the previous discussion, it was decided to take one step further in order to verify our selection of the Incremental Model as the most suitable SDLC for the development of TeMaD. We therefore decided to use a 'Life Cycle Selector' tool offered by SoftDevTeam [93]. This tool assists software developers in selecting an appropriate SDLC by gathering information about the project. This information is obtained through a series of questions presented to the developers, regarding the project requirements, project team, user community, and project type and risks. Answers are then assessed and a recommended SDLC is presented.

Figure 6.1 shows the questions and answers to the first segment: Project Requirements.

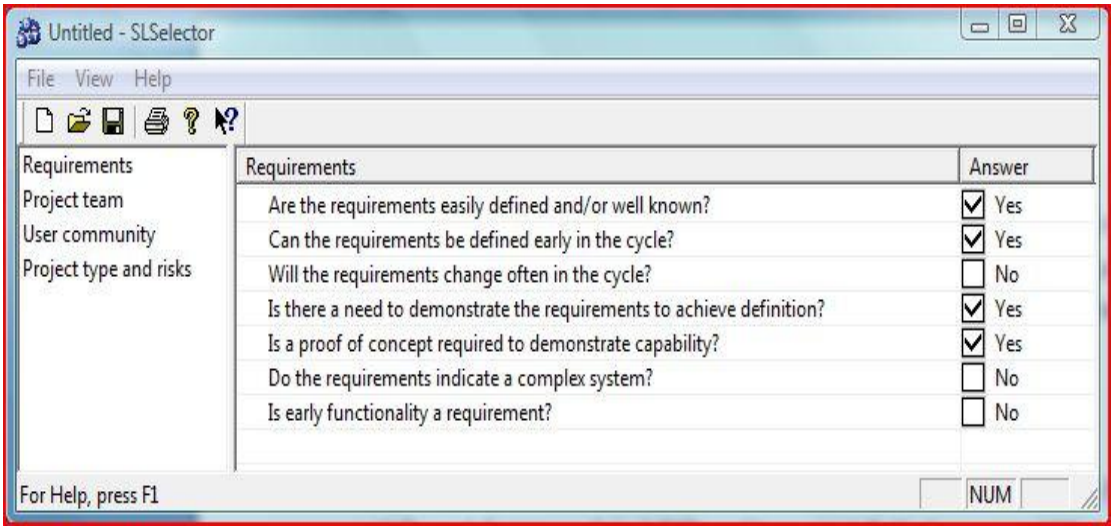


Figure 6.1: Life Cycle Selector: Project requirements

Next, figure 6.2 shows the questions and answers for the next segment, Project Team:

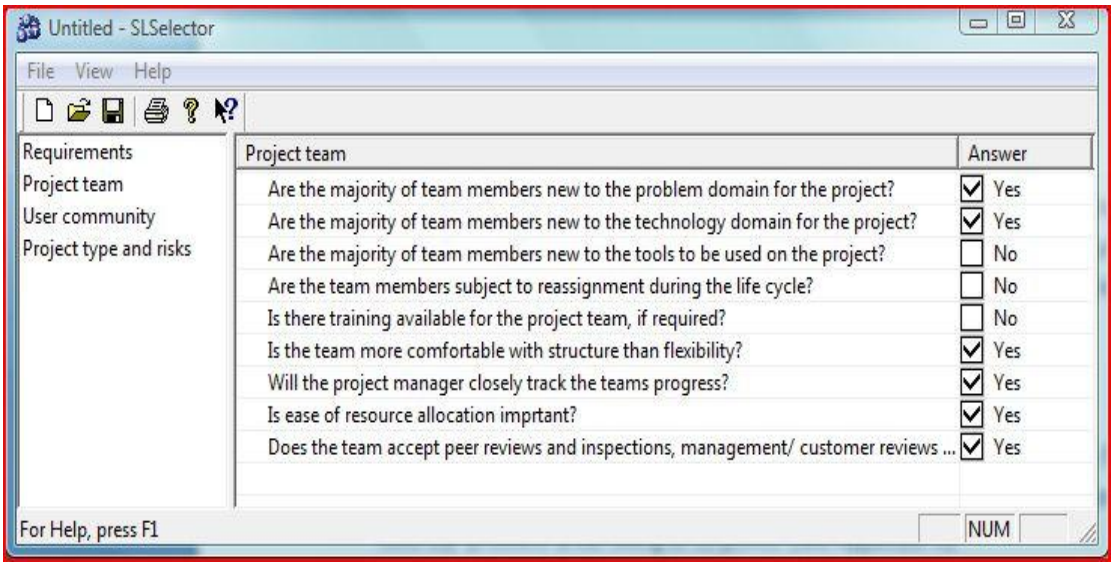


Figure 6.2: Life Cycle Selector: Project team

Figure 6.3 presents the questions and answers regarding the User Community:

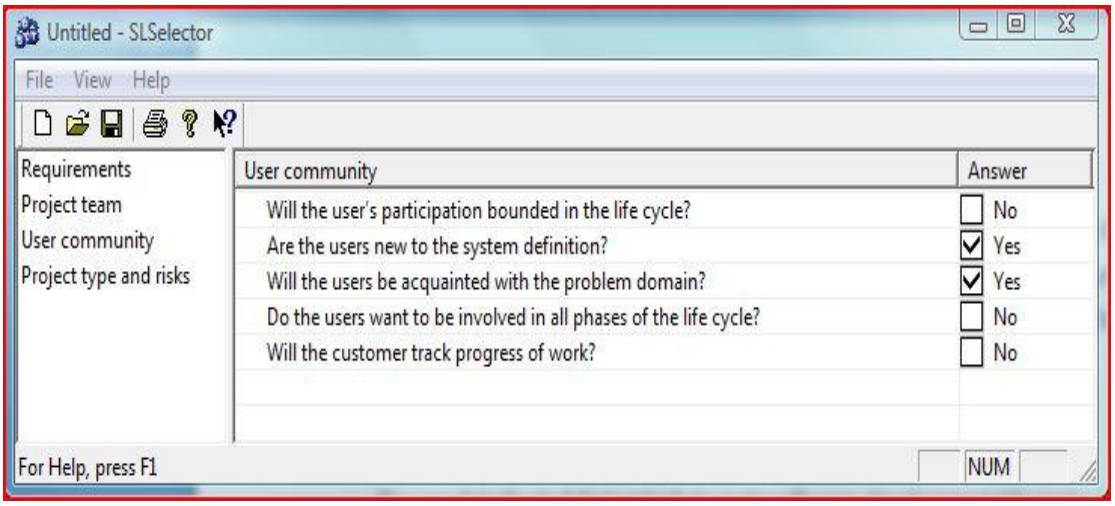


Figure 6.3: Life Cycle Selector: User community

Finally figure 6.4 displays the questions and answers regarding the Project Type and Risks:

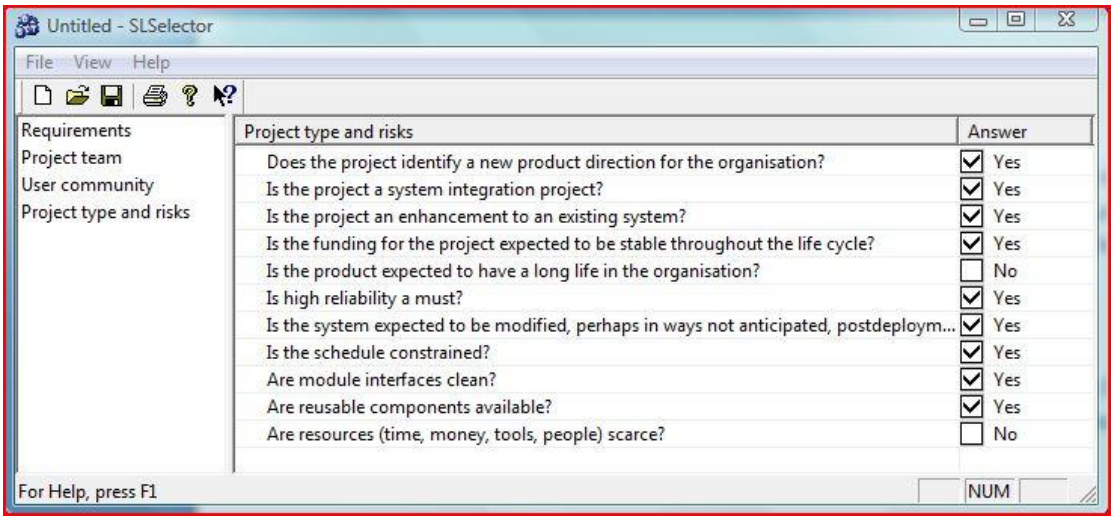


Figure 6.4: Life Cycle Selector: Project type and risks

Based on this information, the Life Cycle Selector tool analysed the answers and presented the result as indicated in figure 6.5.

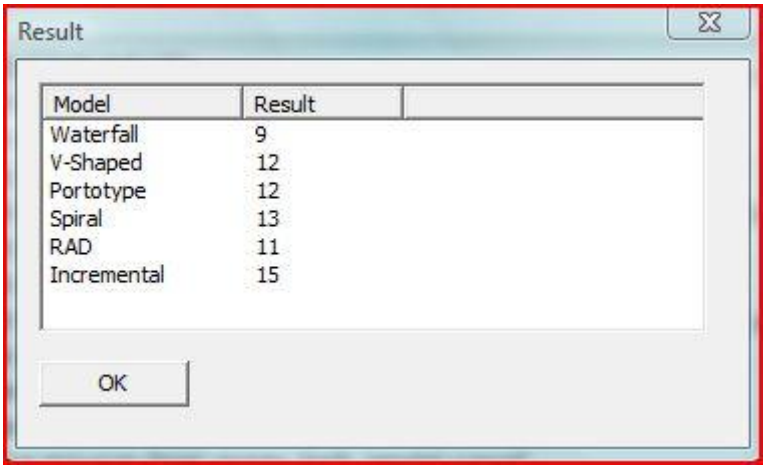


Figure 6.5: Life Cycle Selector: Incremental Model

The result indicated that out of six main software development life cycles (Waterfall, V-Shaped, Prototype, Spiral, RAD, and Incremental) the Incremental Model best suits our problem area rating at 15 points.

6.7.2 The Incremental Model

The Incremental Model is an evolution of the Classic Waterfall Model. It starts by identifying the user needs then defines a subset of the system requirements. It then carries out the development of the whole system in a sequence of builds. The first build incorporates part of the planned capabilities, covering the core of the system. Each build that follows adds more capabilities. This process continues until the system is complete.

Figure 6.6 presents how the incremental model works.

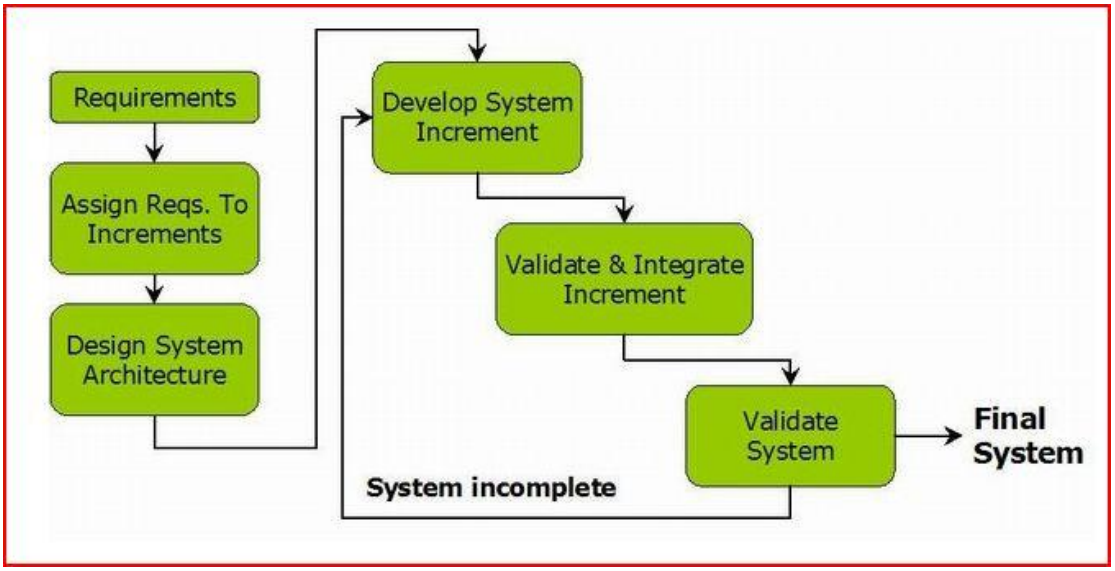


Figure 6.6: The Incremental Model

At the first stage, all the requirements are outlined. The second stage is responsible for assigning a set of requirements to increments. When applied to our situation, we reach the following subsets:

Increment 1: TeMaD Web-based Interface

Requirements – Design – Development – Testing

Increment 2: TeMaD SMS Interface

Requirements – Design – Development – Testing – Integrate with Increment 1

Increment 3: TeMaD Phone Interface

Requirements – Design – Development – Testing – Integrate with Increment 2

This process will continue until all requirements are incorporated into the overall system.

6.7.3 Applying the Incremental Model for TeMaD

The Incremental Model is applied through a series of steps. The following sections will describe the tasks carried out for each one.

6.7.3.1 Define Outline Requirements

The requirements can be divided to three main parts: the Web application, the SMS setup, and the landline setup.

1. Web application (User and Admin Interfaces):

- User Interface, the user (patient) enters his/her readings via the User Interface of the online application (Internet).

- Admin Interface, the administrator (diabetic educator) logs onto the Admin Interface of the online application (NGHA Intranet) to view patient readings, patient information, and other related data.

- The TeMaD application will acquire patient data through four methods:

    1. Data entry (clinic will enter data)

    2. Patient demographics (existing interface with MISYS-CIMS)

    3. Lab results (existing interface between Lab system & MISYS-CIMS)

    4. Pharmacy

2. SMS

- With SMS: a patient can send his/her readings, and the diabetic educator can communicate back to the patient with recommendations.

3. Landline

- Through a landline: a patient can use a telephone to call the diabetic educator at the clinic and give his/her readings.

6.7.3.2 Assign Requirements to Increments & Interfacing with HISs

We now define a number of subset and assign requirements accordingly. Each subset of functionality is designated to an increment.

Increment 1: TeMaD Web-based functionality

- User Interface & Admin Interface (Data entry , Demographic data) → all requirements are ready

- User Interface & Admin Interface (Lab) → use existing interface developed by ISD

Increment 2: TeMaD SMS functionality

- SMS → use existing system running in KAMC-WR

Increment 3: TeMaD Landline functionality

- Landline → have Communication Department add a dedicated telephone extension used solely for TeMaD

Increment 4: Interfacing

- Pharmacy → Meet with them to determine possible link to Pharmacy system.

6.7.3.3 Design System Architecture

Based on our defined requirements, breakdown of increments and functionality, and identification of interfaces needed with existing NGHA HIS, we arrive at our system architecture, displayed in figure 6.7.

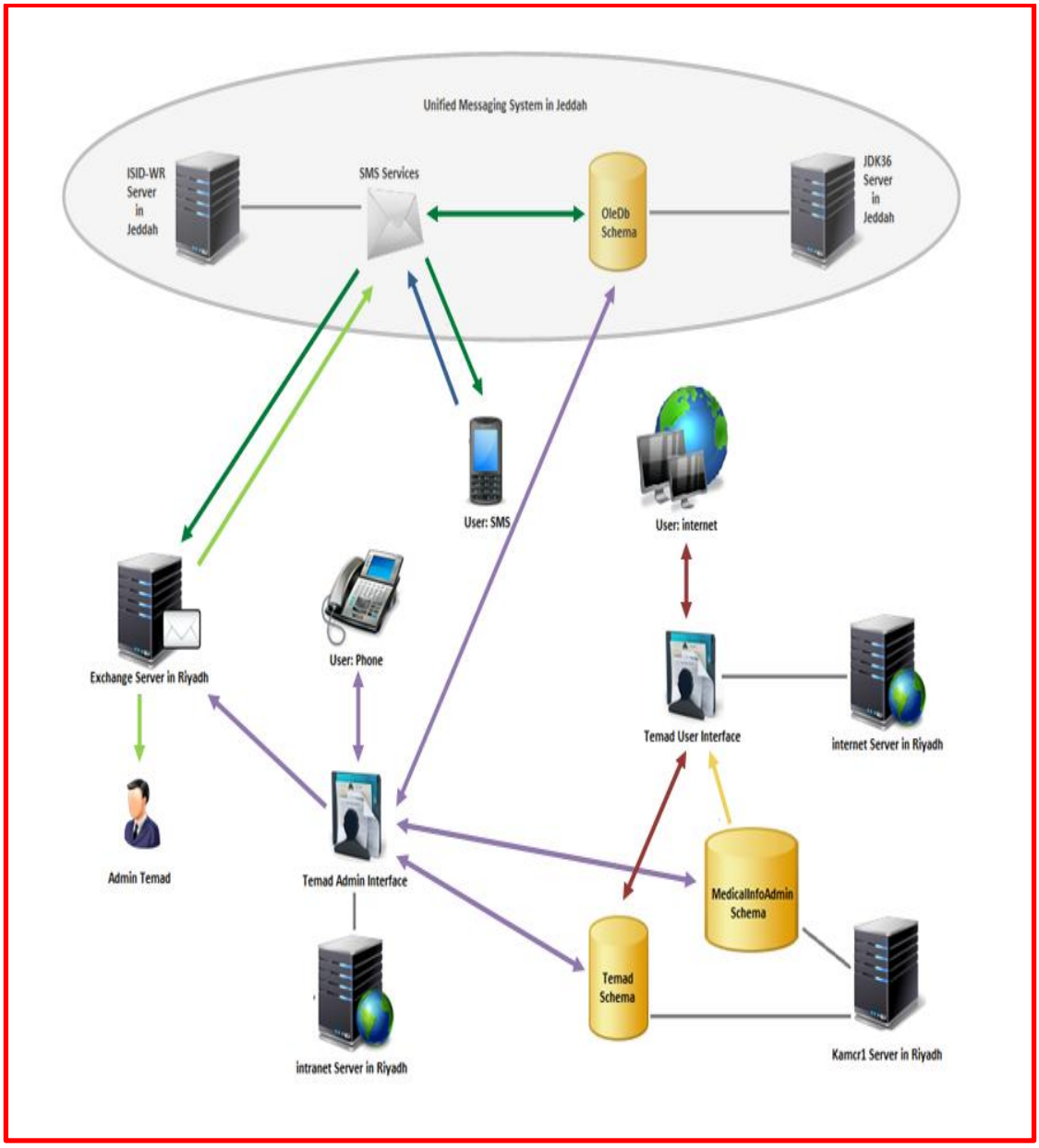


Figure 6.7: TeMaD system architecture

6.7.3.4 Development Environment and Language

In order to ensure smooth integration with existing NGHA systems, and to adhere to the development standards followed by the NGHA IT department, the same development environment and development language used throughout the NGHA was adopted.

- The development language used to code TeMaD is ASP.net, using Visual Basic (VB.net).

- The development environment used to build TeMaD is Microsoft Visual Studio, version 2005.

- The databases used to store data gathered by TeMaD is Oracle 9i (for TeMaD Schema, and Medicalinfoadmin Schema), and Microsoft SQL server 2005.

6.8 Development Timeline

The development of TeMaD was initiated with the I.S.D. developers in July 2008 and actual development began in September of the same year. Development concluded in approximately six months, and the following three months were dedicated towards testing the application.

Increments were developed in sequence and added to the system. Each increment involved a different set of developers, depending on the functionality. I.S.D. developers from both KAMC-CR in Riyadh and KAMC-WR in Jeddah assisted in building TeMaD. The system was completed in July 2009, and at that stage, external users and developers were invited to trial sessions to test the system functionality. This will be discussed at length in Chapter 7.

6.9 Summary

To develop the TeMaD system, we must first gather the requirements. It is understandable that the potential users of the system, the hospital officials directly or indirectly affected by the system, and the NGHA system engineers might each present a slightly different set of requirements. This is due to variance in the set of goals defined by each group. It is essential that we focus on the primary goals of the system and the research it is supporting. It is also necessary to address only the critical needs by the clinicians, system engineers, and healthcare officials, and the major obstacles being faced. And although TeMaD is developed to meet certain goals for the purpose of this research (i.e., reduction of HbA1c levels by 5%), it is essential that TeMaD is designed and developed in a manner that is flexible to allow future growth, compatibility, and scalability. In addition, TeMaD will be customizable to offer use in different medical specialties at NGHA and perhaps other healthcare institutions in Saudi Arabia.

A software development life cycle is adopted to assist in the development of TeMaD. The Incremental Model was found to be the most suitable, and development in increments took place.

The development environment and language conforms to the NGHA IT departmental standards. Since TeMaD is linked to the UMS in Jeddah, and various systems in Riyadh (i.e., Lab system, Pharmacy system, Messaging system, etc…), this conformance ensures compatibility with other HISs, and smooth integration.

CHAPTER 7: TECHNICAL EVALUATION OF TEMAD SYSTEM

7.1 Introduction

The previous Chapter discussed the design and implementation of the Telecare system for diabetic patients at NGHA Clinic 104. This process took place based on the objectives set in Chapter 1.

The software development life cycle used to develop TeMaD is the Incremental model, which allows us to develop individual parts of the system, and finally combine all parts to create the whole. This aspect is especially suitable because the technology used for building TeMaD resides in different NGHA regions, under the supervision of different departments and groups.

During the building of TeMaD parts, a number of tests were carried out on each one. Testing covered both the usability of the system, the functionality, and user-friendliness of the interfaces. Furthermore, it was carried out by different test groups.

This Chapter will present the evaluation framework followed, and discuss in detail the testing which took place prior to launching TeMaD at the clinic.

7.2 Evaluation Framework

The evaluation of the TeMaD system was conducted over two timeframes: Formative evaluation and Summative evaluation.

Figure 7.1 shows the two types of evaluation, indicating the areas of focus for testing and the expected results from each one.

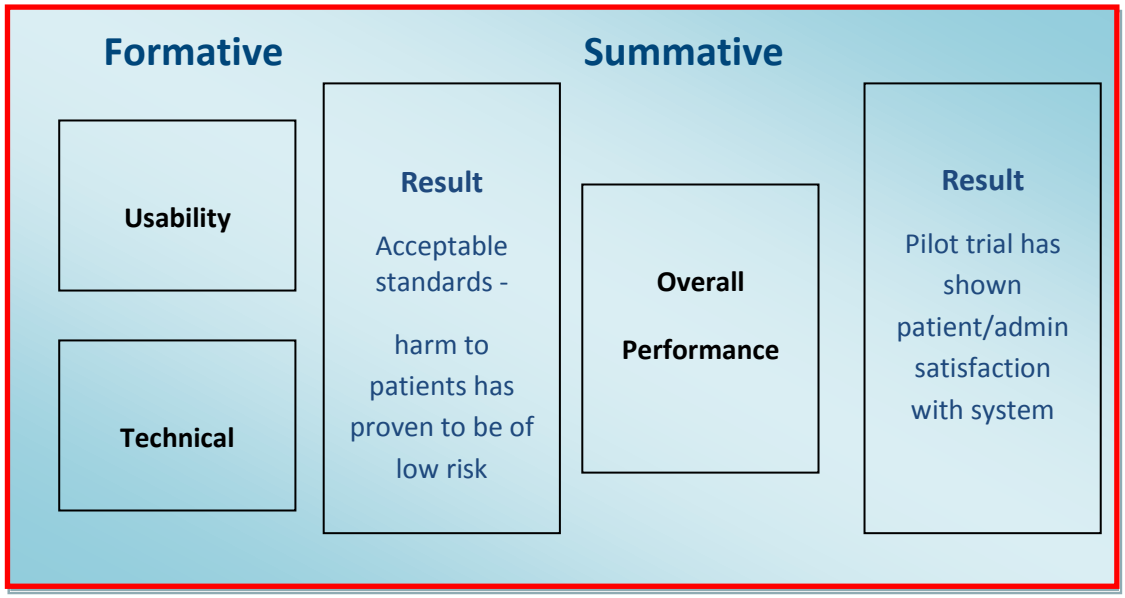


Figure 7.1: Formative VS Summative evaluation

7.3 Formative Evaluation

Formative evaluation is that conducted during the development of the TeMaD system, where testing provides feedback used to improve the system. This evaluation covers two primary areas: Usability and Technical assessment.

Usability: to evaluate the Usability of the TeMaD interfaces, we need to assess the following components as indicated by Sutcliffe [94]: Effectiveness, Learnability, Memorability, and User Satisfaction.

To measure this, all screens were tested against Human-Computer Interaction (HCI) benchmarks to ensure that the system offers its users a user-friendly environment that is easy to manoeuvre within.

Technical: ensuring the technical functionality of the system. All features should lead to the desired outcome. This has been carried out by the ISD senior developer, where all functions of the system have been tested, ensuring they lead to the desired outcome.

7.3.1 Testing Strategy

Our testing strategy will follow that used for object-oriented systems, beginning from the small units, where tests are applied to design increments. Once all units have been checked, the system as a whole is tested, in addition to the interfacing between functionalities of the various increments. Applying the incremental model in Chapter 6 resulted in three increments: Internet, SMS and Landline. Only the first two are evaluated, while the Landline option will entail data entry by the DEs using the Admin Interface of the web application.

As TeMaD is a Web application, we will follow the testing process recommended by Pressman which begins with testing the systems content and interfaces that are visible to the user *(Formative-Usability).* We then move on to test aspects of the design architecture and navigational routes *(Formative-Technical).* Finally, the overall functionality of the technology used is tested *(Summative)* [92]. This will be discussed in Section 7.4.

7.3.2 Selection of Test Groups

The IT specialists working at KAMC-CR ISD developed the TeMaD system. In order to conduct an effective evaluation, individuals not part of the development team were selected as part of a test group.

Two test groups were established. The first group consists of one person, myself, familiar with the goals and objectives of the system and the functionalities.

The second group consists of two developers from ISD, who were not involved in the development process. These developers are familiar with existing NGHA HISs, hospital standards, and interfacing processes between various applications used within NGHA.

The primary task assigned to these two groups, is to evaluate different aspects of the system involving both usability and functionality.

7.3.3 Test Results

TeMaD has two interfaces: User Interface for patients, and Admin Interface for the DEs (figure 7.2). Each interface is tested against seven aspects as exercised by Pressman [92]. These tests evaluate the systems: Content, Interface, Navigation, Component, Security, and Performance.

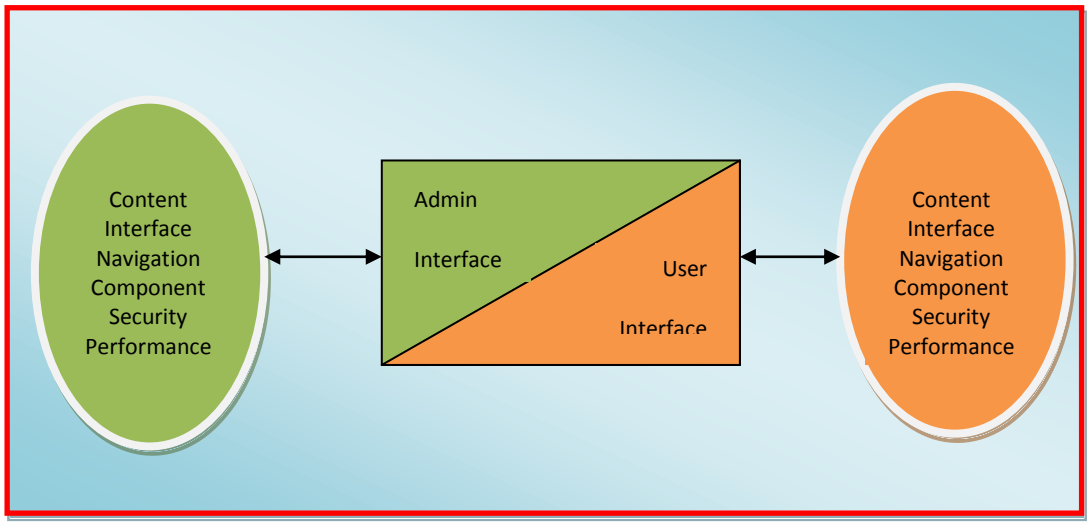


Figure 7.2: TeMaD interface testing

A benchmark evaluation is performed, where evaluation tasks are set and selected users are assigned. The assigned tasks and evaluation of each one is displayed in the following tables according to the functionality. This is an iterative process between the assigned testing group and the TeMaD system developers, where feedback from the testers is used by the developers to improve the system. Here we present the first round of testing, while subsequent steps can be viewed in Appendix (A).

With TeMaD, functionality within the **Admin Interface** includes:

- *Login page*

- *Patient Information Tab*
  - New patient information
  - Update patient information
  - View patient information

- *Blood sugar level info Tab*
    - New blood sugar level info
    - Update by MRN

And functionality within the **User Interface** includes:

- Homepage
- New user
- Existing user
    - Existing user (Login)
    - Existing user (enter readings)
    - Existing user (view readings)
    - Existing user (general information about diabetes)
- Contact us
- Who are we?
- Help
- Sitemap

Admin Interface

Login Page		
1. Content (Syntactic – Semantic – Structural errors)		
Error in message (Syntax)	You have 11 readings	You have 11 new readings
Error in Menu Tabs	Main menu tab should be differentiated from Menu options (highlighting and colour)	Use **BOLD** and/or other **Colour**
Error in Menu Tabs	User should not be able to click on Main menu tab	
2. Interface		
Error in interface mechanism (Link)	Retrieve SMS Readings	No link
3. Component		
(Requires developer testing)		
4. Navigation		
Not required on login page.		
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
NGHA network security applied.	TeMaD Administrator must be authorised (username added to access list) by Application Administrator	
Secure Access SSL VPN	Session times out from Internet link	Session might be too short
Login	Username and password authenticated by network	
7. Performance		
Acceptable		

Table 7.1: Testing Admin interface – Login page

Patient Information Tab

New Patient Information		
1. Content (Syntactic – Semantic – Structural errors)		
Error in message (Syntax)	Administrator Interface	Administrator Interface
Title	Arabic Name, Name	Should be Name (Arabic), Name (English)
Foot care information	Title next to Calendar	Appt Date
2. Interface		
Layout	Centralise title with data entry below	
Message after successful save	Successful save message displayed at top	Should be displayed at bottom near Save button
Save Option	Ensure user wants to SAVE	Message 'Are you sure you want to save this information? Y/N'
Main menu tabs	They block the page title	Make transparent
3. Component		
(Requires developer testing)		
Incorrect result	Enter correct MRN (i.e., 426154) check, then enter incorrect MRN (i.e., 8960790) still displays first MRN info	Should clear previous patient record, validate and give user clear message
Incorrect result	After new info entered and saved, update view shows old info (MRN 426154)	
Field	Mobile number field should be required	Add star
4. Navigation		
Main Page, Back, Forward buttons required at bottom of page.		
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
Validation messages clear	Entered '42615t'	Detected
	Entered 0	Detected
7. Performance		
Acceptable		

Table 7.2: Testing Admin interface – New patient information

Patient Information Tab

Update Patient Information		
1. Content (Syntactic – Semantic – Structural errors)		
Syntax error	Dietician Information	Dietician Information
2. Interface		
Update Option	Ensure user wants to UPDATE	Message 'Are you sure you want to update this information? Y/N'
Validation of correct Patient required	After MRN entered, Patient name should be displayed	
Page layout	The three boxes should be adjacent	Eliminate scrolling if possible
Table layout	Edit button displays dark table	Tables should be consistent
Main menu tabs	They block the page title	Make transparent
3. Component		
(Requires developer testing)		
Update to General Box	Does not record latest entry	
Update all information	Update does not allow updates to certain boxes	
Changes to Lab Test and Dietician Boxes	Changes successfully recorded	
4. Navigation		
Main Page, Back, Forward buttons required at bottom of page.		
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

Table 7.3: Testing Admin interface – Update patient information

View Patient Information		
1. Content (Syntactic – Semantic – Structural errors)		
Syntax error	Dietitian Information	Dietician Information
Syntax error	Under Foot Care: Gangerene	Gangrene
2. Interface		
Page layout	Rearrange boxes to make page shorter	Eliminate scrolling if possible
Add new foot care information	Insert and Cancel should be on same line	
Add new foot care information	When new date entered, ensure user wants to complete, then indicate date has been entered	Message 'Are you sure you want to insert this appt? Y/N' and 'Your date has been saved'
Lab test box	Numbers ambiguous 1, 2	Indicator should be added
Readings box view	User should be offered 'View' Options	Weekly, monthly, 3-month
Main menu tabs	They block the page title	Make transparent
3. Component		
(Requires developer testing)		
Foot care box	Allows user to 'Add New'	This is a View only page
Foot care box	Cancel button does nothing	
4. Navigation		
Main Page, Back, Forward buttons required at bottom of page.		
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

Table 7.4: Testing Admin interface – View patient information

Blood Sugar Level Info Tab

New Blood Sugar Level Info		
1. Content (Syntactic – Semantic – Structural errors)		
None		
2. Interface		
MRN box	No Action box to press after MRN entered	Although pushing the 'enter' button gives result
MRN box	Verify MRN entered is correct and display patient name	To ensure that user is dealing with correct MRN/Patient
Calendar layout	Previous and Successive display of months needs to be unified throughout	Under Patient Info tab, Months indicated by arrows, here months indicated by name
Date chosen from Calendar	Chosen date should be displayed	As confirmation to user
Clear Readings after entry (Save then Additional Reading)	After reading entered and saved, table should be cleared	To avoid user confusion
Clear message when new reading entered (Save then additional reading)	When new reading entered, clear 'reading successfully added' message	To avoid user confusion
Order of 'Save' and 'Additional Readings'	First 'Additional Readings? Click here', then 'Save and Close'	To avoid user confusion
Save Option	Ensure user wants to SAVE	Message 'Are you sure you want to save this information? Y/N'
Message after successful save	Successful save message displayed at top	Should be displayed at bottom near Save button
Main menu tabs	They block the page title	Make transparent
3. Component		
(Requires developer testing)		
Incorrect result when trying to enter New blood sugar level to my existing file (MRN 426154)	Gives error message: Patient Record must be added first *(Patient Information tab > New Patient Information)* before entering any readings	
4. Navigation		
Main Page, Back, Forward buttons required at bottom of page.		
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

Table 7.5: Testing Admin interface – New blood sugar level information

Update by MRN		
1. Content (Syntactic – Semantic – Structural errors)		
Send SMS	Misleading	Title: SMS sent?, Default field 'No'
2. Interface		
Indicator	Readings Type (Admin)	Does this indicate the user entering reading? Add name.
Status	Should change from New to Checked automatically	Minimise user effort
Side scroll	Remove sideway scroll	To minimise user effort and for clarity
Location of Chart	Display of Chart should be at bottom	
Calendar layout	Previous and Successive display of months needs to be unified throughout	Sometimes months indicated by arrows, sometimes by name
Date chosen from Calendar	Chosen date should be displayed	As confirmation to user
Update Option	Ensure user wants to Update MRN	Message 'Are you sure you want to update this record? Y/N'
Message after successful update	Successful save message should be displayed	Should be displayed at bottom
Main menu tabs	They block the page title	Make transparent
3. Component		
(Requires developer testing)		
Error in code	When updating an MRN (changed Other reading, comment, status) error occurred *	Error description below.
Error occurred	When MRN updated reading and date, then 'Update' error occurred *	Error description below.
4. Navigation		
Main Page, Back, Forward buttons required at bottom of page.		
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

Table 7.6: Testing Admin interface – Update by MRN

User Interface

Home Page		
1. Content (Syntactic – Semantic – Structural errors)		
Syntax error	Grammar	
Syntax error	To participate click on link below	No need for 'link below', just 'click here'
2. Interface		
Error in interface mechanism (Link)	Link in Option 2 takes you to same page	
3. Component		
(Requires developer testing)		
4. Navigation		
Not required on home page.		
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

Table 7.7: Testing User interface – Homepage

New User		
1. Content (Syntactic – Semantic – Structural errors)		
Semantic error	Make message box bigger and place 'contact us' on same line (see attachment B)	
Syntax error	To participate click on link	Indicate that 'contact us' is a link
2. Interface		
Specific validation required for incorrect data	When entering incorrect MRN (429817), incorrect character (42615r), or 0	Validation message should be clear explaining cause of error.
Enter new MRN	Message instructs user to register	
Enter existing MRN	Message indicates that a password has already been requested.	
Enter existing MRN	Layout of buttons needs to be re-aligned	
3. Component		
(Requires developer testing)		
4. Navigation		
Back, Forward, and Homepage buttons need to be added to bottom of page	They also need to be aligned	
Homepage and Back buttons	Both go to same page (Homepage)	
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

Table 7.8: Testing User interface – New user

Existing User (Login)		
1. Content (Syntactic – Semantic – Structural errors)		
Ok.		
2. Interface		
Enter existing MRN	Welcome message then Name.	Reverse order. First Name then Welcome message.
Enter existing MRN	Centralise Name.	
3. Component		
(Requires developer testing)		
4. Navigation		
Back, Forward, and Homepage buttons need to be added to bottom of page		
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

Table 7.9: Testing User interface – Existing user (Login)

Existing User (Enter Readings)		
1. Content (Syntactic – Semantic – Structural errors)		
Ok.		
2. Interface		
Clear Readings after entry	After reading entered and saved, table should be cleared	To avoid user confusion
Message displayed when new reading entered (indicate user must first Save then insert additional reading)	When new reading entered, modify 'reading successfully added' message and ask user if there are additional readings	To avoid user confusion
Save Option	Ensure user wants to SAVE	Message 'Are you sure you want to save this information? Y/N'
3. Component		
(Requires developer testing)		
4. Navigation		
Back, Forward, and Homepage buttons need to be added to bottom of page	They also need to be aligned.	
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

Table 7.10: Testing User interface – Existing user (Enter readings)

Existing User (View Readings)		
1. Content (Syntactic – Semantic – Structural errors)		
Ok.		
2. Interface		
Readings Table sorting	Sorts Oldest entry first	Should sort latest first
Chart view	User should be able to view readings in chart format	
3. Component		
(Requires developer testing)		
4. Navigation		
Back, Forward, and Homepage buttons need to be added to bottom of page	They also need to be aligned.	
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

Table 7.11: Testing User interface – Existing user (View readings)

General Information about Diabetes*		
1. Content (Syntactic – Semantic – Structural errors)		
More content needs to be added	Content used from Bader website	Approval granted from site administrator.
2. Interface		
Layout of page	Topics should be in a table format	
Display of diabetes topic	Centralised, should be right indented	
3. Component		
(Requires developer testing)		
4. Navigation	They also need to be aligned.	
Back, Forward, and Homepage buttons need to be added to bottom of page		
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

Table 7.12: Testing User interface – General Information about Diabetes

** this table includes comments about the homepage link General Information about Diabetes*

Contact Us		
1. Content (Syntactic – Semantic – Structural errors)		
Ok.		
2. Interface		
Ok.		
3. Component		
(Requires developer testing)		
4. Navigation		
Back, Forward, and Homepage buttons need to be added to bottom of page	They also need to be aligned.	
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

Table 7.13: Testing User interface – Contact us

Who are we?		
1. Content (Syntactic – Semantic – Structural errors)		
Font size	Make larger	
2. Interface		
Ok.		
3. Component		
(Requires developer testing)		
4. Navigation		
Back, Forward, and Homepage buttons need to be added to bottom of page	They also need to be aligned.	
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

Table 7.14: Testing User interface – Who are we?

Help		
1. Content (Syntactic – Semantic – Structural errors)		
How to Register link	Make sentence shorter	To register click here
How to Enter link	Make sentence shorter	To Enter click here
2. Interface		
Registration and Entry demo	Shift up to eliminate scrolling	Minimise user effort
At demo completion	Display 'Close Window' button	Minimise user effort
Prolong instruction box time	To give the user more time to read the instructions	
Update Demo	Contains old screen layouts (spelling mistakes, missing features, old calendar layouts, etc…)	TeMaD demo needs to be recorded from final application version
3. Component		
(Requires developer testing)		
Link problem	Entry demo, then close window, then 'Homepage'	System hangs
4. Navigation		
Back, Forward, and Homepage buttons need to be added to bottom of page	They also need to be aligned.	
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

Table 7.15: Testing User interface – Help

Site Map		
1. Content (Syntactic – Semantic – Structural errors)		
'Important info about Diabetes' or 'Useful info about Diabetes'	Consistency required	Avoid user confusion
Present content in a hierarchical layout	Clarity for user	Avoid same layout used in Homepage
2. Interface		
Screen layout too wide	Eliminate scrolling	Minimise user effort
Remove 'Goals' link	Links gives error*	
Remove 'Site Map' link	Link gives error**	
3. Component		
(Requires developer testing)		
4. Navigation		
Back, Forward, and Homepage buttons need to be added to bottom of page	They also need to be aligned.	
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

Table 7.16: Testing User interface – Sitemap

7.4 Summative Evaluation

This evaluation is concerned with the overall performance of the system once the development is complete and the application is in running mode. Two groups of users have been selected to test the system. The first group consists of two diabetic educators testing the Administrator Interface, while the second group consists of two volunteer patients to test the User Interface.

The objective is to find out whether or not the system gains an overall acceptance from the test groups. Each group was granted a one week period to evaluate the system.

Group 1: DEs testing the Admin Interface.

The DEs each separately evaluated the application by testing the functionality of each option within the tabs located in the main page. Their comments were logged, reviewed by the developer, and modifications made when required.

Group 2: Volunteer patients testing the User Interface.

Two volunteer patients being treated at the diabetic clinic evaluated the system by using the interface, and testing the functionality of each link on the homepage and subsequent Web pages. Their comments were logged, reviewed by the developer, and modifications made when required.

7.5 Evaluation of TeMaD System

This section evaluated the TeMaD system which consists of three main modes of access: Web access, SMS, and Landline.

For the purposes of testing and evaluation, my personal medical record number (MRN) is used (426164). This MRN is an active medical record on the NGHA system, with real data. It has been used with TeMaD to portray a participating diabetic patient. However, the TeMaD readings stored on this MRN have been entered as 'dummy data' only. In order to maintain participating patient confidentiality, this MRN will be used throughout this Chapter to demonstrate the capabilities and functionalities of the application.

7.5.1 Admin Web Interface

Here we evaluate the Web interface used by the DEs to administer the application. We will refer to this interface as the 'Admin Interface'.

7.5.1.1 Security

In adherence to NGHA ISID security policies, the same network username and password granted to all NGHA personnel to access the NGHA network is used to access the TeMaD system. This also minimises the number of usernames and passwords NGHA employees need to memorise, making the application more user-friendly.

Once the NGHA intranet is accessed with the DE network username and password, the DE will access the e-services page, which displays all NGHA applications, as shown in figure 7.3.

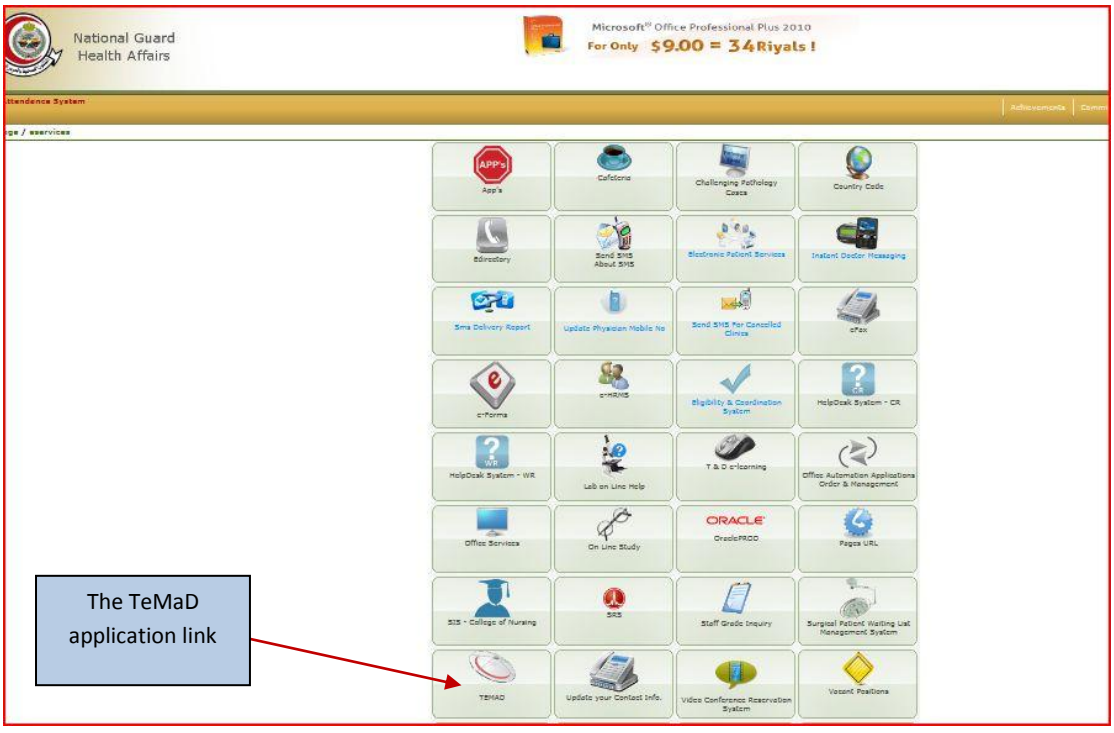


Figure 7.3: TeMaD application link on NGHA Intranet/e-services

The DE is then required to login to the TeMaD application. The application already has a set of identified DEs authorized to access the information. Authentication is conducted as indicated in figure 7.4.

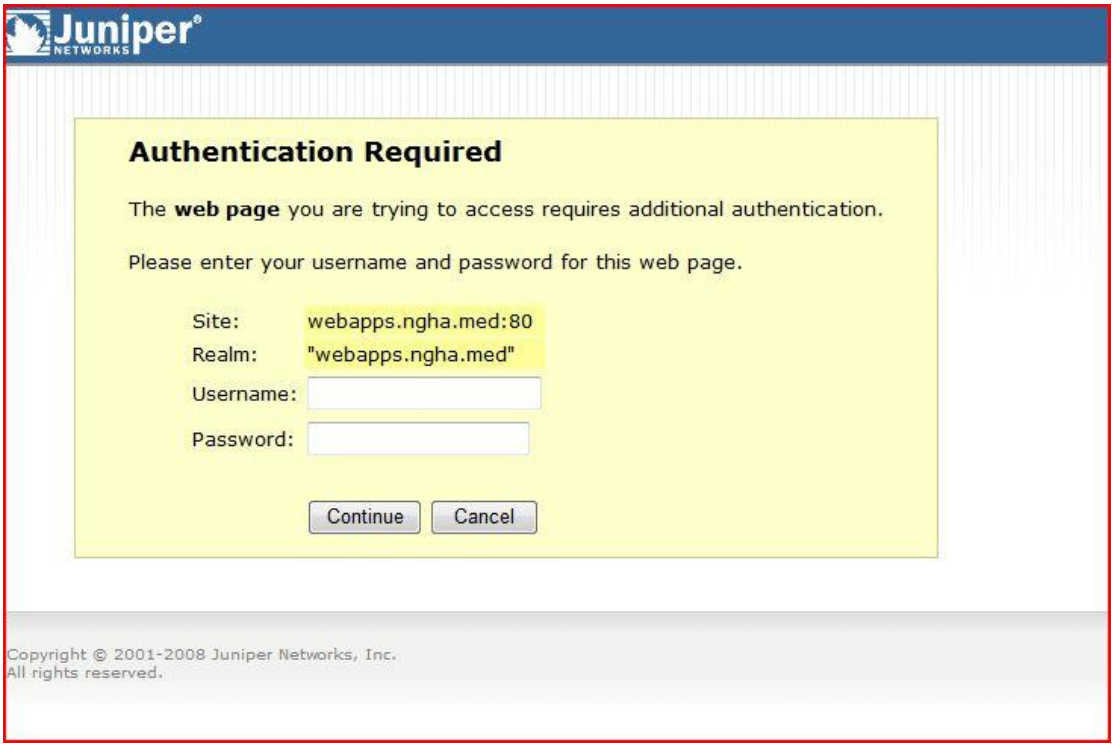


Figure 7.4: Authentication for DE authorized to use TeMaD

Once the DE has successfully logged in, the TeMaD homepage is displayed with the numerous functionalities available.

Finally, after the DE has concluded work with the application, a 'Logout' button is clearly located in the main menu as a separate tab. The DE should log out to ensure that unauthorised personnel cannot use the application, especially when DEs access the application from public computers on the NGHA network.

7.5.1.2 Design Aspects of TeMaD Admin Interface

The TeMaD homepage has a simple and clear design, as shown in figure 7.5. It presents the DE with a welcome note, and displays the number of new readings entered. New readings are individual readings that may have been viewed by the DE but have not been accessed for any action. A 'Refresh' button is located immediately underneath the number of readings, allowing the DE to check for any new readings entered recently.

Figure 7.5: TeMaD Admin homepage

The design of the interface adheres to HCI principles [94], of being consistent, compatible, predictable, adaptable, economical, giving user control, and structural.

- As indicated by the answers in the questionnaires given to all participating DEs, which will be discussed in Chapter 8, the application is user-friendly with simple screens and instructions.

- The web pages are clear, with calm background colours, and legible font size and colour.

- The application is easy to follow and navigate through, with clearly marked navigational buttons.

- The application also offers the user helpful hints, as shown in figure 7.6.

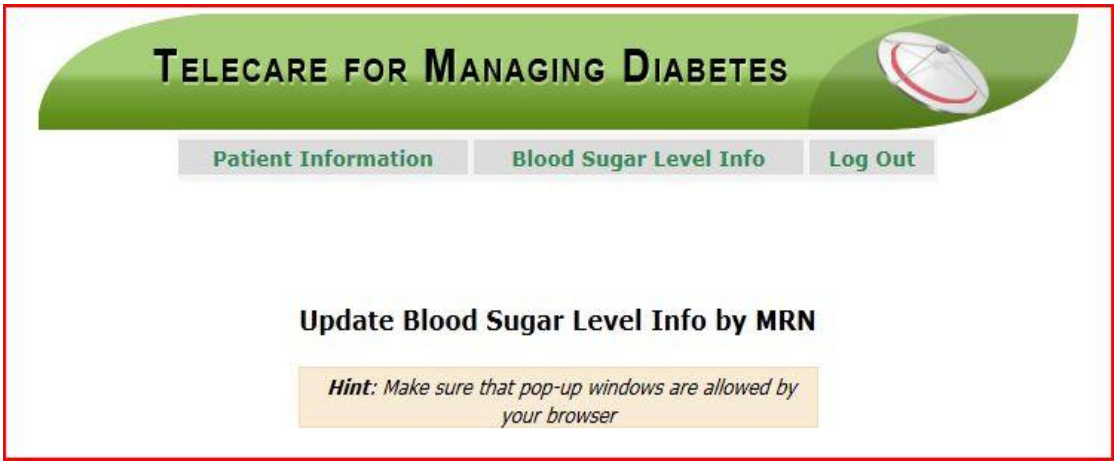


Figure 7.6: TeMaD helpful hints

7.5.1.3 Functionality – Login

As soon as the DE logs into the application, the following features are displayed:

1. The application immediately displays the number of new readings entered since the last login, and the number of registered patients.

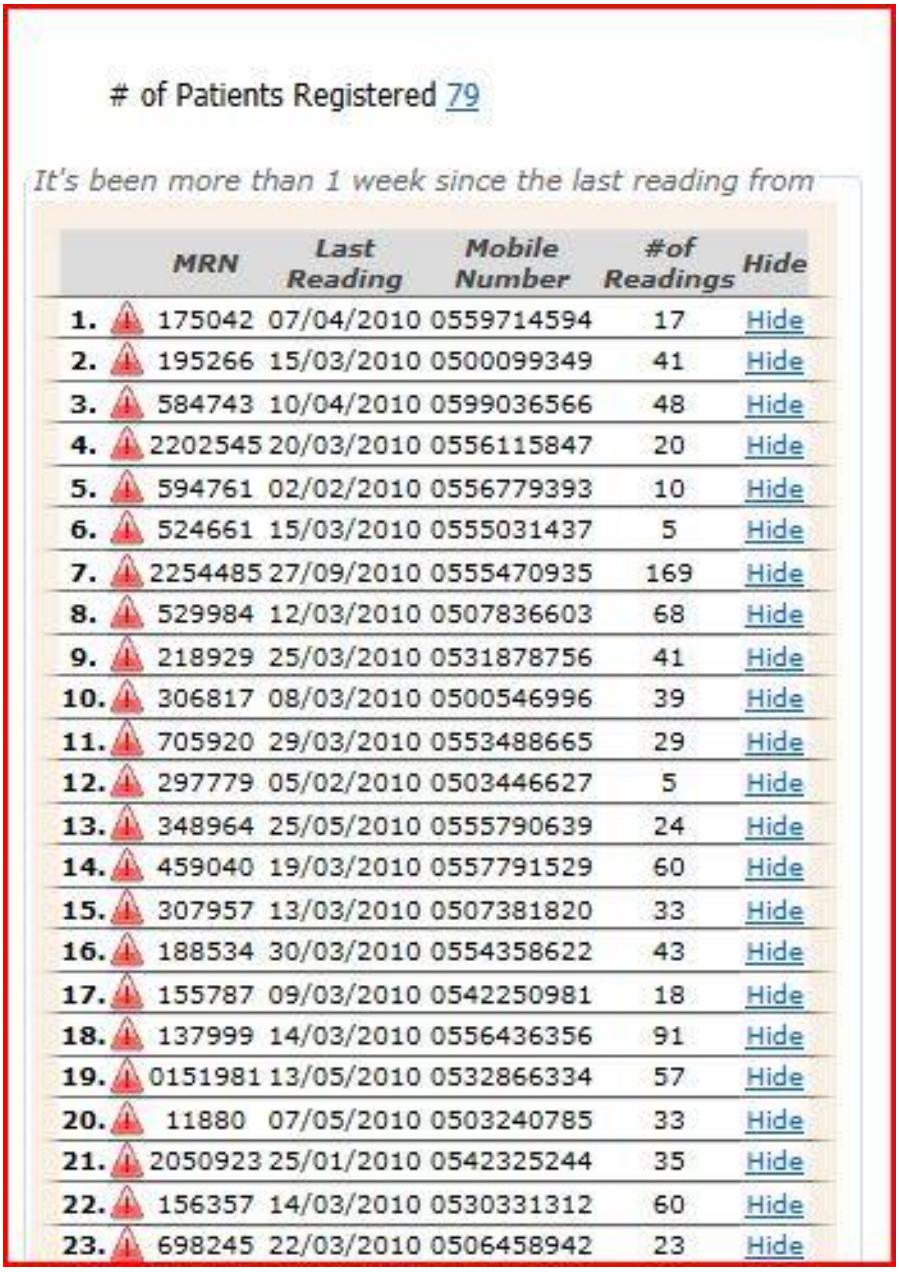
2. It also displays a list of all participating patients that have completed the 12-week period indicating the completion of the trial. Figure 7.7 shows the relative information displayed. This feature assists the DE in managing the participants and coordinating the following steps of the trial, i.e., questionnaires, incentives, reimbursements, etc.

Patients who completed 12 weeks

	MRN	First Reading	Mobile Number	Hide
1.	175042	21/12/2009	0559714594	Hide
2.	195266	17/12/2009	0500099349	Hide
3.	584743	20/01/2010	0599036566	Hide
4.	2202545	21/12/2009	0556115847	Hide
5.	594761	24/01/2010	0556779393	Hide
6.	524661	23/02/2010	0555031437	Hide
7.	2254485	20/02/2010	0555470935	Hide
8.	529984	02/01/2010	0507836603	Hide
9.	218929	01/01/2010	0531878756	Hide
10.	306817	23/01/2010	0500546996	Hide
11.	705920	30/12/2009	0553488665	Hide
12.	42352	27/12/2009	0504206809	Hide
13.	297779	29/01/2010	0503446627	Hide
14.	348964	03/03/2010	0555790639	Hide
15.	459040	30/12/2009	0557791529	Hide
16.	14568	24/12/2009	0598137750	Hide
17.	307957	16/12/2009	0507381820	Hide
18.	188534	09/01/2010	0554358622	Hide
19.	155787	28/12/2009	0542250981	Hide
20.	137999	13/12/2009	0556436356	Hide
21.	2192349	29/12/2009	0558629544	Hide
22.	0151981	06/02/2010	0532866334	Hide
23.	11880	06/03/2010	0503240785	Hide
24.	2050923	13/12/2009	0542325244	Hide
25.	156357	14/12/2009	0530331312	Hide
26.	698245	07/01/2010	0506458942	Hide
27.	715924	24/12/2009	0509149967	Hide
28.	575067	16/12/2009	0551888526	Hide

Figure7.7: List of patients completing 12 weeks

3. The DE is also alerted of any patients who have not sent any readings for more than one week. This feature minimizes trial drop-outs, assists the DE in monitoring participating patients and improves outcome by identifying patients that might require additional encouragement and motivation. Figure 7.8 displays the results.



# of Patients Registered 79

It's been more than 1 week since the last reading from

	MRN	Last Reading	Mobile Number	#of Readings	Hide
1.	175042	07/04/2010	0559714594	17	Hide
2.	195266	15/03/2010	0500099349	41	Hide
3.	584743	10/04/2010	0599036566	48	Hide
4.	2202545	20/03/2010	0556115847	20	Hide
5.	594761	02/02/2010	0556779393	10	Hide
6.	524661	15/03/2010	0555031437	5	Hide
7.	2254485	27/09/2010	0555470935	169	Hide
8.	529984	12/03/2010	0507836603	68	Hide
9.	218929	25/03/2010	0531878756	41	Hide
10.	306817	08/03/2010	0500546996	39	Hide
11.	705920	29/03/2010	0553488665	29	Hide
12.	297779	05/02/2010	0503446627	5	Hide
13.	348964	25/05/2010	0555790639	24	Hide
14.	459040	19/03/2010	0557791529	60	Hide
15.	307957	13/03/2010	0507381820	33	Hide
16.	188534	30/03/2010	0554358622	43	Hide
17.	155787	09/03/2010	0542250981	18	Hide
18.	137999	14/03/2010	0556436356	91	Hide
19.	0151981	13/05/2010	0532866334	57	Hide
20.	11880	07/05/2010	0503240785	33	Hide
21.	2050923	25/01/2010	0542325244	35	Hide
22.	156357	14/03/2010	0530331312	60	Hide
23.	698245	22/03/2010	0506458942	23	Hide

Figure 7.8: Patients with no readings for more than one week

7.5.1.4 Functionality – Patient Information

Once the DE logs into the application, the following functions are offered under the *Patient information tab*:

Patient information tab

- New patient information: Enter information of a new patient

Figure 7.9 displays the webpage used to add a new patient to the system. Fields include:

a) New patient MRN

b) General information

c) Medical information

d) Lab test information

e) Physical activity information

f) Foot care information

g) Dietician information

h) Insulin information

All fields marked with an '*' are required fields.

Figure 7.9: New patient information webpage

- Update patient information: update information of an existing patient.
  This option allows the DE to enter the MRN, view the information, and click on 'Edit' to make any adjustments or updates, as shown in figure 7.10.

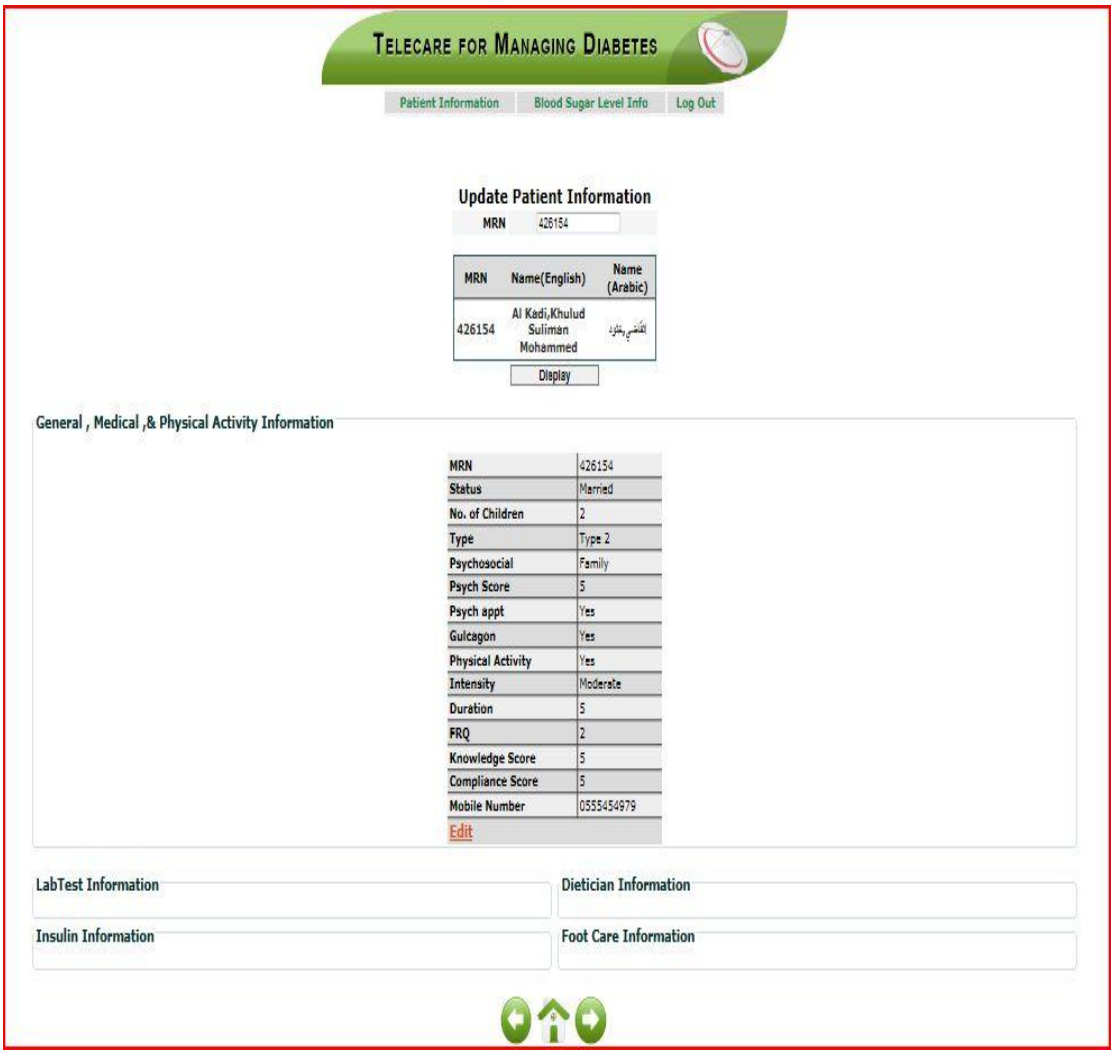


Figure 7.10: Update patient information

- View patient information: view all information of an existing patient.
  This option allows the DE to review all the information stored in his/her record. Figure 7.11 displays the layout of the information.

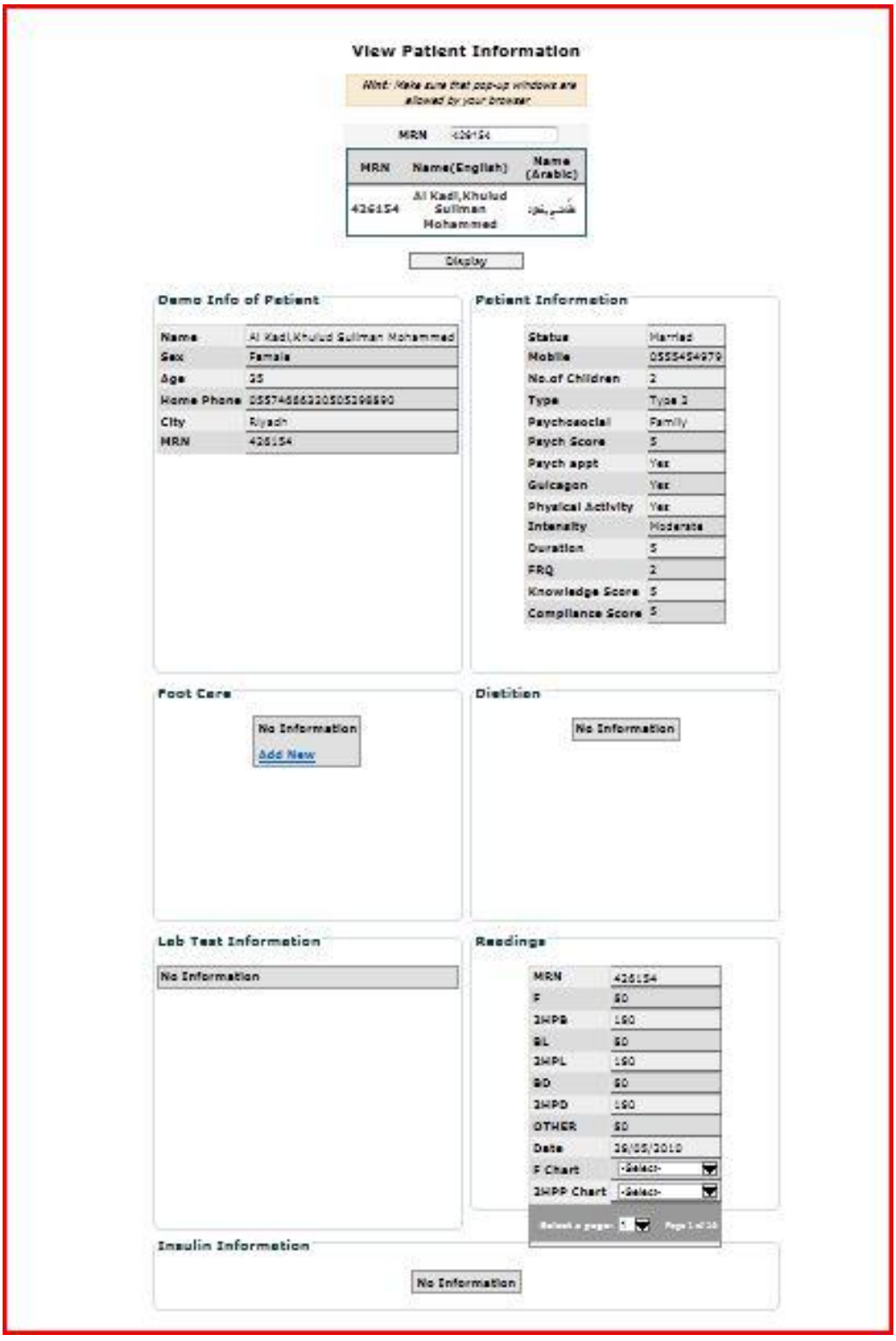


Figure7.11: View patient information

7.5.1.5 Functionality – Blood Sugar Level Info

Blood sugar level info tab

- New blood sugar level info: enter new blood sugar level reading(s)

The application allows the DE to enter new blood sugar levels, after verifying that the MRN is compatible with the patient name, as shown in figure 7.12.

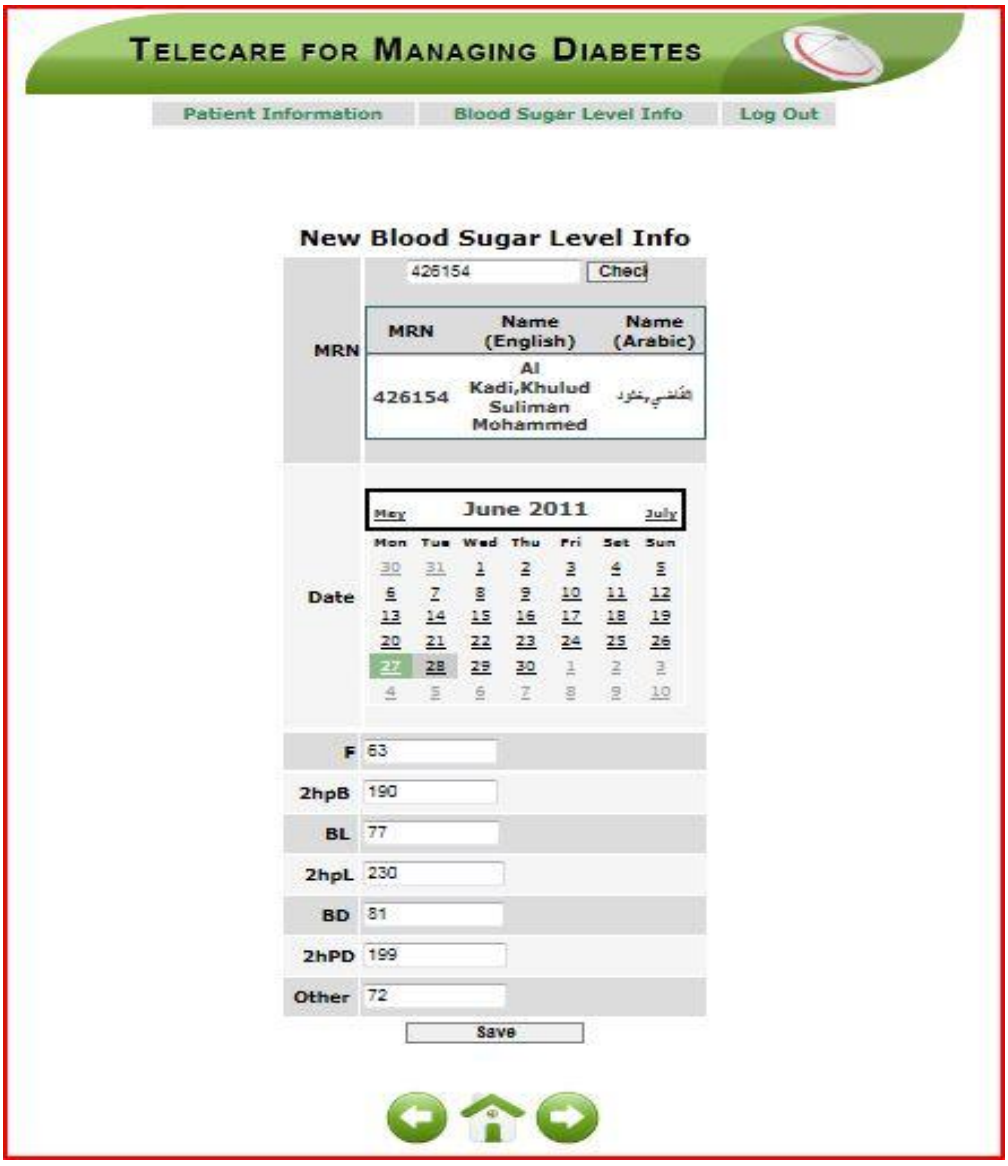


Figure 7.12: New blood sugar level info webpage

The application has a strict validation system, to reduce errors. The following features assist users in minimizing errors and user effort:

- The DE cannot enter readings for a future date.

- The DE is allowed to enter readings for multiple days.

- Once readings have been entered, and the DE has clicked on the 'Save' button, a message is displayed to ensure that these readings are to be saved, as displayed in figure 7.13.

- The DE is informed once readings have been successfully saved, as displayed in figure 7.14.

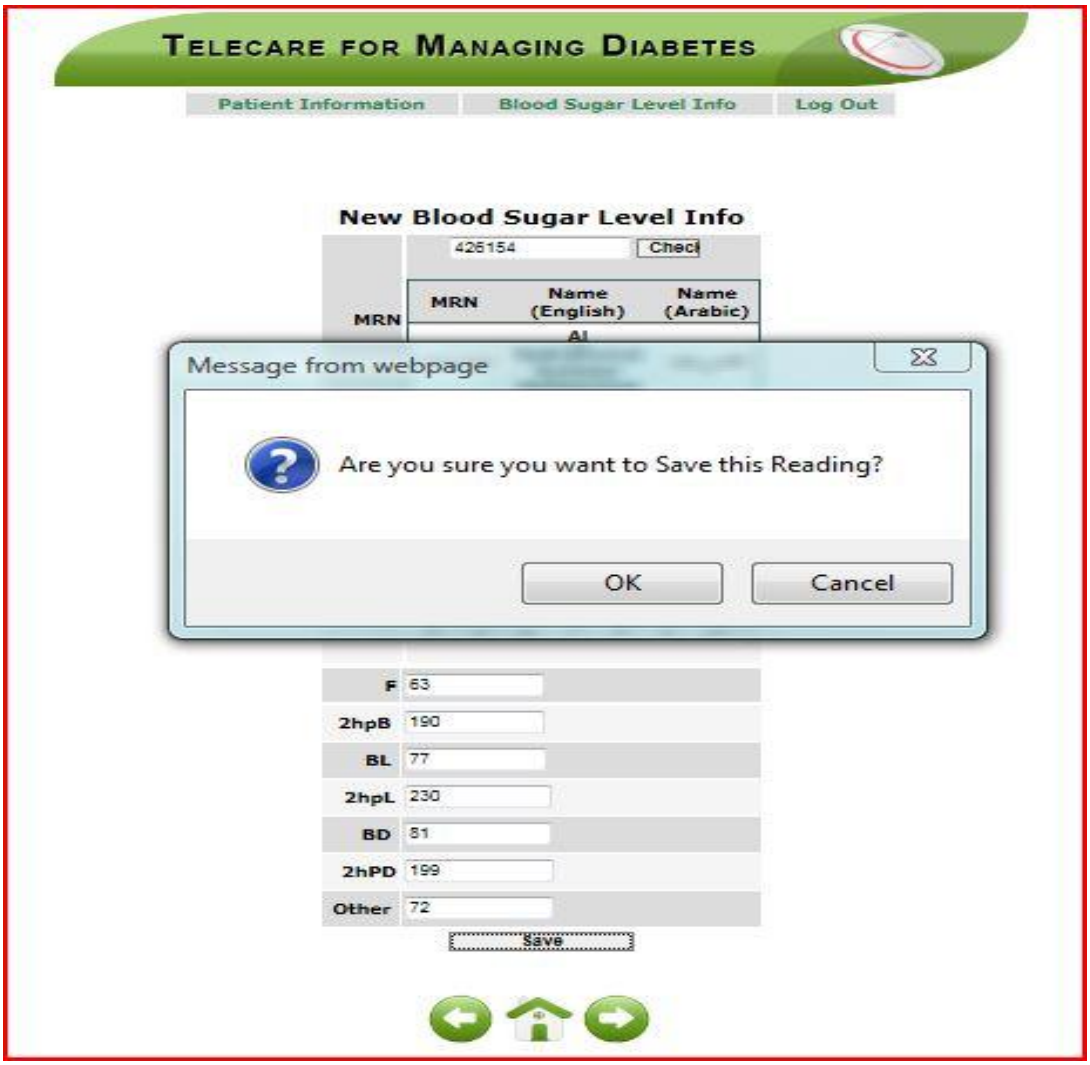


Figure 7.13: New blood sugar level info webpage- readings validation

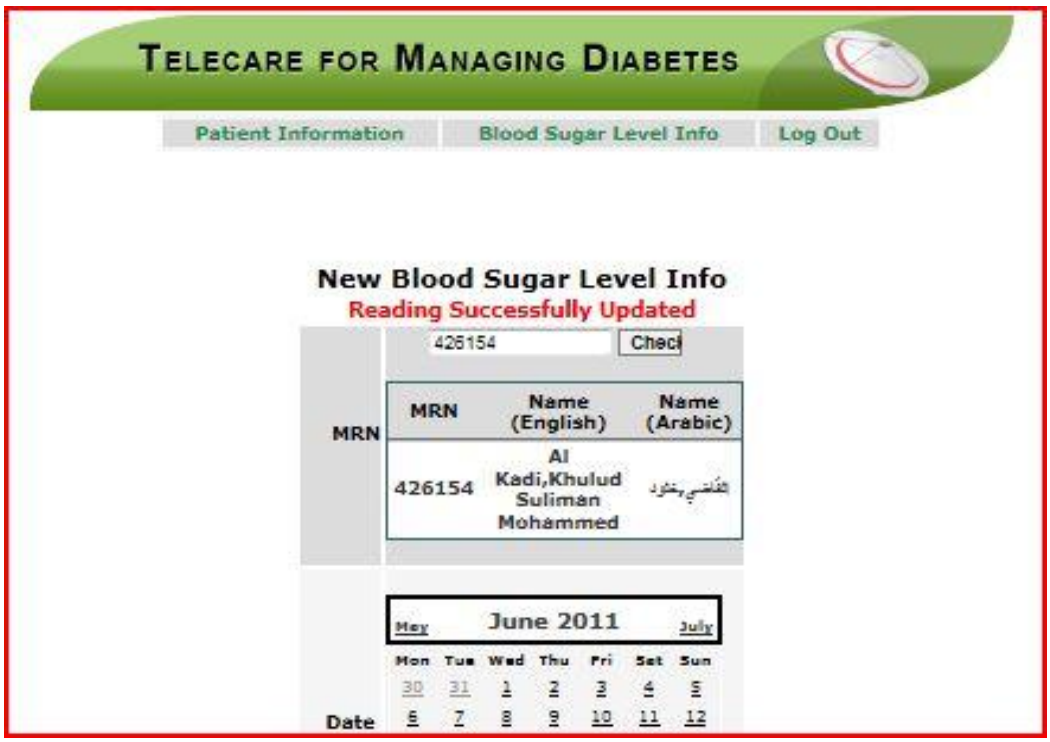


Figure 7.14: New blood sugar level info webpage- readings saved

- Update by MRN: allows access of a specific patient file (via the MRN)

This option allows the DE to access the information of a specific patient and carry out a number of tasks (figure 7.15), such as:

- Review patient information displayed in a table format, ordered chronologically

- Review readings and accordingly send the patient an SMS with instructions, or simply send a motivational and/or awareness SMS

- Delete readings entered at any particular date

- View graphs depicting patient blood sugar levels over a period of time (weekly, monthly, every three months) for both fasting and 2HPP, to assess performance levels

- Identify readings entered by which DE (when patient uses Landline option), or by SMS, or through web application

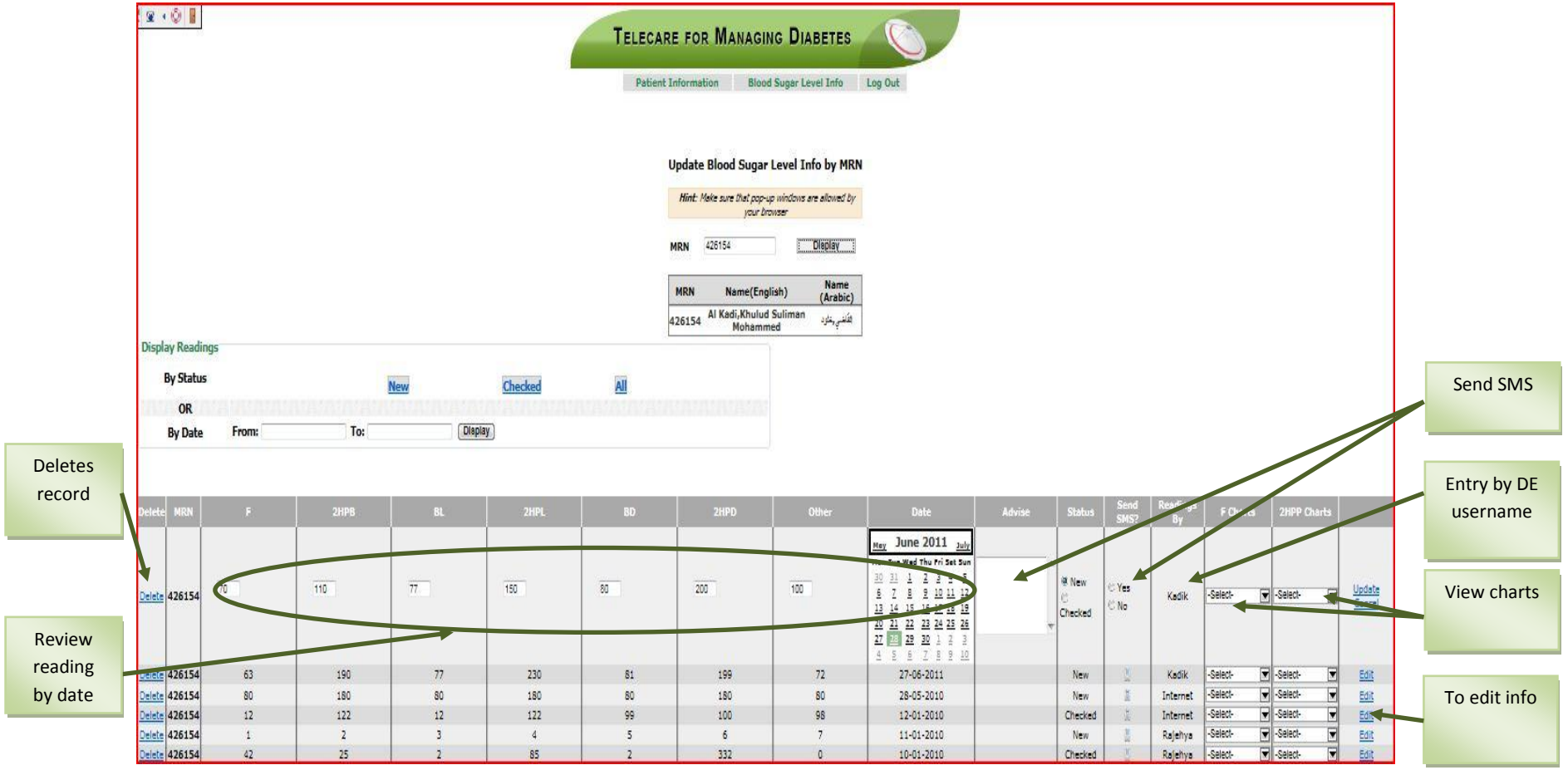
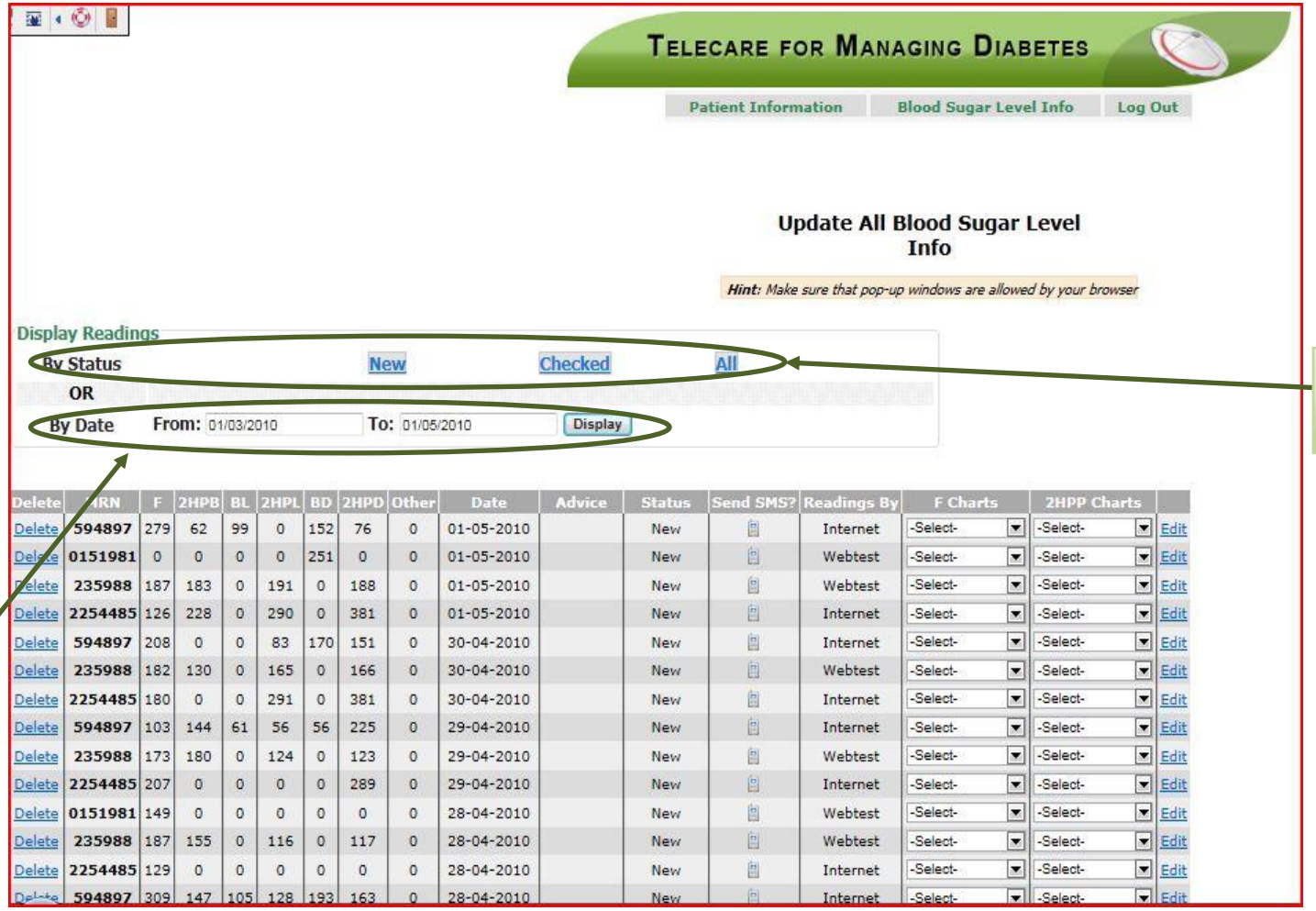


Figure7.15: Update blood sugar level info by MRN webpage

- Update all blood sugar level info

This option allows the DE to access readings of all patients, and carry out the same tasks discussed in 'Update by MRN'. It conveniently allows the DE to select a date range, where the start and end dates are specified. It allows the DE to list the readings based on their status, being either 'New', 'Checked', or 'All'. See illustration of web page in figure 7.16.



Delete	HRN	F	2HPB	BL	2HPL	BD	2HPD	Other	Date	Advice	Status	Send SMS?	Readings By	F Charts	2HPP Charts	
Delete	594897	279	62	99	0	152	76	0	01-05-2010		New		Internet	-Select-	-Select-	Edit
Delete	0151981	0	0	0	0	251	0	0	01-05-2010		New		Webtest	-Select-	-Select-	Edit
Delete	235988	187	183	0	191	0	188	0	01-05-2010		New		Webtest	-Select-	-Select-	Edit
Delete	2254485	126	228	0	290	0	381	0	01-05-2010		New		Internet	-Select-	-Select-	Edit
Delete	594897	208	0	0	83	170	151	0	30-04-2010		New		Internet	-Select-	-Select-	Edit
Delete	235988	182	130	0	165	0	166	0	30-04-2010		New		Webtest	-Select-	-Select-	Edit
Delete	2254485	180	0	0	291	0	381	0	30-04-2010		New		Internet	-Select-	-Select-	Edit
Delete	594897	103	144	61	56	56	225	0	29-04-2010		New		Internet	-Select-	-Select-	Edit
Delete	235988	173	180	0	124	0	123	0	29-04-2010		New		Webtest	-Select-	-Select-	Edit
Delete	2254485	207	0	0	0	0	289	0	29-04-2010		New		Internet	-Select-	-Select-	Edit
Delete	0151981	149	0	0	0	0	0	0	28-04-2010		New		Webtest	-Select-	-Select-	Edit
Delete	235988	187	155	0	116	0	117	0	28-04-2010		New		Webtest	-Select-	-Select-	Edit
Delete	2254485	129	0	0	0	0	0	0	28-04-2010		New		Internet	-Select-	-Select-	Edit
Delete	594897	309	147	105	128	193	163	0	28-04-2010		New		Internet	-Select-	-Select-	Edit

Figure 7.16: Update all blood sugar level info webpage

7.5.1.6 Logout

Once the DE has completed working with the application, the Logout button is located on the main menu. Logout ensures the confidentiality of patient information is preserved, and unauthorized personnel cannot access the application. The logout webpage is displayed in figure 7.17.

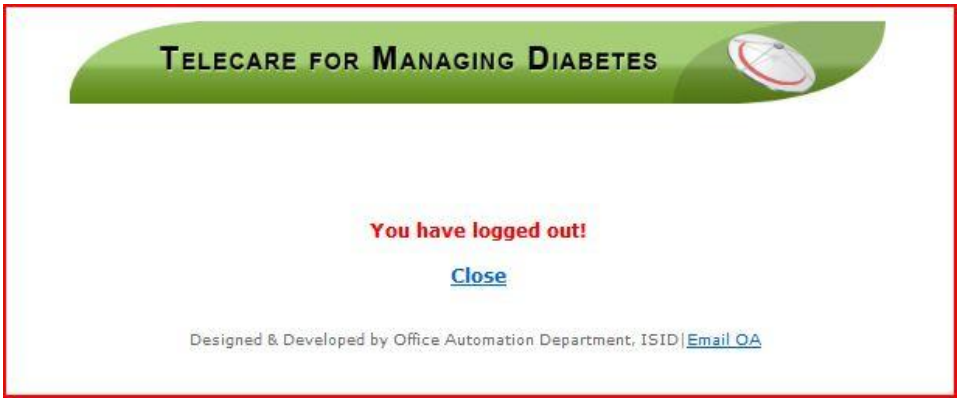


Figure7.17: Logout webpage

7.5.1.7 Overall Performance

Let us examine the overall performance of the Admin interface used by the DEs, by looking at the following qualities:

- Although the application is available for DEs to access on the local NGHA network, it is also *accessible remotely*, giving the DEs the convenience to connect to the application remotely. This allows DE to be available after-hours, on weekends, and during their leave time, if and whenever there is an urgent need.

- The application was developed using the same NGHA software development standards, development language and environment, and on the same platforms and hardware. This ensures that the *application is secure* conforming to security policies, *reliable and accessible*, as is the case with other HIS in the NGHA network.

- For DEs, there is *no cost* when accessing the application through the NGHA network; however, when accessed remotely, an Internet connection will be required.

- In this study, the Admin interface is primarily used by the DE. However, the *application is flexible* and will allow any other healthcare giver access, such as a physician or nurse, as long as the individual has been authorized to use the application by the management, and has been cleared for access by the network administrator.

7.5.2 Patient Web Interface

In order to minimize user effort and make the TeMaD application accessible, it has been listed under the 'Patient Services' link, available on the NGHA homepage. Figure 7.18 displays the location of the TeMaD link.

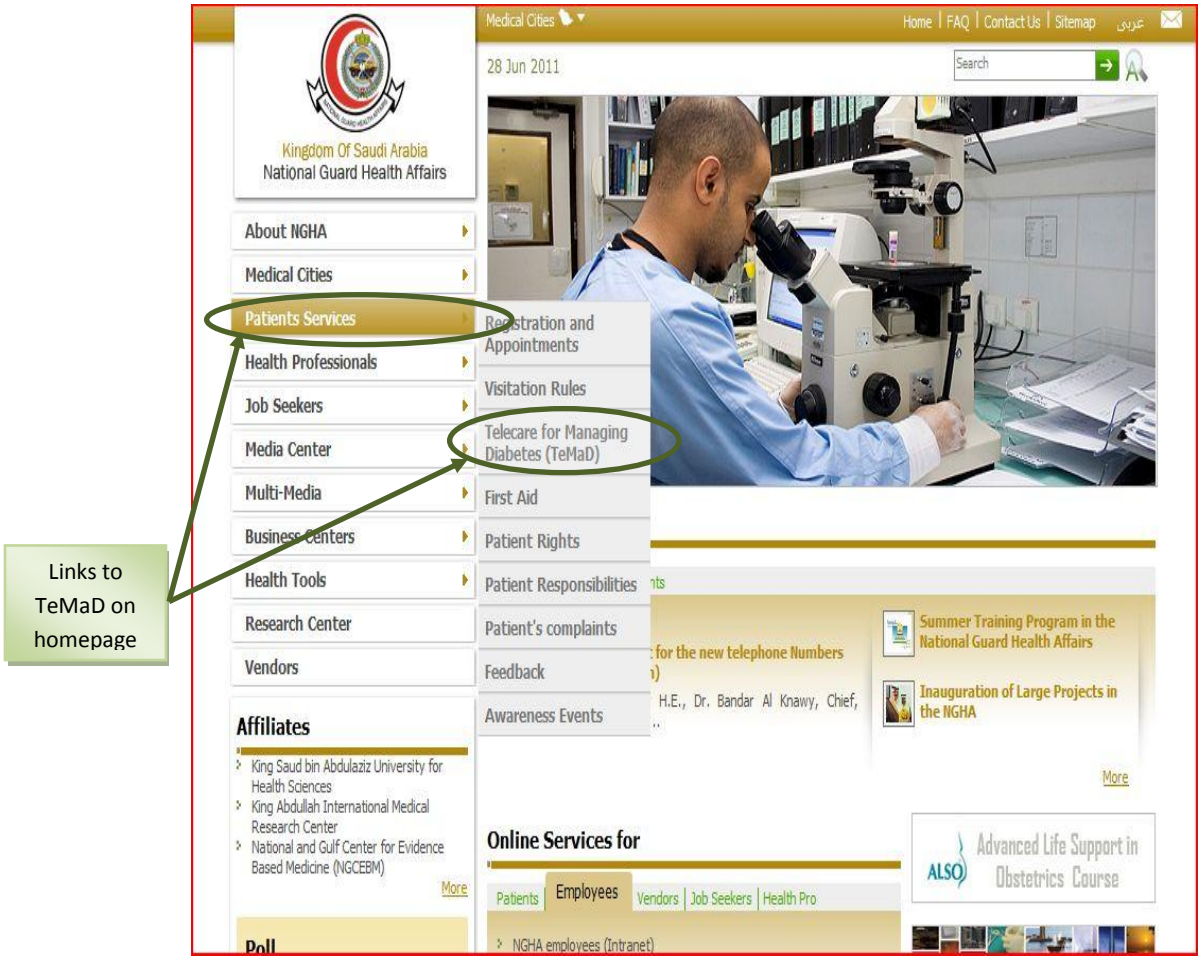


Figure 7.18: NGHA homepage (www.ngha.med.sa)

Once the patient has clicked on the TeMaD link, the TeMaD homepage is displayed as shown in figure 7.19. The TeMaD application patient interface uses the Arabic language, since most participating patients speak little or no English.

The homepage includes a brief introductory of the TeMaD application, then, lists the three modes of use: Internet, SMS, and Landline. It also contains an icon for registration used by new users of the application, and lists the functions of the system on the right-side panel. Finally a 'Contact Us' button is located at the very end.

Figure 7.19: TeMaD user homepage

7.5.2.1 Security

The patient is first required to register with the DEs at the clinic. Once this process has been completed, the patient can log into the application as a 'New' user. This will take the patient to a page which will simply request the MRN, then click on the 'Send' button, as shown in figure 7.20. This prompts the application to randomly generate an initial password by the Unified Messaging System (UMS) and sends it to the patient via SMS.

Figure 7.20: New user login webpage

If the patient is already an existing user, then the 'Existing user' option is selecting, taking the patient to a webpage which requests the entry of the MRN and the password (see figure 7.21).

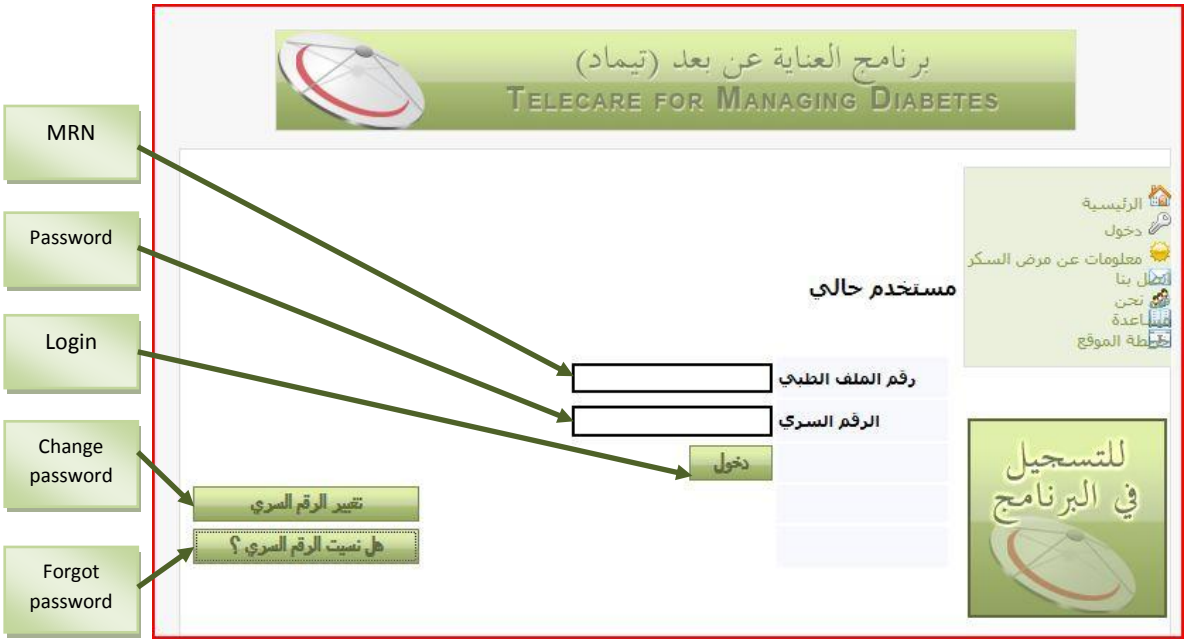


Figure 7.21: Existing user login webpage

The application also allows the patient to change the password, and issue a new one by the UMS when a patient has forgotten the password, as shown in figure 7.21.

7.5.2.2 Design Aspects of TeMaD Patient Interface

As the case with the development of the TeMaD Admin interface, the patient interface also adheres to HCI principles [92] of being consistent, compatible, predictable, adaptable, economical, giving user control, and structural.

Moreover, the patient interface takes into consideration a number of factors associated with our group of patients:

- Many diabetics suffer from low vision – therefore the interface uses clear font styles and sizes, and also comfortable text and background colours.

- Many of the participants do not regularly use the Internet, therefore reducing user familiarity with similar web applications – the interface uses short phrases for instructions, and has a strong but simple navigational structure with helpful hints throughout.

- Entry of readings needs to be done daily (on average) – in order to minimize time of data entry, all web-pages minimise use of text, with simple and direction instructions.

7.5.2.3 Functionality – Enter New Readings

The application allows the patient to perform a number of tasks, as displayed in figure 7.22.

- First select the date, then enter up to seven readings – as required by DEs.

- Validation checks ensure that a date is selected first, and patient must confirm entry before a 'Save' is applied.

- The application also allows the patient to enter readings for more than one day. After the entries for one day have been entered and saved, the patient is asked if there are more readings. If 'Yes', the fields for readings are cleared, and new readings can be entered. Similar validation checks apply.

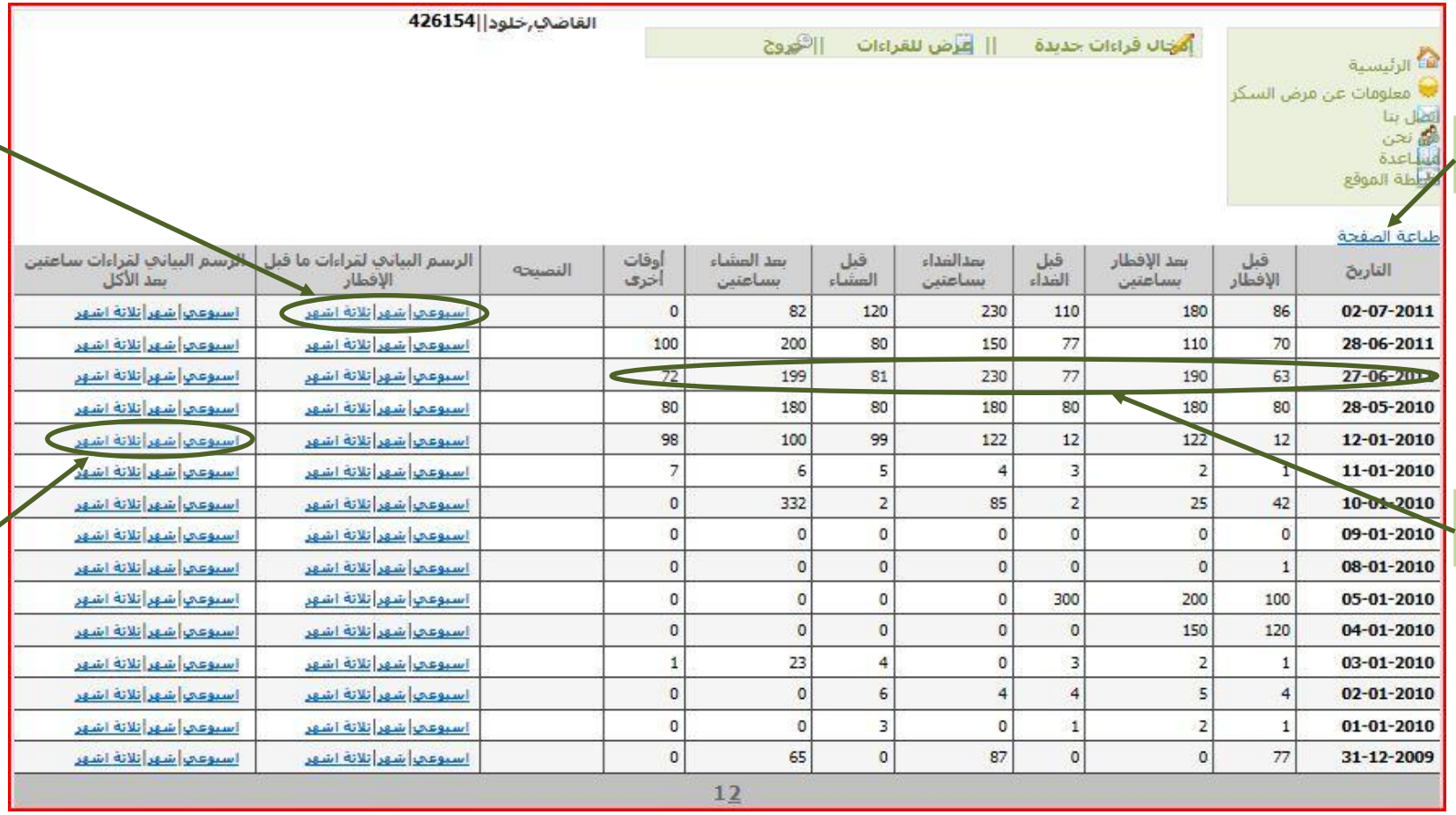
Figure7.22: New readings entry

7.5.2.4 Functionality – View Readings

The application provides the user with the history of all readings entered, and a number of tools that can assist in monitoring performance and trends, as demonstrated in figure 7.23.

The following features are offered:

- Data is listed in a table, sorted chronologically with the most recent readings first.
- Tables also show any advice/recommendations given by DE.
- Tables can be printed.
- Data can also be viewed in a graphical format.
- Graphical representations of the readings show performance levels for both Fasting and 2HPP.
- The graphs use a colour system to show normal and abnormal reading levels. As best practice, we use a colour-blind safe colour scheme to differentiate between reading categories. High and low reading levels are represented in **Grey**, and normal reading levels in **Blue,** as displayed in figure 7.24. All colours used for the TeMaD graphs have been tested using the VisCheck tool (www.vischeck.com) and comply to colour-blind safe standards.
- Graphical representations can be viewed on weekly, monthly, or three month time-frame.
- Graphical representations assist patients in monitoring their blood sugar levels and assessing their performance.



التاريخ	قبل الإفطار	بعد الإفطار بساعتين	قبل الغداء	بعدالغداء بساعتين	قبل العشاء	بعد العشاء بساعتين	أوقات أخرى	النصيحه	الرسم البياني لقراءات ما قبل الإفطار	الرسم البياني لقراءات ساعتين بعد الأكل
02-07-2011	86	180	110	230	120	82	0		اسبوعي|شهر|ثلاثة اشهر	اسبوعي|شهر|ثلاثة اشهر
28-06-2011	70	110	77	150	80	200	100		اسبوعي|شهر|ثلاثة اشهر	اسبوعي|شهر|ثلاثة اشهر
27-06-2011	63	190	77	230	81	199	72		اسبوعي|شهر|ثلاثة اشهر	اسبوعي|شهر|ثلاثة اشهر
28-05-2010	80	180	80	180	80	180	80		اسبوعي|شهر|ثلاثة اشهر	اسبوعي|شهر|ثلاثة اشهر
12-01-2010	12	122	12	122	99	100	98		اسبوعي|شهر|ثلاثة اشهر	اسبوعي|شهر|ثلاثة اشهر
11-01-2010	1	2	3	4	5	6	7		اسبوعي|شهر|ثلاثة اشهر	اسبوعي|شهر|ثلاثة اشهر
10-01-2010	42	25	2	85	2	332	0		اسبوعي|شهر|ثلاثة اشهر	اسبوعي|شهر|ثلاثة اشهر
09-01-2010	0	0	0	0	0	0	0		اسبوعي|شهر|ثلاثة اشهر	اسبوعي|شهر|ثلاثة اشهر
08-01-2010	1	0	0	0	0	0	0		اسبوعي|شهر|ثلاثة اشهر	اسبوعي|شهر|ثلاثة اشهر
05-01-2010	100	200	300	0	0	0	0		اسبوعي|شهر|ثلاثة اشهر	اسبوعي|شهر|ثلاثة اشهر
04-01-2010	120	150	0	0	0	0	0		اسبوعي|شهر|ثلاثة اشهر	اسبوعي|شهر|ثلاثة اشهر
03-01-2010	1	2	3	0	4	23	1		اسبوعي|شهر|ثلاثة اشهر	اسبوعي|شهر|ثلاثة اشهر
02-01-2010	4	5	4	4	6	0	0		اسبوعي|شهر|ثلاثة اشهر	اسبوعي|شهر|ثلاثة اشهر
01-01-2010	1	2	1	0	3	0	0		اسبوعي|شهر|ثلاثة اشهر	اسبوعي|شهر|ثلاثة اشهر
31-12-2009	77	0	0	87	0	65	0		اسبوعي|شهر|ثلاثة اشهر	اسبوعي|شهر|ثلاثة اشهر

1 2

Figure7.23: View readings

One of the main strengths of the application is how it displays the blood sugar levels over a period of time selected by the patient. This feature allows the patient to monitor readings and assess performance in order to maintain healthy blood sugar levels. It enables the patient to gain more control over this disease using a simple and clear tool, and allows the patient to have more independence from the clinic.

Figure 7.24 displays the 2HPP blood sugar levels of a patient over a period of one month.

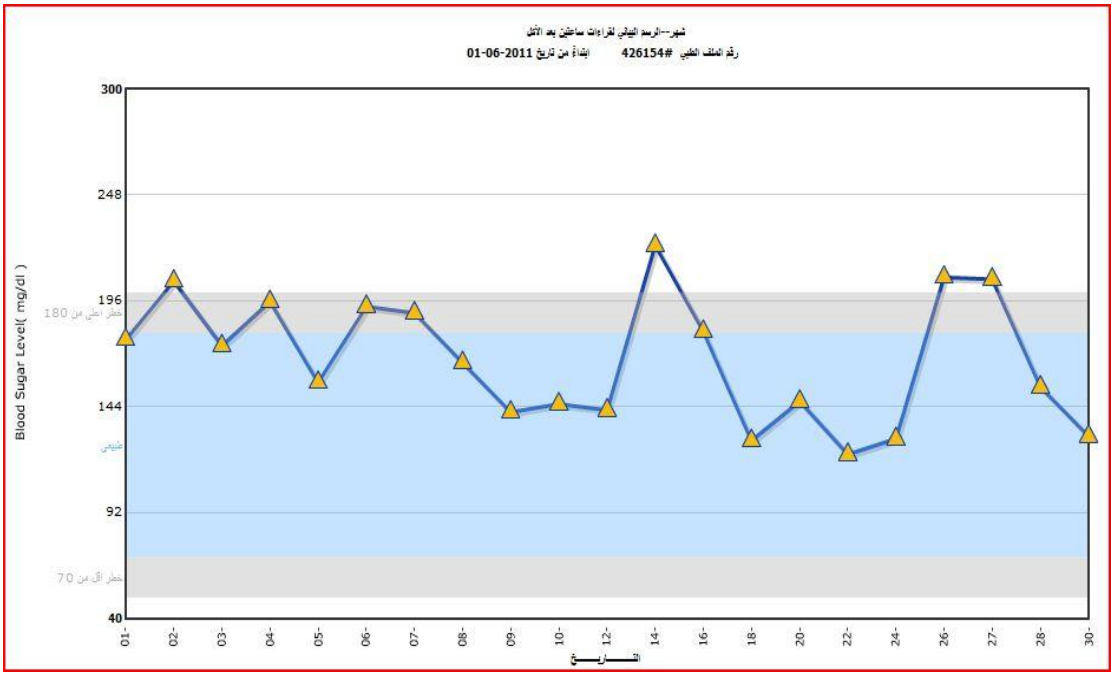


Figure 7.24: 2HPP graph (one month)

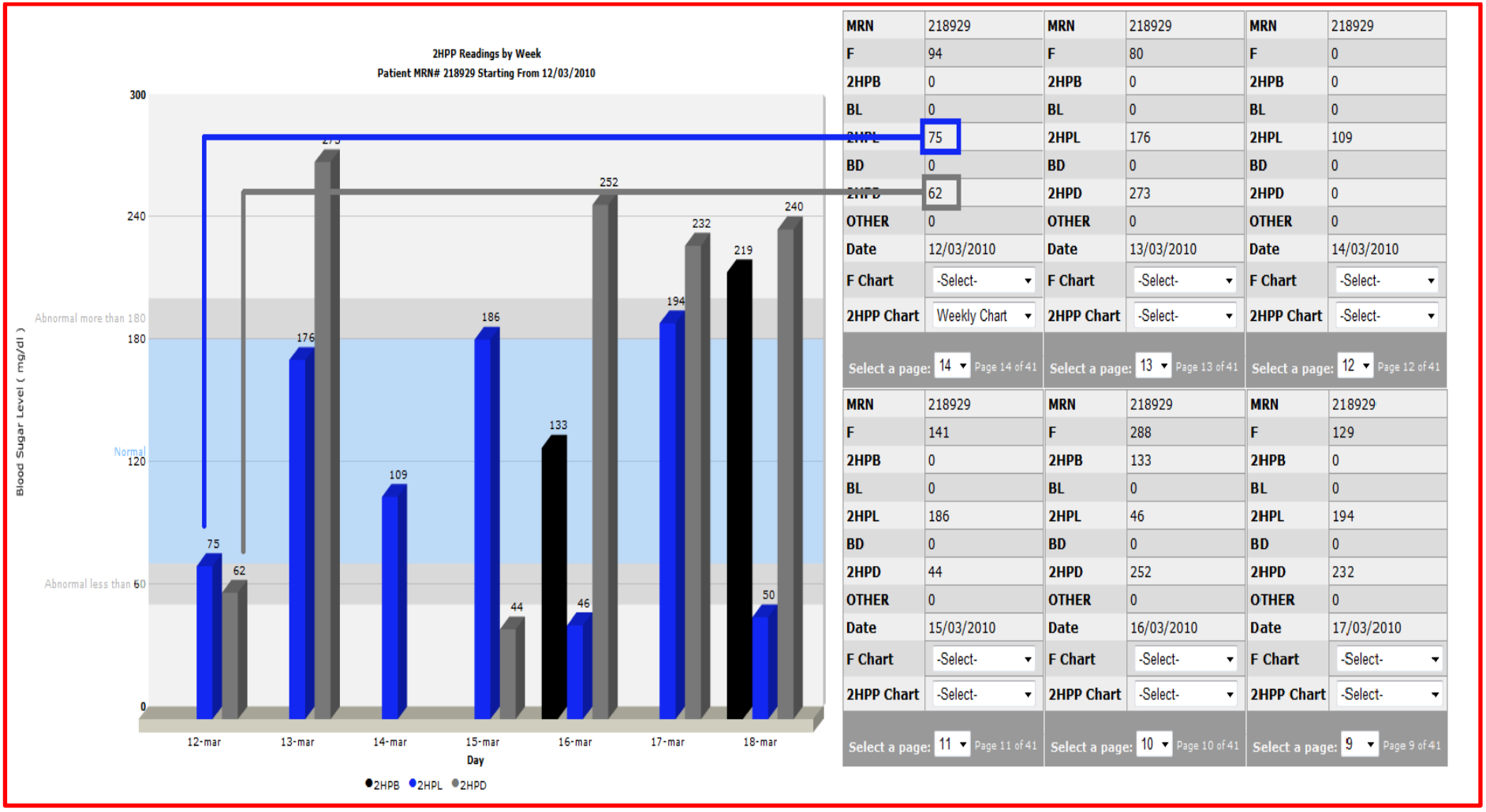
Since the patient can enter up to three 2HPP readings daily, the monthly graph uses a simple calculation to get an average reading per day, where the sum of the 2HPP readings are calculated, then divided by the number of recorded 2HPP readings available, as follows:

Average readings = (2HPB + 2HPL + 2HPD) / number of readings entered

By presenting only one reading, we reduce clutter on the graph and offer the user an average performance level.

The patient can also view readings taken weekly, as shown in figure 7.25. Once more, colours conforming to a colour-blind safe scheme are used to simplify the information, where:

- **Black** is used to indicate a 2HPP (after breakfast) reading,
- **Blue** indicates a 2HPP (after lunch) reading, and
- **Grey** indicates a 2HPP (after dinner) reading.



MRN	218929	MRN	218929	MRN	218929
F	94	F	80	F	0
2HPB	0	2HPB	0	2HPB	0
BL	0	BL	0	BL	0
2HPL	75	2HPL	176	2HPL	109
BD	0	BD	0	BD	0
2HPD	62	2HPD	273	2HPD	0
OTHER	0	OTHER	0	OTHER	0
Date	12/03/2010	Date	13/03/2010	Date	14/03/2010
F Chart	-Select-	F Chart	-Select-	F Chart	-Select-
2HPP Chart	Weekly Chart	2HPP Chart	-Select-	2HPP Chart	-Select-
Select a page: 14	Page 14 of 41	Select a page: 13	Page 13 of 41	Select a page: 12	Page 12 of 41

MRN	218929	MRN	218929	MRN	218929
F	141	F	288	F	129
2HPB	0	2HPB	133	2HPB	0
BL	0	BL	0	BL	0
2HPL	186	2HPL	46	2HPL	194
BD	0	BD	0	BD	0
2HPD	44	2HPD	252	2HPD	232
OTHER	0	OTHER	0	OTHER	0
Date	15/03/2010	Date	16/03/2010	Date	17/03/2010
F Chart	-Select-	F Chart	-Select-	F Chart	-Select-
2HPP Chart	-Select-	2HPP Chart	-Select-	2HPP Chart	-Select-
Select a page: 11	Page 11 of 41	Select a page: 10	Page 10 of 41	Select a page: 9	Page 9 of 41

Figure 7.25: 2HPP graph (one week)

7.5.2.5 Functionality – Other

The interface also includes the following links, to provide the user with useful information:

- General Information about Diabetes: provides general information about diabetes, and related articles, with the aim to increase patients' awareness and knowledge.

- Contact Us: offers telephone number and extension to use for registration or any questions regarding the application.

- Who are we: briefly states the objective of the trial, the goals, and the sponsors of the TeMaD trial.

- Help: offers the user an online demonstration on how to register, and how to use the application.

- Sitemap: displays a complete structure of site.

7.5.2.6 Logout

The 'Logout' button is clearly positioned on the top left-hand corner of the web-page. This is the most familiar position of the Logout button used in most websites.

7.5.2.7 Overall Performance

The overall performance of the patient interface can be assessed as follows:

- User does not need any additional software or hardware to run the application, other than an Internet connection and PC. Therefore, there are no additional costs.

- The application is available and can be accessed from anywhere, lifting physical restrictions from users.

- It is also reliable, with no downtime, unless there are routine maintenance downtimes by the ISD, which in this case, affects all applications.

- The interface is user-friendly, ease to learn, and adaptable. It uses familiar designs, and provides the user with helpful hints, reminders, and validation checks.

7.5.3 Evaluation of SMS Mode

The SMS mode is the second option offered by TeMaD. Since SMS is a familiar and available technology, the assumptions were that it would be used most, especially that it only requires the use of a mobile phone.

In order to utilise existing technologies at NGHA, the SMS mode was linked to the NGHA UMS. This system is currently being used with NGHA patients. For instance, it sends SMSs for appointment reminders and to raise awareness.

However, when this technology was integrated into the TeMaD system, drawbacks were realized. These drawbacks had a negative impact on the usage of this mode. They can be summarized as follows:

1. The syntax used to send readings to the system was very long and complicated. No template was designed for mobile phones, to ease the data entry process.

2. The syntax did not allow patients to enter readings for more than one day. Entries for multiple days needed to be sent individually, one SMS for each day.

3. Many diabetics have low vision, therefore resulting in increased user error when entering the data. This was a turn-off for many patients.

4. The number used by the TeMaD system to send the SMS to is not a free number. Patients complained from associated high costs, although they were reimbursed after the study concluded.

7.5.4 Evaluation of Dedicated Landline

The landline option was used frequently by patients. Although its availability of use was limited to weekdays during the clinic working hours, it was a huge success. This can be contributed to the following factors:

- It enables patients to directly contact the DE.
- Allows patients to verbally describe symptoms and/or problems more easily than typing them.
- This mode is relatively low in cost.
- A dedicated line was situated solely for use by the TeMaD patients, with a DE appointed to answer all calls during working hours. This aspect ensured availability of the DE.

7.6 TeMaD Goals

The following goals have been set:

1. Decrease HbA1c level in diabetics by 5%.
2. Provide diabetics with an alternative method of managing their disease.
3. Raise patient awareness using appropriate technology.
4. Managing diabetics at home, and reducing hospital visits, unless necessary.

7.7 TeMaD Study Approach

Our study on the impact of TeMaD on participating diabetic patients at NGHA clinic 104 will use the Before/After approach. This is an approach commonly used to assess the impact of an intervention. It measures outcomes before an intervention, then compares them to outcomes measured afterwards [95].

Figure 7.26 demonstrates this approach as stated by the American College of Physicians.

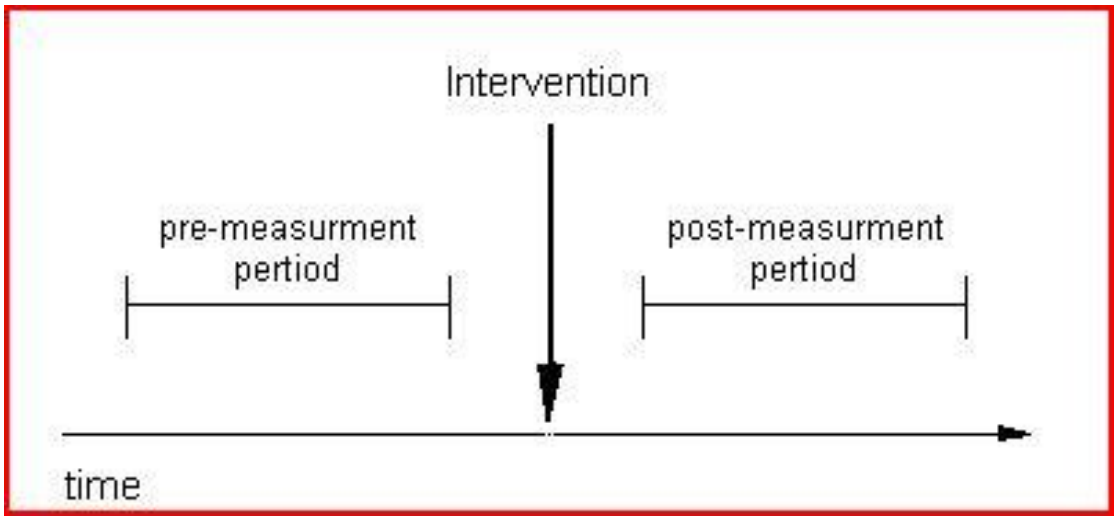


Figure 7.26: Before/After study

Our study will apply the Before/After test as follows:

- Pre-measurement: the value of the blood sugar level of a participating patient obtained through an HbA1c test, before using TeMaD.
- Intervention: using TeMaD for a period of 12 weeks
- Post-measurements: the value of the blood sugar level of a participating patient obtained through an HbA1c test, after using TeMaD.
- The two measurements will be compared to evaluate whether or not TeMaD had an impact on the blood sugar levels of participating patients.

7.8 NGHA TeMaD Grant

A proposal was submitted to the Research Committee at NGHA-CR for two purposes:

1. Gain approval to offer TeMaD as an official alternative healthcare service at Clinic 104, and

2. To obtain a grant to assist in establishing and offering TeMaD to patients.

Based on NGHA policy, an approval by the Research Committee is required before any healthcare service is offered to patients. The grant is required to assist in the development of the application, and to support the logistics of the study, covering required software, developer overtime, patient incentives, reimbursements to patients over incurred costs, and other related costs.

The proposal was approved, so was the grant, as indicated in Appendix B.

7.9 TeMaD Launching

Prior to the launching of TeMaD, a number of procedures needed to be followed. These procedures include Departmental consent to begin the study at the diabetic clinic, request from SMS system administrator to approve an SMS account to be used by TeMaD users, and a dedicated landline as the third option of TeMaD for patients to directly access the DEs.

7.9.1 Departmental Consent

As per NGHA policy, before the commencement of any study in a clinic, the Head of Division must be notified. A letter was sent a few weeks prior to the commencement of the study (see Appendix C).

7.9.2 Establish TeMaD SMS Account

The second option in TeMaD is to use SMS technology for communication between the diabetic patients and the DEs. The NGHA Unified Messaging System is located in NGHA-WR, and administered by the IT team in Jeddah. In order to establish an SMS account for TeMaD, a request was submitted to the Department Chairman. The request specifies how many SMSs will be required per month and the justification of usage (see Appendix D).

7.9.3 Establish TeMaD Dedicated Landline

The third option in TeMaD uses a dedicated landline for participating patients to contact the DEs during clinic working hours. A request was sent to the Director of Communications Department requesting a dedicated extension to be used for TeMaD. A dedicated extension was granted and connected to a new telephone in the clinic, situated in the assigned DEs room. When the diabetic clinic moved to another area, a follow-up letter was sent, and the dedicated telephone and extension was relocated to a different room (see Appendix E).

7.9.4 Patient Demographics at Diabetic Clinic

Information was requested from the I.S.D. regarding the demographics of diabetic patients at clinic 104 during 2007-2008 between the ages 16-70 years. This information is necessary to better understand the patients being treated at the clinic, and to consider this when selecting the sample group of patients for TeMaD.

The data obtained included information about the number of patients, their genders, dates of birth, ages, contact information, marital status, admission date, city, and other related information. The data most importantly showed that:

- The total number of patients = 1,509
- The total number of male patients = 635
- The total number of female patients = 874

These numbers indicate that 42% of the diabetic patients at the clinic are male, while 58% are female.

7.9.5 Patient Consent Form

As per NGHA policy, any study involving patient participation requires consent from the patients. Accordingly, a patient consent form was designed, compatible with consent forms used for studies supported by the Research Committee. The consent form includes a description of the study, the duration, its goals, patient selection criteria, incentives, study steps, and side effects. After the DE discusses the study with the candidate participant, the consent form is presented. The patient reads the form, and then signs it, registering the mobile number to be used during the study. Two additional signatures are required to confirm the participation, one by the DE and another by any other personnel at the clinic (i.e., another DE or nurse).

The consent form was designed in Arabic then translated to English (see Appendix F).

7.9.6 Patient Training on TeMaD

All participating patients receive a brief training session on how to use TeMaD. This session is administered by the DE. The 'Demo' link on the TeMaD homepage is used, giving the participating patient a graphical view of the different functionalities. This link can be used repeatedly by the patient to learn how to use the system. Furthermore, the participating patient is given an 'Information Booklet' which describes the different modes of TeMaD in a clear and simple manner. The Information Booklet was designed in Arabic since all participating patients speak Arabic, and this document is not required by any involved department (see Appendix G).

7.9.7 TeMaD Protocol

The following steps are to be followed by the DEs at the diabetic clinic:

1. Explain TeMaD project to patient:
    a. Describe different components
    b. Give online demo of Internet component
    c. Give demo of SMS component
    d. Give information booklet
    e. Talk about incentives

2. If patient would like to participate, they are given a consent form to fill out and sign, and give the information booklet to take home.

3. Patients are also given a lab test request to measure the HpA1c level. They must conduct the blood test immediately.

4. Patient information is then immediately entered into TeMaD by the Diabetic Educator, so patients are registered and can start using the system.

5. Start-up:

    a. Landline: patient using landline can start calling the designated extension (#18227) and gives the readings.

    b. SMS: patient can start sending readings to the designated mobile number (0500383686). Patients using this mode should be encouraged to save number to contact list.

    c. Internet: patient needs to register online by going to the website and entering their MRN. They will then receive a SMS with their Internet account password. Using the MRN and the password sent, they can start uploading their readings.

6. Midway through study, patient is awarded first incentive.

7. Throughout study period, the patient can call the Diabetic Educator at anytime on extension 18227 regarding any inquiries.

8. After a 12-week participation period, patients are required to do another lab test to measure the HpA1C level.

9. Study concluded.

10. Second incentive awarded, and reimbursement given for costs related to study.

7.10 Completion of TeMaD

Patients were recruited between December 2009 and March 2010. The last participating patient completed the study in June 2010.

A total number 79 patients signed up for TeMaD. Only 52 patients completed the 12 weeks required, with a total of 27 drop-outs.

All 52 patients were required to fill-out a 'Patient TeMaD Completion' questionnaire before being awarded the incentives.

In addition, all participating DEs were also required to fill-out a 'DE TeMaD Completion' questionnaire.

7.11 Summary

Once the Telecare system was designed and developed, two phases followed: the testing phase, and the launching phase. The first phase explained in detail the testing strategy followed, and how testing was carried out. It described how different testing groups were selected and how modifications to the system were made. Results of testing the interfaces were presented in a tabular format which made them easy to follow and understand. This facilitated smooth communication between the testers and the system developers.

After the system was thoroughly tested, a number of steps needed to be followed prior to launching TeMaD, such as consent forms, department notifications, training for DEs and participating patients. Due to the close coordination between the ISID developers, the clinicians, and other involved personnel, this process was smooth and TeMaD was launched successfully.

CHAPTER 8: EVALUATION

8.1 Introduction

The TeMaD system was launched at NGHA clinic 104, as an alternative method of managing diabetes. The trial involved diabetic educators at the clinic and initially 79 registered patients to participate. Each patient is required to complete a 3 month period. The trial lasted for 6 months, with a total number of 52 patients that completed the required 3 month period.

This Chapter will present the findings and offer an analysis. Before this takes place, it is important to identify the primary areas to be examined.

1. Examine if the Telecare solution has improved the healthcare services offered to diabetic patients at clinic 104.

2. Examine the impact of social and cultural factors on our results.

3. Examine the impact of the Telecare solution on disease management (i.e., health outcome of participants, blood sugar glucose levels, targeted HbA1c reduction percentage).

The data being evaluated in this Chapter has been gathered from two sources: the TeMaD system, and the TeMaD Completion Questionnaires distributed to both involved DEs and participating patients.

8.2 Evaluation of Data

Data has been gathered throughout the study from the TeMaD application, and presented in graphical and tabular format. This data will be presented in the following sections and results derived.

Data gathered from questionnaires designed for the DEs and another set designed for participating patients have both been analysed used the Statistical Package for the Social Sciences (SPSS v14) tool, using measuring 'Frequencies' as a descriptive statistical tool.

8.2.1 Evaluation of TeMaD Data

The data captured through the TeMaD system has been evaluated against a number of factors.

8.2.1.1 Demographics of Participating Patients

8.2.1.1.1 Gender

As stated in Chapter 7, the gender ratio of the total number of patients being treated at the clinic is 42% male and 58% female.

Our gender ratio of the total number of patients participating in the TeMaD study is 46% male and 54% female. This shows that our chosen sample size closely resembles actual gender ratios being treated at the clinic, with 24 males and 28 females from a total of 52 participating patients.

8.2.1.1.2 Number of Participants

- The total number of patients registered for the TeMaD study = 79
- The total number of participating patients completing the 12-week study period = 52
- The total number of patients dropping out of the study = 27

8.2.1.1.3 Age Groups

TeMaD has been designed for patients between the ages of 16 and 70 years. Participating patients were divided into four age groups: 16-29, 30-44, 45-59, and 60-70. The age ratios of participating patients are listed in figure 8.1.

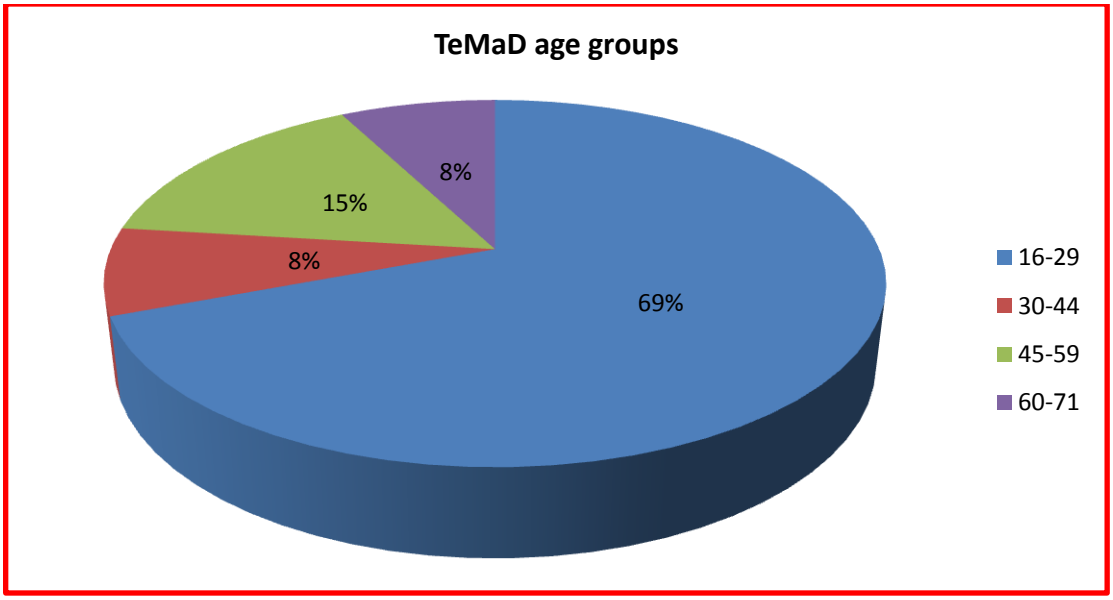


Figure 8.1: TeMaD participants age groups

The largest age group participating in TeMaD is those between 16-29 years. This can be attributed to the following reasons:

- As indicated in Chapter 3, Saudi Arabia has a largely young population, and
- Younger patients are more accepting of new alternative methods of delivering healthcare, especially those methods using technology.

8.2.1.1.4 Occupation

Patients would indicate if they were employed in the public sector, private sector, or none. The intention of 'None' is to capture those unemployed; however, it was also used by patients to indicate that they are students. The ratios are displayed in figure 8.2.

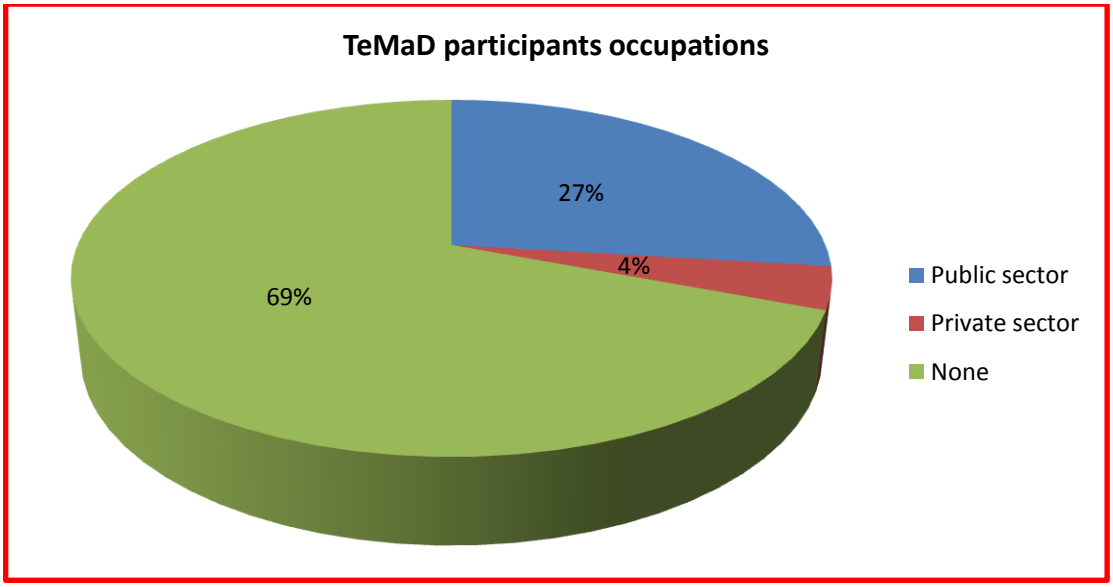


Figure 8.2: TeMaD participants' occupation

These results can be interpreted as follows:

- The category 'None' is largely due to the fact that it represents both unemployed patients and students. This is misleading and an additional category for 'Students' should have been added.

- Unemployed patients may have more problems managing transportation to and from the hospital. Therefore, they may be more accepting of TeMaD since it assists in overcoming such obstacles.

- Students may be more accepting of TeMaD since it reduces disruption to their daily schedules.

8.2.1.1.5 Marital Status

More single patients participated in the study, where gathered statistics indicated that 62% of participants were single, while 38% were married.

This can be attributed to the following reasons:

- The fact that the majority of participates are young, within the age group of 16-29 years, and are therefore mostly single.

- As discussed in Chapter 3, social and cultural factors may put a tag on young diabetics as 'unhealthy' and therefore unfit for marriage, where most marriages remain to be arranged by families.

8.2.1.1.6 Residency

A large number of participating patients live in Riyadh or within Riyadh suburbs, as indicated in figure 8.3.

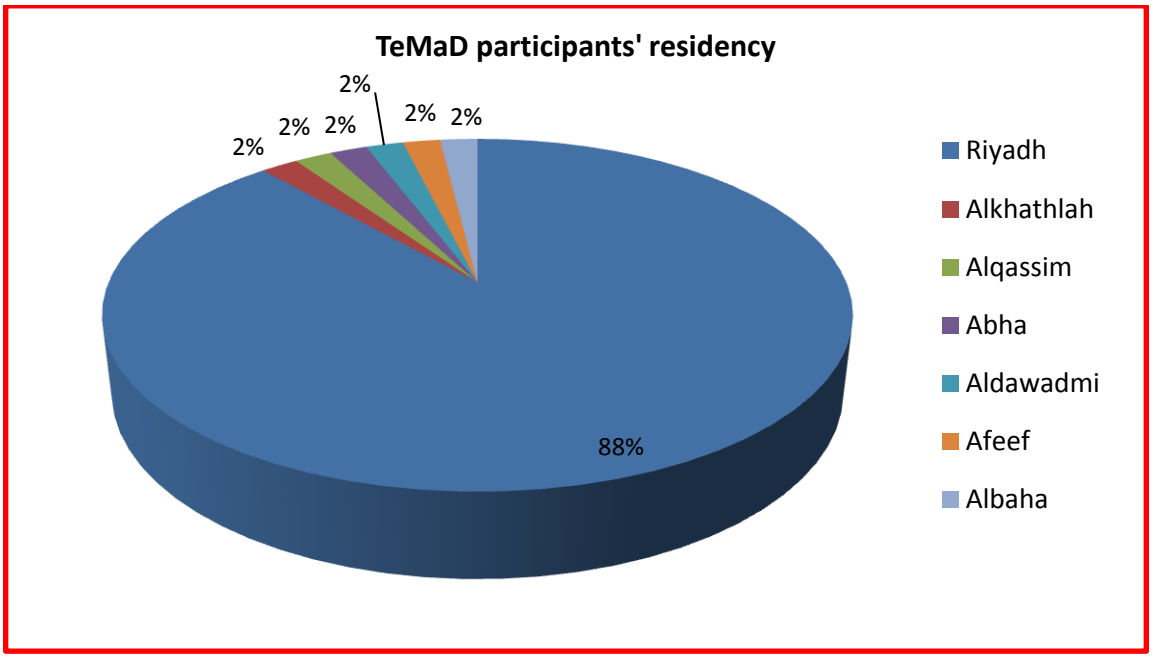


Figure 8.3: TeMaD participants' residency

However, Riyadh is the capital and according to the latest statistics published in 2009 by the High Commission for the Development of Arriyadh, the urban area of the city is 2435 km2, with almost 5 million inhabitants [96].

As the KAMC-CR is located in the extreme east part of the city, as shown in figure 8.4, reaching the hospital can take up to one hour for those living in opposite parts of the city, and even longer during peak travel times.

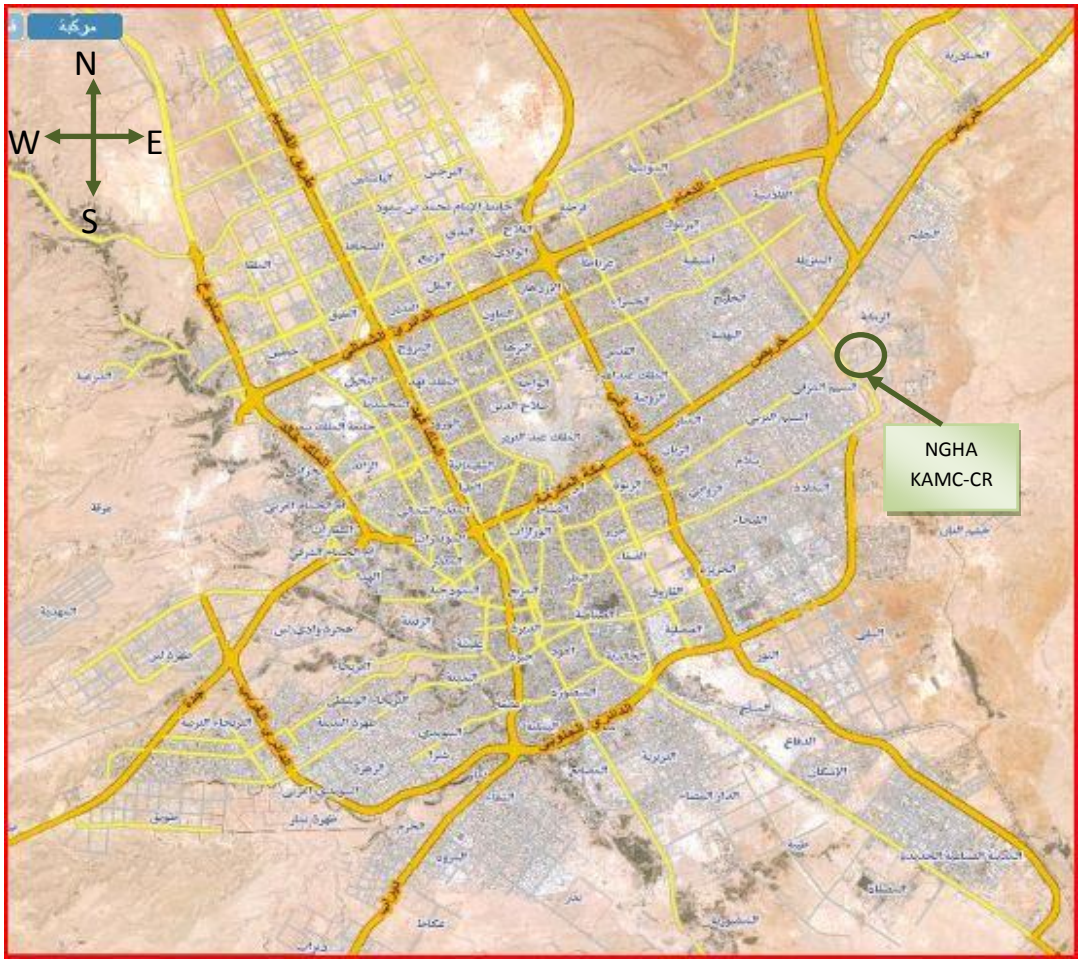


Figure 8.4: Riyadh map

8.2.1.2 Hba1c Levels Before & After

As discussed in Chapter 7, the Before/After methodology was used to measure the impact of TeMaD on disease management of diabetes. Participants took a blood test to measure the HbA1c level pre- TeMaD usage, then after completing the 12-week study period, another post-TeMaD blood test was taken to measure the HbA1c level. The primary goal of TeMaD is to reduce the HbA1c levels of participating patients by at least 5%.

8.2.1.2.1 Complete Results

Table 8.1 displays the results recorded, listing the patient information and HbA1c levels taken before TeMaD, 12 weeks later immediately after completing TeMaD,

and approximately 3 months after TeMaD. Impact on HbA1c levels are indicated using colour, where:

- **Red** indicates a drop in HbA1c
- **Green** indicates an increase in HbA1c
- **Grey** indicates no change in HbA1c

The percentage of change in the Hba1c levels is calculated as follows:

Reading 1 – Reading 2 = Hba1c change

(Hba1c change / Reading 1) X 100 = Percentage of increase/decrease of Hba1c level

where:

Reading 1: is the Hba1c level taken before starting TeMaD, and

Reading 2: is the Hba1c level taken after completing TeMaD, and

Hba1c change: is the difference between Reading 1 and Reading 2.

No.	MRN	a1c before temad	date	a1c thru temad	date	a1c after temad	date		a1c final	date	
1.	155787	6.5	24/10/09	5.8		6.4	13/4		6.9	30/9	
2.	2050923	8.5	13/12/09			8.4	18/4		10.4	24/11	
3.	137957	8.3	14/12/09	7.6		7.2	13/3		8.3	9/10	
4.	307957	10.8	16/11/09			11.8	12/4		10.3	5/7	
5.	195266	9.2	16/12/09			8.6	7/3		9.7	26/9	
6.	502788	8.5	23/12/09	8		7.8	21/3		8.3	24/8	
7.	14568	9.8	14/12/09			9.6	27/3		9	16/10	
8.	180530	11.4	9/11/09	7.3		9.8	14/4		8.1	9/11	
9.	156357	9.2	21/12/09	7.9		8.2	17/3		9.2	11/10	
10.	546293	8	1/11/09			8.4	6/4		8.1	27/4	
11.	112438	8.2	30/12/09			6.7	21/3				
12.	698245	7.1	28/10/09	7.3		6.7	10/4		7.3	24/10	
13.	188534	8	8/12/09			7.7	6/4		6.8	2/9	
14.	236098	7.8	6/10/09			6.5	12/4				
15.	306817	12.7	4/1			11.4	1/4		10.7	7/8	
16.	2209543	5.9	16/12/09	8.7		7.6	12/4				
17.	69752	7.2	25/10/09	6.7		6.6	10/5		7.3	28/11	
18.	419959	9.7	20/1			11.2	23/5		10.2	20/6	
19.	488604	9	16/1			8.4	2/6		8.8	8/11	
20.	594897	5.4	11/1	6		5.4	23/5		5.3	9/11	
21.	524661	9	10/2			7.9	31/5				
22.	235988	10.9	10/1			8.5	20/6				
23.	11880	12.8	7/1			10.9	6/6		11.2	30/9	
24.	569312	9.1	8/3			9.5	20/6		10.4	20/11	
25.	250727	8.4	13/10/09			7.8	24/4				
26.	473703	9.8	13/12/09			8.7	20/3		8.6	17/4	
27.	2246242	7.7	14/12/09			7.4	3/3				
28.	2202545	6.8	13/12/09			6	27/4				
29.	175042	9.9	15/12/09			9.4	7/4				
30.	575067	8.7	1/11/09	8.4		8	16/3		8.5	11/12	
31.	2255488	16.8	9/1			12.8	29/3				
32.	218929	8	21/11/09			7.4	1/4		7.5	18/9	
33.	715924	6.4	19/11/09	6.9		6.7	11/3		7.5	25/11	
34.	529984	9.1	19/12/09			8.3	12/4		8.8	20/11	
35.	562385	10	26/7/09	9.4		9.6	6/4		9.3	28/9	
36.	551864	7.9	17/11/09			7.3	6/4		7.2	5/8	
37.	42352	8.1	20/12/09			8.3	27/3		8.7	12/5	
38.	2192349	10.3	10/11/09			4.9	3/3		7.8	24/7	
39.	705920	8.7	28/12/09	8.8		8.6	27/3		7.5	6/11	
40.	459040	8	6/12/09			7.9	21/3		8	22/11	
41.	216329	8.5	7/12/09	7.8		7.7	4/4		8.1	30/10	
42.	2126555	13.3	12/11/09			15	25/3		15.7	2/12	
43.	176491	12.9	2/11	11		10.3	12/5		11.5	7/9	
44.	594761	11.2	28/7/09			9.4	20/5				
45.	584743	12.1	31/12/09			9.5	16/3		8.7	6/6	
46.	590819	9.9	23/11/09			9.3	22/2		10.2	4/10	
47.	241084	11.6	9/12/09			9.4	13/3		9	21/7	
48.	479732	5.7	31/1			5.3	31/5				
49.	151981	8.4	30/1			8.3	9/2		7.3	9/8	
50.	2193342	10.7	21/2			9.2	19/5				
51.	348964	7.9	1/3			6.6	31/5				
52.	193116	8.4	29/12/09	7.2		7.7	8/5		8.7	29/11	

Table 8.1: HbA1c levels for TeMaD

8.2.1.2.2 HbA1c Levels

A relatively high percentage of participating patients recorded a drop in their HbA1c levels, after using TeMaD as indicated in figure 8.5.

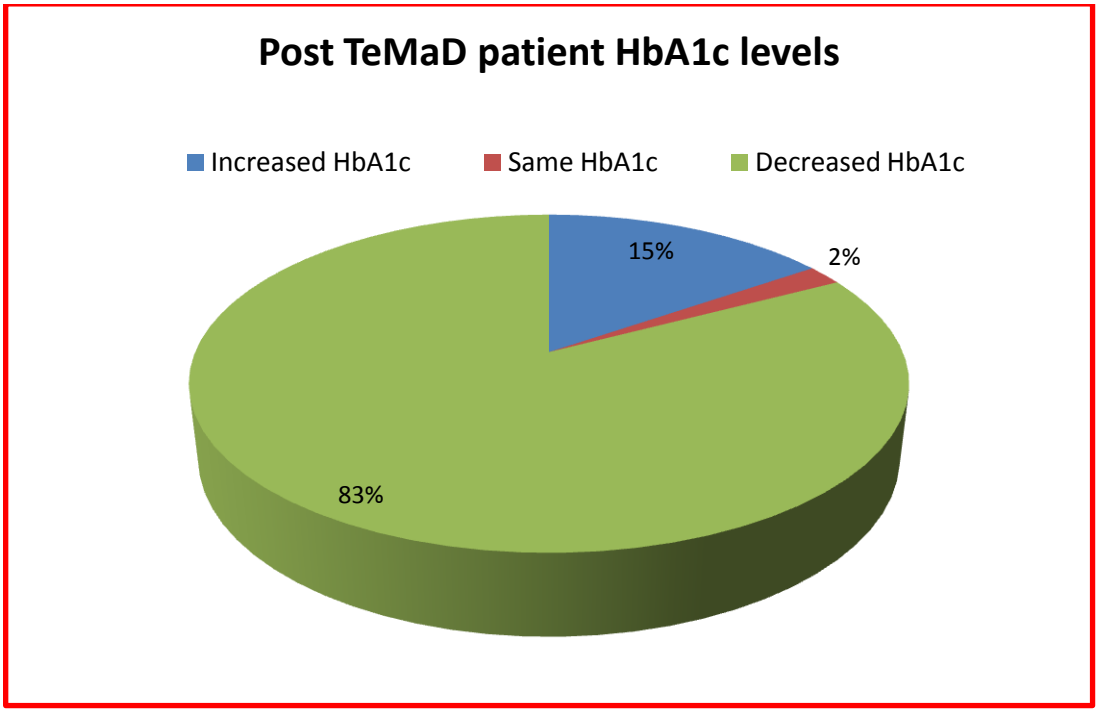


Figure 8.5: Post TeMaD patient HbA1c levels

We now examine these statistics regarding gender. We find that more female patients were able to reduce their HbA1c levels, as shown in figure 8.6.

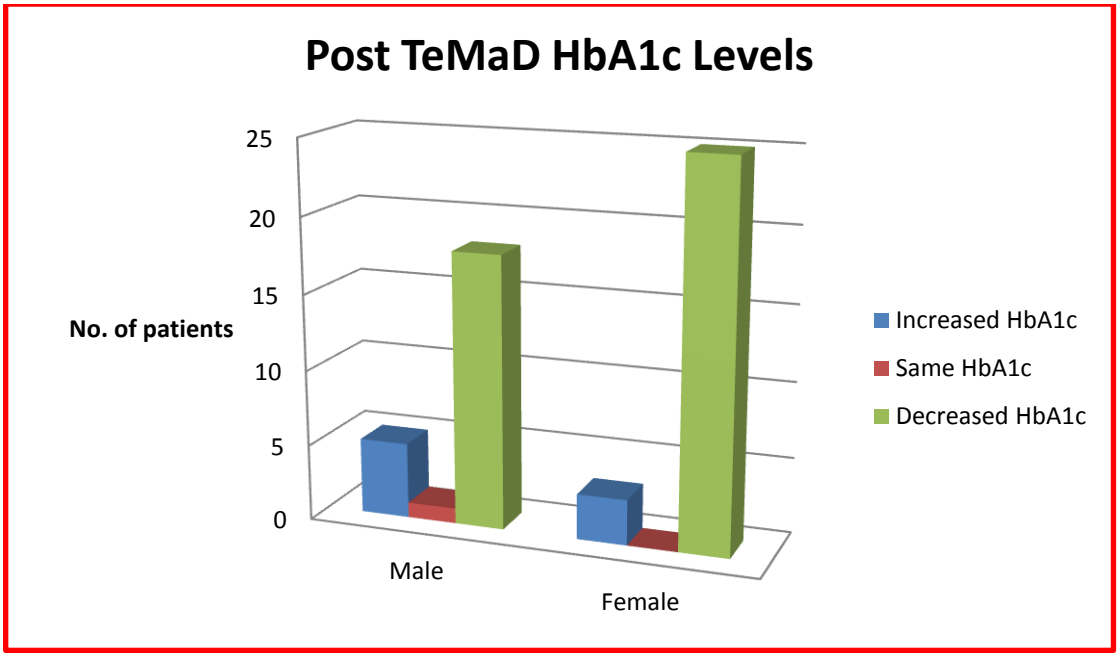


Figure 8.6: Post TeMaD patient HbA1c levels by gender

TeMaD has had a greater impact on female patients. This can be attributed to the following reasons:

- TeMaD offered female patients a more convenient way of managing their disease,
- It provided the patients with a simple method of remotely communicating with their diabetic educators at the clinic, avoiding obstacles, in particular, those related to transportation,
- the service also offered female patients communication channels sensitive to the Saudi culture, enabling female patients to deal with diabetic educators indirectly, avoiding gender-related issues.

We find that out of the 82.6% of patients with recorded drops in their HbA1c levels 48% are females, and only 34.6% are male.

With regards to the TeMaD goal of reducing HbA1c levels by at least 5%, data shows that 34 patients (65%) were successful in doing so, 14 males and 20 females. See figure 8.7.

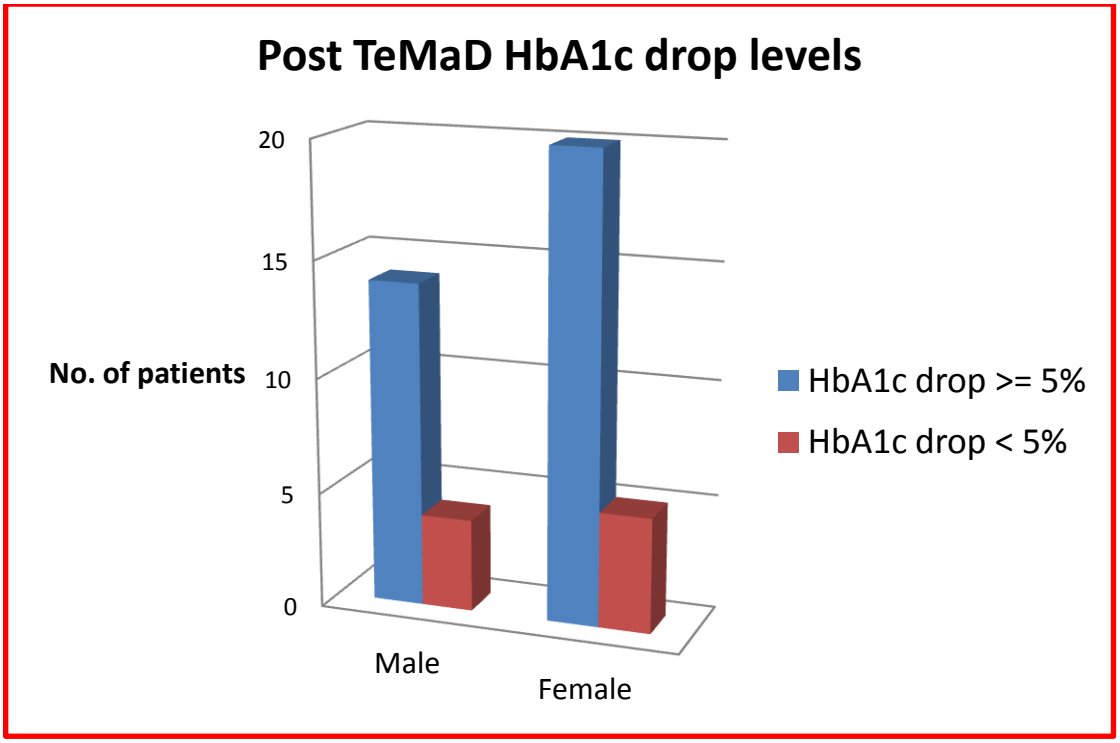


Figure 8.7: Post TeMaD HbA1c drop by 5% or more

Data shows that almost 15.3% of participating patients had an increase in their HbA1c levels after participating in the study for 3 months, see table 8.2.

	Total # of patients	% of total patients	Male	% of Male patients	Female	% of Female patients
total number of patients who have an increased hba1c level	8	15.3%	5	9.6%	3	5.7%

Table 8.2: Post TeMaD patients with increased HbA1c levels

Out of the eight patients with increased HbA1c levels, five are men and three are female. Out of the five men, three are in their early 50's, one of which suffers from other medical complications (heart problems and is hearing impaired). Another patient lived in a different city (Abha).

No patterns were found among the three females.

After the analysis of the patients recording a 5% drop in the HbA1c levels, we found patients that had exceeded predictions and recorded drops of 10% or higher.

In figure 8.8, we find that out of the total number of participating patients recording drops in their HbA1c levels, approximately 37% were able to lower it by 10% or more, exceeding our expectations.

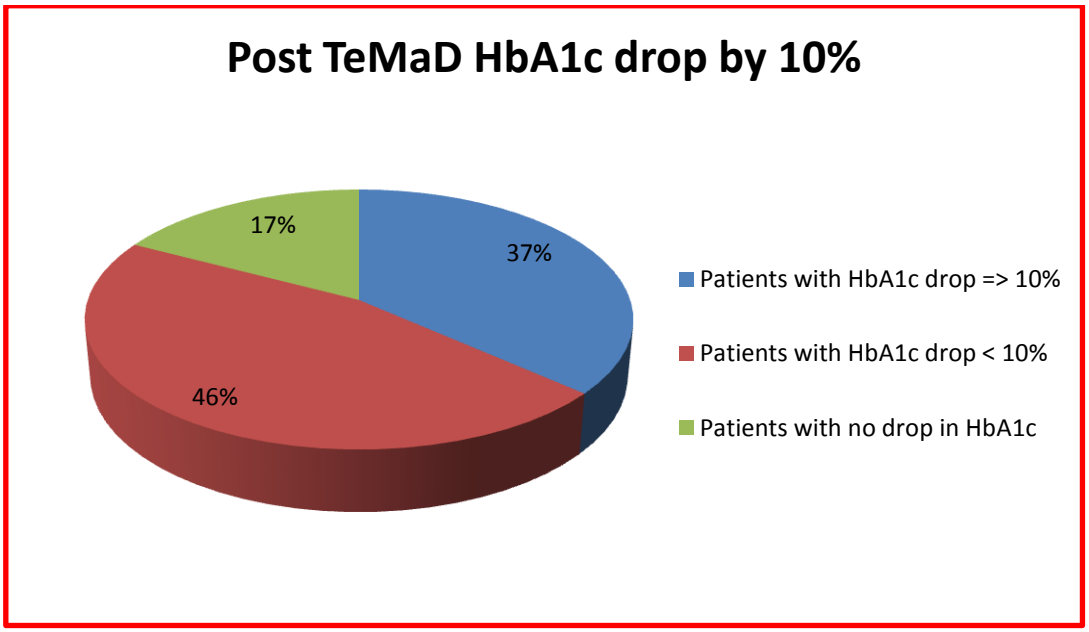


Figure 8.8: Post TeMaD HbA1c drop levels by 10%

When cross-checking this result on the basis of gender, we again find female patients performing better than males. Figure 8.9 demonstrates the difference between genders in this regard.

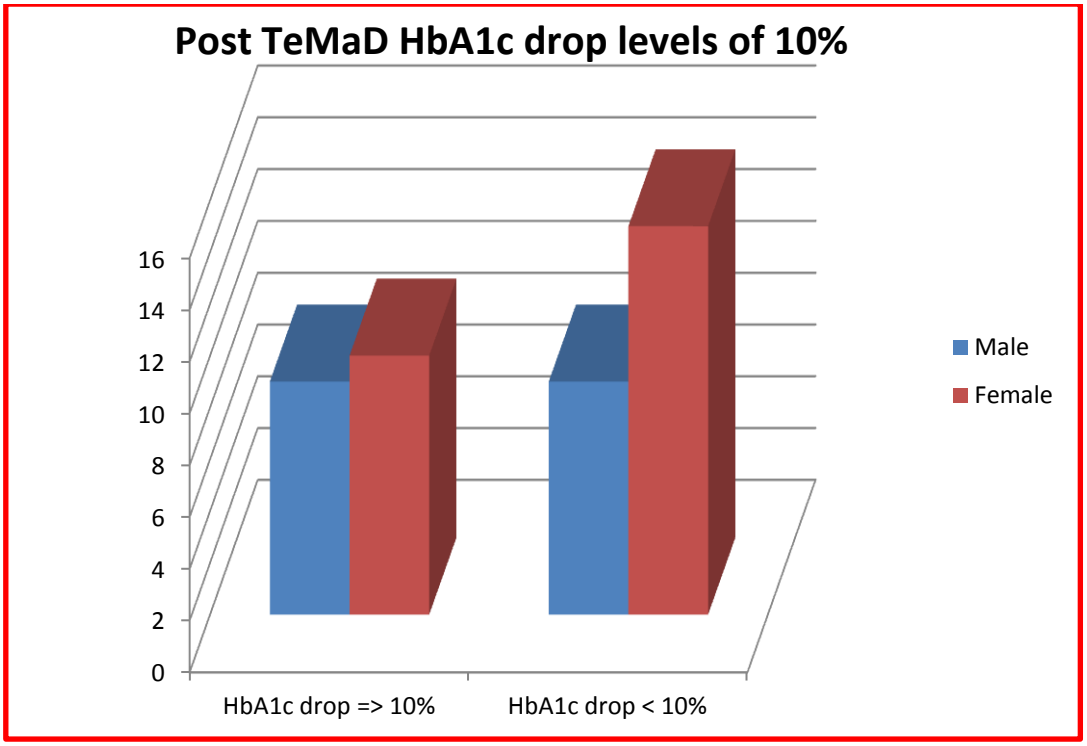


Figure 8.9: Post TeMaD HbA1c drop levels of 10% by gender

HbA1c levels were revisited after the completion of TeMaD by three or more months. Data was gathered for 34 participating patients, out of the total number of 52. The 34 patients had their HbA1c levels measured, and the following results were found:

Total number of patients = 34

Total number of patients recording an increase in HbA1c levels = 22

Total number of patients recording a decrease in HbA1c levels = 12

These statistics can be seen in figure 8.10.

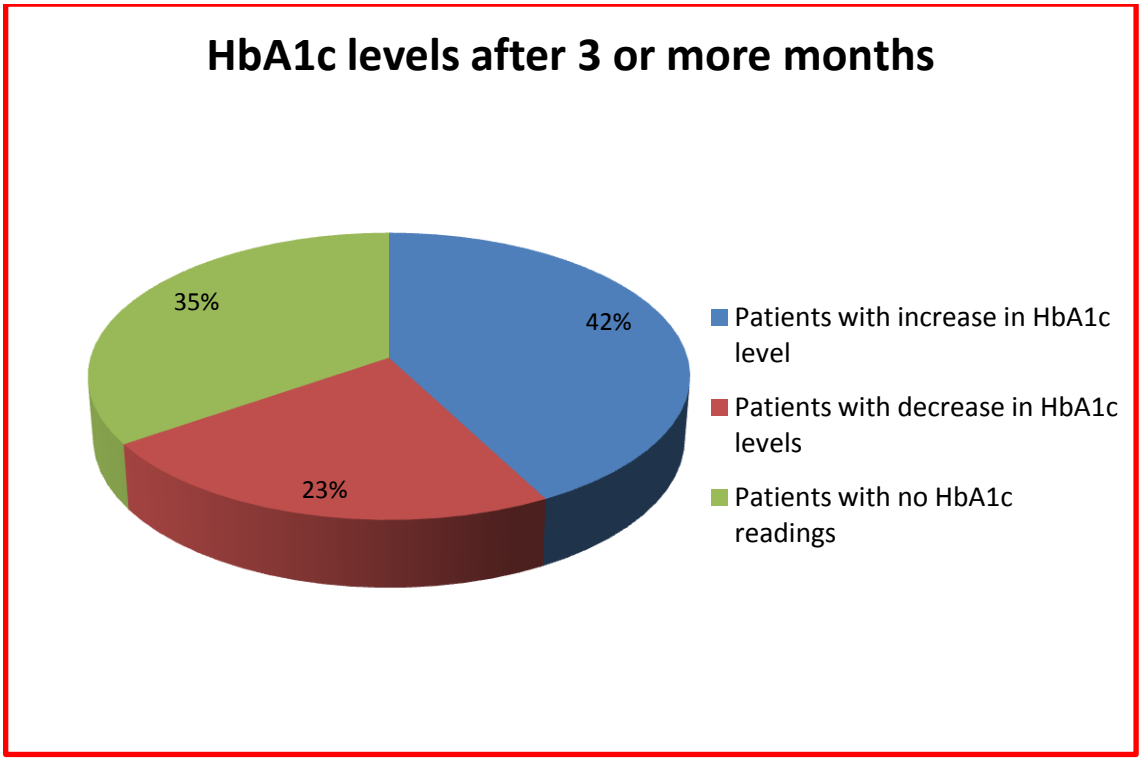


Figure 8.10: HbA1c levels of participants after 3 or more months

These results indicate that after the completion of TeMaD, when participating patients returned to the conventional method of diabetes management at the clinic, the *progress made during TeMaD was reversed*, and HbA1c levels for 42% of the revisited patients had risen again.

8.2.2 Evaluation of Questionnaires Data

Here we examine the results obtained from the questionnaires distributed to both involved DEs and participating patients, immediately after the completion of the TeMaD study. Data was analysed using SPSS (v14) based on frequencies. Questionnaires were designed in English, then translated into Arabic. DEs used the English version, but the Arabic version was distributed to the patients. The English version of the questionnaires can be found in Appendices. See Appendix (H) for DE TeMaD Completion Questionnaire and Appendix (I) for Patient TeMaD Completion Questionnaire.

8.2.2.1 DE Questionnaires and Findings

Out of the four involved DEs at the clinic, only three filled out the questionnaire. The results can be summarized as follows:

- All DEs request that high risk patients make weekly appointments at the clinic.
- While two DEs require that a newly diagnosed patient be seen once a week, one DE can request a visit every three days.

- On average, each DE sees 10-15 patients daily, which includes booked appointments and walk-ins.

- Out of four rankings: 'Excellent', 'Good', 'Acceptable', and 'Poor', all DEs rated hospital services as 'Acceptable'.

- All DEs indicated that the following two services need improvement:
  - Number of DEs at the clinic
  - Number of Physicians at the clinic

- All DEs indicated that female patients do complain about lack of transportation.

- DEs stated that 10%-20% of patients are late for their appointments, and that these patients are most likely to be female.

- All DEs believe that patients would be reluctant to use TeMaD if the system administrator is male.

- All DEs feel that TeMaD can assist them in managing the growing number of diabetic patients against the limited resources available at the clinic.

- Two of the DEs have never heard of Telecare solutions.

- Two of the DEs felt that the landline option of TeMaD was the most practical one.

- All DEs stated that the SMS option is effective for quick intervention and for raising awareness.

- All DEs indicated that the Admin interface of TeMaD was 'Fairly easy' to use.
- All DEs felt that TeMaD made it easier for them to contact patients, was more convenient than traditional services, and helped patients to manage their blood sugar levels better.
- Two DEs indicated that TeMaD would be 'most beneficial' to female patients and patients diligent about their readings.
- All DEs felt that TeMaD would be 'most beneficial' to patients living in rural areas and patients with access to technology.
- Two DEs believe that TeMaD will help in reducing long-term complications.
- All DEs would like NGHA to use TeMaD as a permanent solution.
- DE suggestions on how to improve TeMaD:
    - Assign a DE to administer the TeMaD application
    - Add information about patient medications

8.2.2.2 Patient Questionnaires and Findings

All 52 patients participating in the TeMaD study filled out a TeMaD completion questionnaire.

Data gathered, provided the following statistics:

- Of the total number of participants, 9.6% required more than one hour reaching the hospital, while 2% require 24 hours of travelling.
- 46.2% of patients indicated that they visit the hospital twice a month.
- 84.6% of patients stated that their appointments with the DEs are booked on time, so no problems setting up appointments.

- Out of the total number of participating patients, 86.5% rated hospital services to be 'Excellent'.

- Approximately 29% of patients, as displayed in figure 8.11, do not have permanent access to private cars, and are required to rely on alternative modes of transportation.

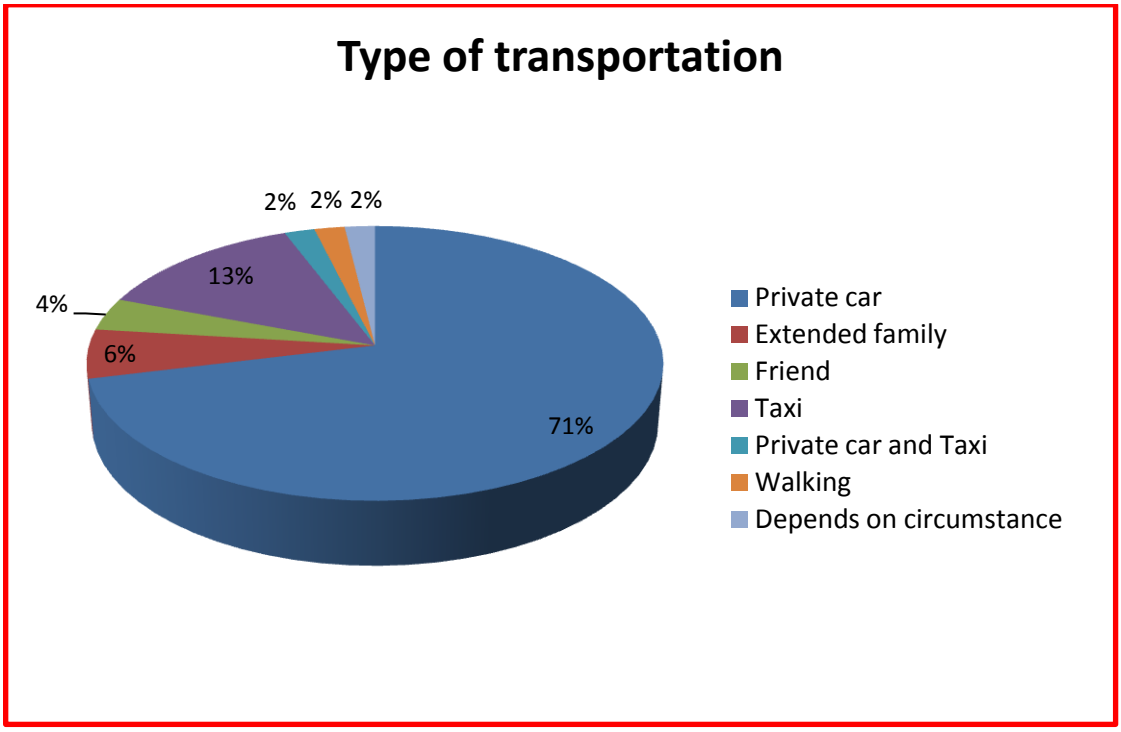


Figure 8.11: Type of transportation

- Approximately 38% of patients either *do have* or *sometimes have* problems arranging transportation, as indicated in figure 8.12.

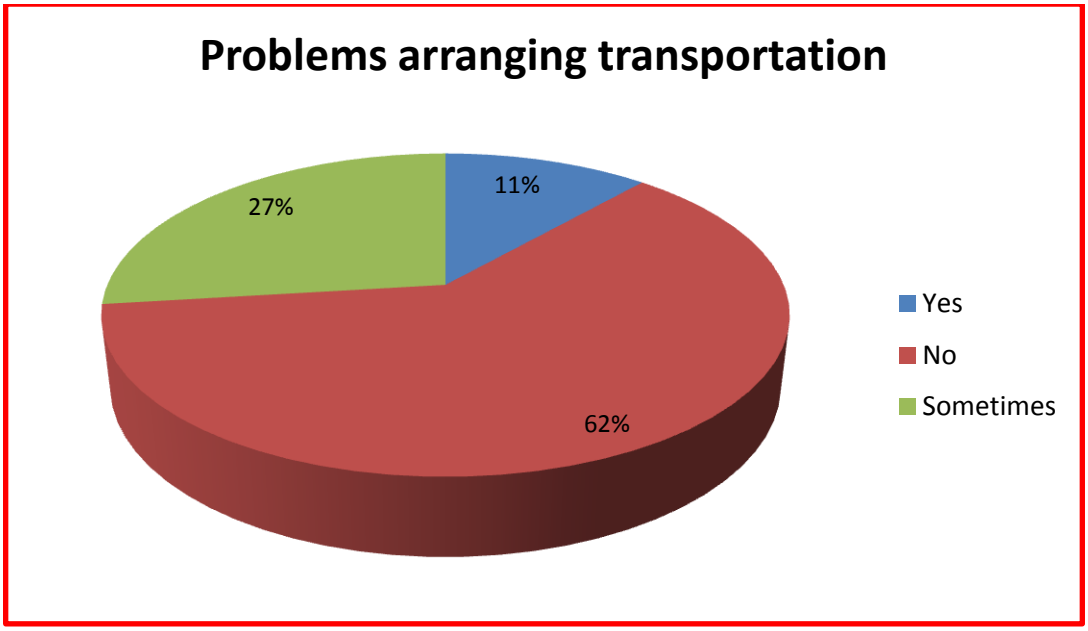


Figure 8.12: Problems arranging transportation

- Almost 62% of patients preferred dealing with the same-sex DE. This is most likely contributed to the sensitive nature of the Saudi society and the adherence to cultural and traditional factors which mainly promote segregation between the two genders.

- Before TeMaD, patients were asked if ever hearing about Telecare solutions, 65.3% stated that they had not.

- TeMaD offered three modes of use: Internet, SMS, and landline. Statistics show that the Internet mode was used the most, followed by the SMS mode, and finally the landline mode, as indicated in figure 8.13.

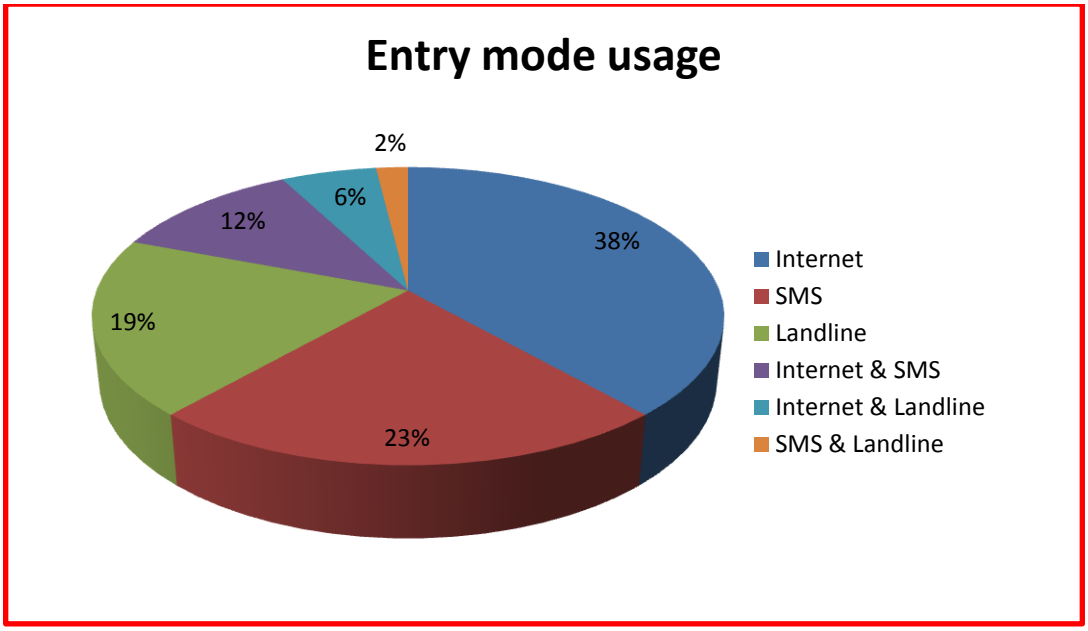


Figure 8.13: Entry mode usage

- While examining the three modes, we found that 48% used the Internet the most, and 52% preferred using the Internet mode.

- Almost 94% of TeMaD Internet mode users ranked it as 'Very easy' to use. This can be attributed to the design characteristics of the application, discussed in Chapter 7, and adequate training and supporting documentation available to participating patients.

- Approximately 70% of TeMaD SMS mode users ranked it as 'Very easy' to use.

- The statistics indicate that 84.6% of patients found TeMaD a more convenient way of dealing with their diabetes than traditional services offered by the clinic.

- Approximately 83% were happy with TeMaD response times. The application is developed following NGHA ISID development policies and standards, and adheres to interfacing protocols. This has resulted in an efficient, available, and reliable system.

- Almost 98% of patients stated that TeMaD assisted in better management of their diabetes.

- 90.4% of patients indicated that TeMaD made it easier for them to access the DEs at the clinic.

- One of the TeMaD goals is to raise awareness about diabetes, and features supporting this were incorporated into the application. Accordingly, 86.5% of patients confirmed that they received useful advice and comments from the TeMaD system.

- A number of improvements were suggested by patients. These will be discussed in Chapter 9.

- A total 96.2% of patients would like TeMaD to be offered as a permanent healthcare service at clinic 104.

8.2.2.3 Correlations

- Users of the Internet mode were mainly from the age group between 16-29 years.

  Internet users in Saudi are mainly of the younger population.

- Users of the landline mode were mainly from the age group 60-71.

  Older patients may steer away from newer technologies and therefore prefer landlines.

- Users of the SMS mode were mainly from the age group 30-49 years.
  This age group mainly consists of a working-class layer, where Internet technology may not necessarily be offered at the workplace, and SMS may therefore be more practical.

- Almost 63% of single female patients preferred dealing with same-sex DEs, much higher than their male counterparts in the same category.

  This indicates that there are more constraints on women than there are on men. These constraints are likely to be put in place by the parents, to ensure their daughters are seen as appropriate candidates for marriage. On the other hand, single males do not face the same constraints, where only 18.8% preferred dealing with the same-sex DEs.

- Out of the total number of patients indicating that they do have problems arranging transportation and rely on taxis as their primary mode of transportation from and to the hospital, approximately 29% are male and 14% are female.

  This can indicate that the taxi system in Saudi is not a reliable mean of transportation.

- Almost all patients living outside Riyadh (with the exception of one) requested that TeMaD be offered as a permanent service at the diabetic clinic and felt that TeMaD made contacting the DEs easier and helped in managing their disease better.

  TeMaD is a Telecare solution mainly targeting the remote care of patients. This is particularly beneficial to those living in rural areas or other cities, reducing the need to travel to receive medical services.

8.3 Summary

The study has shown that Telecare solutions can address many obstacles currently being faced by both the clinicians and the patients. These obstacles include factors attributed to the conservative Saudi society and culture.

The results presented in this Chapter have demonstrated how a Telecare solution can not only replace existing traditional methods of healthcare delivery, but also offer improvements on many fronts.

After completion of the trial, all involved DEs and many participating patients urged that TeMaD be offered as a permanent service at the clinic.

In this next Chapter, we will present an in-depth discussion of the impact TeMaD has had on the healthcare system at NGHA, in addition to recommendations for future work.

CHAPTER 9: DISCUSSION

9.1 Introduction

This research is concerned with examining the impact of Telecare solutions on the healthcare system in Saudi. The TeMaD system developed (Chapter 6), launched, and evaluated (Chapter 8) introduces a Telecare solution for diabetes management as an alternative method of delivering healthcare services.

The data gathered from this study is analysed in Chapter 8 and results derived. This Chapter will now present an in depth review of the TeMaD system, with an examination of the impact on diabetes management in particular. It discusses the influence TeMaD has had on the cultural and traditional aspects, and the benefits gained from using technology.

It is vital to assess if this research has maintained a steady track towards the aims identified in Chapter 1.

Finally, we discuss a number of paths that can be adopted for future research. All paths mentioned will provide healthcare officials in Saudi Arabia and the Gulf States with the necessary information required to take more steps towards eHealth solutions.

9.2 Review of the TeMaD System

The TeMaD system has proven to have a positive impact on the management of blood sugar levels of diabetic patients at KAMC-CR. While achieving this, the Telecare system contributed to many other areas related to the well-being of the patients. These areas include: improved disease management, enabling higher levels of patient independence, benefitting from technology, raising diabetes awareness, raising Telecare awareness, and successfully dealing with some cultural and traditional factors of a conservative society.

9.2.1 Disease Management

Since the very early stages of planning to build the Telecare system, and during numerous discussions with the clinicians at the diabetic clinic, it was clear that patients were categorised into different groups: *high risk, medium risk,* and *low risk*. Each group requires different management strategies. The characteristics of these groups are described in the following sections.

9.2.1.1 Risk Categories

Identifying the three risk categories and accordingly appointing patients to the appropriate group.

9.2.1.1.1 High Risk Patients

Patients under this category might share the following characteristics:

- All or most blood sugar level readings are extremely low or extremely high
- not diligent about measuring their blood sugar levels
- no/low awareness about their disease
- usually newly diagnosed

9.2.1.1.2 Medium Risk Patients

Patients under this category might share the following characteristics:

- a mixed setup of both normal and abnormal blood sugar levels
- not consistent in measuring their blood sugar levels
- low/medium awareness about their disease
- occasionally newly diagnosed

9.2.1.1.3 Low Risk Patients

Patients under this category might share the following characteristics:

- most blood sugar level readings normal
- diligent about measuring their blood sugar levels
- high awareness about their disease
- rarely newly diagnosed

9.2.1.1.4 Risk Assessment

The Telecare system allowed the DEs to easily place patients in the appropriate category based on their performance. This performance can be easily determined by reviewing the patient's weekly, monthly, and three-month chart.

Patients with most readings in the high and/or low sections of the graph depicted in red, as seen in figure 9.1, are categorised as high risk patients.

Figure 9.1: High risk patients

Those with mixed readings, normal and abnormal, falling in both the red and green sections of the graph, as seen in figure 9.2, are categorised as medium risk patients.

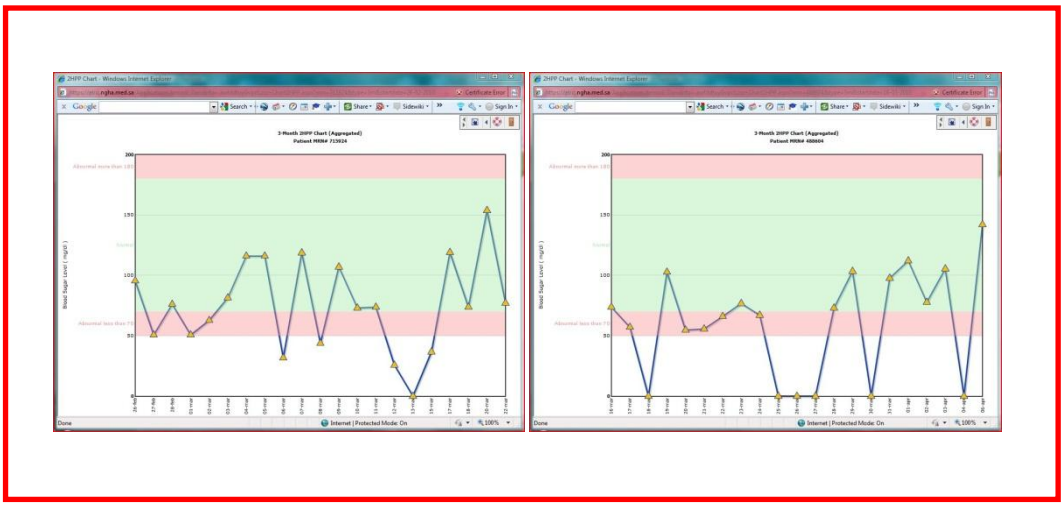


Figure 9.2: Medium risk patients

Finally patients with most readings in the normal range, depicted in green in the graph, as seen in figure 9.3, are categorised as low risk patients. Patients in this category are seen to be the most suitable candidates to use Telecare solutions, as stated by the DEs at the diabetes clinic.

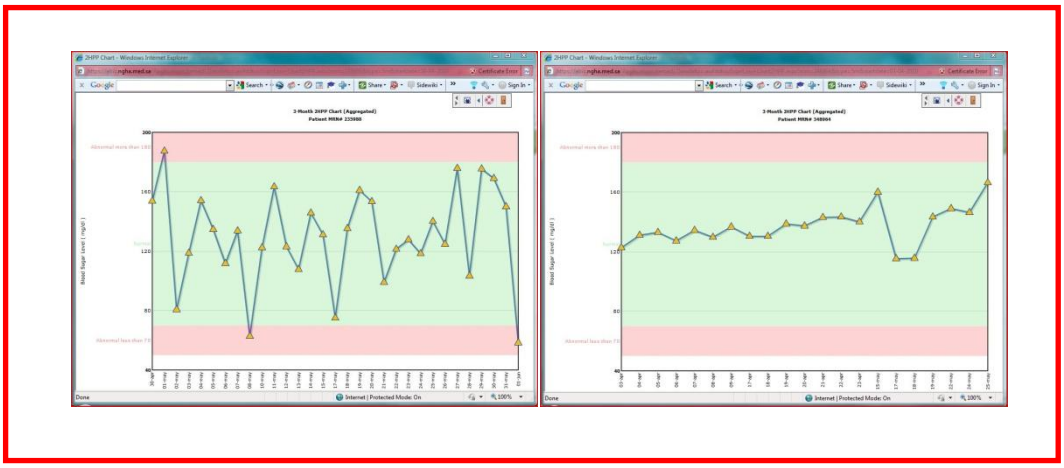


Figure 9.3: Low risk patients

This visual feature allows clinicians to easily categorise patients and deal with them accordingly based on their needs.

The graphs in Figures 9.1, 9.2 and 9.3 were recorded during the trial period and therefore use the previous colour scheme (red and green). As indicated in section 7.5.2.4 in Chapter 7, a colour-blind safe scheme (using different colours) was later adopted to enhance the system offering a more user-friendly interface.

9.2.1.2 Time of Diagnosis Categories

Diabetic patients were also grouped into two sets in relation to time of diagnosis: *newly diagnosed* and *previously diagnosed*. Again management strategies differ with dealing with these two sets.

9.2.1.2.1 Newly Diagnosed

Diabetic patients in this category might share these characteristics:

- visit the clinic more frequently (i.e., 3 – 5 times monthly)
- receive longer appointment slots for discussions with DEs
- attend educational sessions to raise their awareness of diabetes
- are monitored more closely

9.2.1.2.2 Previously Diagnosed

Diabetic patients in this category might share these characteristics:

- visit the clinic less frequently (i.e., once or twice monthly)
- receive shorter appointment slots for quick review of recorded readings
- require occasional monitoring

9.2.1.2.3 Patient Assessment

The Telecare system grants the clinicians the ability to deal with the patients based on when they were diagnosed. Newly diagnosed patients would require:

- additional advice sent via SMS
- periodic encouragement sent via SMS
- more diabetes information available on the website
- close monitoring of recorded readings
- information about diabetes-related events sent via SMS to raise awareness
- reminders promoting daily physical activity

While previously diagnosed patients might require:

- less frequently sent advice via SMS
- moderate monitoring of recorded readings
- information about diabetes-related events sent via SMS to raise awareness

DEs had strong opinions about Telecare solutions being more suitable for a specific group of patients, such as those who are not newly diagnosed, are low risk patients, with access to technology.

9.2.2 Giving Diabetic Patients More Control

Telecare solutions are adopted in order to achieve a number of goals. Many of these goals are oriented towards improving healthcare services. Better services can usually lead to happier patients, and hopefully healthier individuals.

TeMaD was offered as a Telecare solution, alternative to the traditional methods offered at NGHA clinic 104. Based on statistics produced from data gathered in the patient questionnaires, TeMaD received a high approval rate from participants, assisted in better management of the disease, and was requested by many patients to be offered as a permanent solution at the clinic.

TeMaD offers patients a number of easy methods (i.e., Web interface, SMS, and Landline) to record their readings, allowing immediate intervention by DEs when necessary. Numerous projects have indicated that telecare applications with Web interfaces, in particular, may guarantee accessibility and usability advantages to both the patients and healthcare givers [97].

It also granted patients more control over their disease, by easily monitoring the history of their readings using the graphs. It strengthened communication channels between the DEs at the clinic and the patients.

Most importantly, TeMaD allowed patients more independence, reducing the number of hospital visits, with less interruption to their daily routines.

A study examining how autonomy may motivate diabetics to control their glucose levels stated that "*patients may display improved physiological outcomes*" when "*the health care climate is experienced as being rich with provision of choice, information about the problem, acknowledgement of the patients' emotions, and minimal pressure to behave in particular ways*" [98]. It concludes by stating "*that attention to psychosocial factors in patient care can have a significant influence on important physiological outcomes*".

9.2.3 Shifting Towards an Electronic System

The healthcare industry in Saudi Arabia is struggling with the growing population, rapid increase in chronic diseases, in particular diabetes, and other related factors. In spite of the tremendous support offered by the Government, a lack of resources continues to exist. This situation is the same in many other developing countries.

Over the past few decades, technology has been adopted in the healthcare field to assist in overcoming struggles. Many applications have been extremely successful in achieving their goals, such as clinical information management systems and patient electronic health records. In particular, research examining the effect of mobile phone intervention on glycemic control in diabetes self-management has concluded with positive results [99]. The implementations of such applications have been able to provide the healthcare industry with the necessary means to overcome some common obstacles such as lack of resources, as is the case with Tele-nursing [100].

Such applications have also proven effective in offering higher availability, reliability, and reduction in human errors. In addition, they offer quick access to information, which could sometimes be critical in the healthcare field.

However, Telecare solutions attempt to target remote patients they may not have adequate access to medical resources. In order for such solutions to succeed, the technology needs to be stable and reliable. Also, the speeds at which data is transmitted between the Telecare system or healthcare giver and the patient, are crucial to ensure accuracy and allow for timely intervention. As indicated by Al-Damen *"Mobile access to the Internet and wireless services have improved in Saudi Arabia, but are still not universally reliable, thus causing potential issues for medical monitoring."* [101].

Finally, while taking steps towards an electronic system, we must closely examine western-based systems to optimise the possible impact on the healthcare system, by comparing similar factors and associated issues. The EU-funded project, Multi-Access Services for Telematic Management of Diabetes Mellitus (M2DM), shares many concepts with TeMaD. This project offered a successful telecare solution that is "well accepted by patients and clinically effective" [102].

9.2.4 Dealing with Cultural and Traditional Factors

As discussed previously in Chapters 3 and 4, this research is involved with examining whether or not Telecare solutions can address cultural and traditional factors of a highly conservative society bound by strong religious beliefs.

Telecare has been defined repeatedly by many in the health informatics field as a means to provide remote healthcare services, using existing technologies, to those in need. Most definitions of the term particularly focus on patients with a number of common factors, such as: elderly patients, patients in rural areas, and patients physically less able.

The UK Department of Health, defined Telecare in 2005 as that which*: offers the promise of enabling thousands of older people to live independently, in control and with dignity for longer* [103]. The Telecare services association defines Telecare as "*a service which provides people who are usually elderly or vulnerable with the support to help them lead independent lifestyles" [104]*.

Finally a study by the European Telecommunications Standardisation Institute states that Telecare *"is a strategic enabler of independent living for people with functional limitations"* [105].

Given these categories of patients that Telecare targets, this research attempts to broaden the scope of Telecare. It suggests that Telecare can also be used for a category of patients that may be younger, physically able, and capable of leaving their homes, but face obstacles in the form of traditions and cultures which limit their access to quality healthcare services.

A successful Telecare solution is that which can address the needs of both the healthcare givers and the patients in a way that is welcomed by both. It can achieve positive medical results while smoothly integrating into the patients' lifestyles. If this can be achieved, little or no resistance can be expected from users.

When deploying a Telecare solution in Saudi Arabia, the case might slightly differ than in other countries, due to conservative traditions and culture. Factors discussed at length in Chapter 3 portray how the Saudi society is a truly unique one.

The TeMaD Telecare solution offered the healthcare system at the KAMC-CR diabetes clinic a method to deliver quality healthcare services to specific patients where Saudi traditions and culture would have otherwise been limited or even prevented.

It offered to maintain gender segregation between patients and healthcare givers. It also offered patients a less intrusive manner of dealing with their disease, which in turn maintained higher levels of privacy for patients. It granted patients more independence from the hospital, contradicting the idea by some on the society that diabetics are unhealthy individuals, affecting both their personal and professional lives.

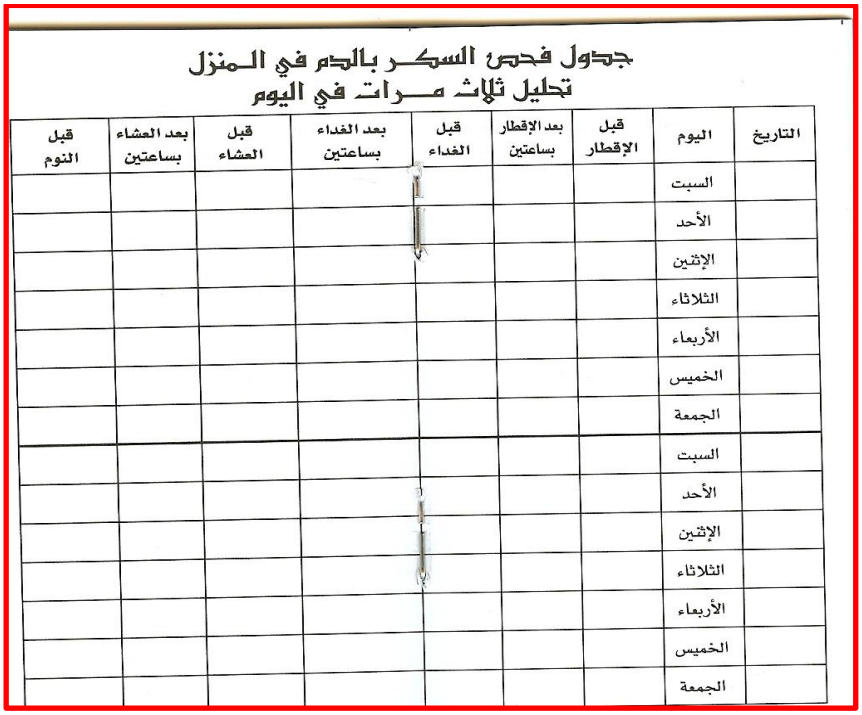
9.2.5 Better Communication Channels Allowing Immediate Intervention

Prior to the introduction of TeMaD, all diabetic patients at clinic 104 were required to record their blood sugar levels daily in a small booklet distributed by the clinicians. At every appointment, the patient submits the booklet to the clinician, for a complete review of all readings taken since the last appointment.

Although the readings booklet is the size of a hand, see figure 9.4, there is a high probability that the patient loses the booklet, or forgets to bring in to the appointment. This means that the clinician would have no accurate information indicating how the patient has been managing the blood sugar level.

Figure 9.4: NGHA Blood Glucose Readings Booklet

The booklet displays a table for seven reading entries for a period of two weeks on each page. Table 9.1 shows the 'time of reading' in the columns area, and the 'day' in the rows area. This design may lead to error in readings entry, resulting in inaccurate data.



جدول فحص السكر بالدم في المنزل
تحليل ثلاث مرات في اليوم

التاريخ	اليوم	قبل الإفطار	بعد الإفطار بساعتين	قبل الغداء	بعد الغداء بساعتين	قبل العشاء	بعد العشاء بساعتين	قبل النوم
	السبت							
	الأحد							
	الإثنين							
	الثلاثاء							
	الأربعاء							
	الخميس							
	الجمعة							
	السبت							
	الأحد							
	الإثنين							
	الثلاثاء							
	الأربعاء							
	الخميس							
	الجمعة							

Table 9.1: Blood Sugar Level Readings Entry Page

In addition, this system cannot support immediate intervention if needed. Drops or rises in the blood sugar levels can only be detected at the next appointment. This can be dangerous when dealing with patients who do not conform to treatment regiments. TeMaD offers open communication channels between the patients and the clinicians, and enables clinicians to monitor patient readings more closely, allowing immediate intervention whenever necessary.

9.3 Future Work

Previous chapters discussed the design, development, testing, and integration of the TeMaD system. The system was developed to serve a number of purposes with a clear set of goals and objectives. Here we discuss how this research can be continued, offering a number of suggestions and recommendations.

9.3.1 A More Powerful TeMaD System

NGHA consists of four primary medical cities located in three different regions [106]:

1. King Abdulaziz Medical City, Central Region: Riyadh

2. King Abdulaziz Medical City, Western Region: Jeddah

3. King Abdulaziz Hospital, Eastern Region: Al Ahsa

4. Imam Abdulrahman Al Faisal Hospital, Eastern Region: Dammam

In addition, it offers its patients healthcare services through 60 primary health clinics located in different parts of the Kingdom.

Although TeMaD was designed and developed with full integration into existing NGHA HIS's, connecting to resources (i.e., databases, networks, etc.) in both the central and western regions, it was only used at the diabetes clinic at KAMC-CR.

However, the system was designed in a manner that would allow it to be deployed at any of the other three primary medical cities of NGHA. Future work could most definitely examine the impact and performance of the system as follows:

- over the NGHA WAN spanning across three regions and four cities, using the existing TeMaD authentication and access processes, examining system integration, accessibility, interoperability, and efficiency,

- it could be deployed in the 60 primary health clinics which are mostly positioned in rural areas that are hard to reach, to maximise on the benefits of Telecare,

- it is natural to find variations in the traditions of people living in different regions, it might therefore be beneficial to examine if TeMaD can overcome different social aspects that may pose as healthcare obstacles faced in the other regions.

In addition, feedback gathered from the patient and DE questionnaires revealed some useful recommendations on how to improve the TeMaD system.

Recommendations by the DEs included:

- Appointing a permanent DE to deal with the application

- Giving the DE access to all medications prescribed for a given patient

Recommendations by the patients included:

- Setting up a forum
- Online support sessions
- Involving the Endocrinologists in the TeMaD system
- Send advice to patients through SMS more frequently
- Have the physicians use the system
- Establish a toll-free number for the landline and SMS options
- Provide more information on diabetes on the website
- Use email to communicate with the patients
- Allow patient to send additional information to DE
- Reduce number of readings needed
- Add diabetes-related FAQ on the website

For TeMaD to become a more powerful system, it would be beneficial to conduct further studies on how immediate medical intervention enabled by TeMaD can possibly affect the number of hospital readmissions of diabetics at NGHA. An article published by the *Hospital Impact Organisation* stated that mobile applications have the potential to reduce hospital readmissions [107].

In addition, the current advancements in wireless technology, and its integration with diabetes monitoring tools is a promising concept. Current research is examining the use of mobile wireless glucose meter, enabling patients to upload their readings directly to a central system [108]. Such a feature may prove to enhance the TeMaD system and increase user satisfaction.

9.3.2 Incorporate the Use of Smartphones with TeMaD

Smartphones are mobile phones that offer advanced communication and computing capabilities. These may include Internet access and geo-positioning systems. They normally offer larger screens with high resolution. Newer generation Smartphones

have built-in cameras, recording capabilities, and personal management tools [109]. The availability of various platforms (i.e. Android, Apple iOS, RIM Blackberry, Symbian, and Windows Mobile 6.x and Windows Phone 7 Platform) and numerous data plans have led to reduction in cost, allowing ownership by younger generations [109].

The research presented here examines the potential of mobile phones in impacting how healthcare services may be offered. However, Mobile health (mHealth) applications are on the rise, and many clinicians and healthcare professionals are adopting Smartphones in everyday practices. Furthermore, patients are now getting more involved in their healthcare, using Smartphones to accessing healthcare information and also as a means to stay in contact with their healthcare givers [110, 111].

According to Kailas et al. [110], in 2010 there were more than 7000 Smartphone health applications. Many support the care of patients with chronic diseases such as Diabetes offering remote monitoring capabilities. One such application is the WaveSense Diabetes Manager, a free iPhone application from AgaMatrix, which offers the user an interactive tool to manage their disease, stay in touch with their healthcare giver, and easily access related information. In addition, AgaMatrix has developed a "WaveSense Direct Connect Cable" which connects to a Glucometer, allowing automatic upload of blood sugar levels [112].

A more advanced system which targets patients with multiple chronic diseases is the EU-funded eCAALYX (Enhanced Complete Ambient Assisted Living Experiment). It uses an Android Smartphone application which receives input from a Body Area Network (BAN) through a patient-wearable smart garment with wireless health sensors, and a Global Positioning System (GPS) location sensor in the Smartphone, and communicates through the Internet with a remote server accessible to the healthcare givers [106].

Having discussed these recent advances with Smartphones, TeMaD should be expanded in the future to include a Smartphone application offering its users more features and functionality, in order to achieve higher levels of quality patient care.

9.3.3 Using TeMaD for Managing Other Chronic Diseases

Telecare solutions have been developed for use in a number of medical specializations. They have been particularly successful in assisting patients with chronic diseases, due to the nature of these diseases and the methods of healthcare

services associated with them. Numerous studies in the past two decades have taken place, examining the impact of Telecare on the management of chronic disease.

Many Telecare solutions have been developed for managing patients with hypertension. A study conducted in 2002, indicated that telemedicine improves diagnosis of essential hypertension compared with the traditional care services [113].

Another study examined the impact of Telecare solutions on diabetes, heart failure, cognitive impairment (dementia and/or Alzheimer's disease), chronic obstructive pulmonary disease, chronic wounds and mobility disabilities. The results indicated that patients were generally satisfied with the Telecare and that it did result in a reduction of cost due to time saving and avoidance of travelling [114].

Having taken this into consideration during the initial planning stages of the TeMaD project, the application was designed in a manner that will allow customisation. This flexibility in the design can be used for TeMaD to manage other chronic diseases. The same system interfaces with other HISs are used, while additional ones can be created to link to other required HISs at NGHA. The same patient and healthcare giver access to the system can be used, relying on patient MRN as the primary ID, and the NGHA network account as the primary healthcare giver ID. The friendly graphical user interfaces of the online application can be used to add new web-pages as necessary. Current security measures will apply.

Furthermore, during the TeMaD trial at the diabetic clinic, a number of participating patients suggested using TeMaD:

- in the Dermatology clinic
- for patients with physical disabilities

These suggestions are worth examining more closely to determine the viability of such implementations. Many Tele-dermatology studies are currently being conducted to establish the suitability of such an application, and a number of benefits are being realised. However, caution is necessary, since a recent study by Yale University researchers warned about relying on Tele-dermatology as a substitute for total body examinations of patients that are suspected in having skin cancers [115].

9.3.4 TeMaD for Hajj

This research looks at aspects that make Saudi Arabia unique from any other country. It examines the impact Telecare can have on factors that are unique and new, and explores possible benefits from such applications.

A factor that also is unique to the Kingdom and has not been previously discussed in this work is the fact that Saudi Arabia is the home of the two holy mosques held sacred by all Muslims. It hosts the annual Hajj season, in which pilgrims from all over the world come to Saudi to participate in this ritual. Their visit to Saudi mainly consists of visiting the 'Masjid Al Haram' in Makkah and participating in a structured ritual carried out mostly in Makkah and its surrounding areas.

Each year, Saudi Arabia hosts over two million pilgrims over an average period of two weeks. The Saudi government has pledged full support to these pilgrims, also called 'guests of the Merciful'. Support includes health services, transportation and accommodation. The health services are primarily provided by the Ministry of Health and are free of charge.

The latest statistics provided by MOH indicate that in 2009, a total of 2.3 million worshippers travelled to Makkah, with 69% arriving from outside the kingdom. The MOH provided 21 hospitals, 7 of them are seasonal operational only during the Hajj period. It also provided 157 health centres, 119 of them are seasonal during Hajj. These resources offer a bed capacity of 3,408, with a ratio of one bed / every 679 pilgrims. Each health centre has the capacity to provide health services to 14,734 pilgrims. In addition, the rate of outpatient visits to hospitals and health centres is 40 visits / 100 pilgrims [116].

The number of manpower MOH recruited to work in the pilgrimage season is 17,886, with 68.9% physicians. The average physician served 612 pilgrims, while the average nurse served 372 pilgrims, and the allied health personnel served 996 pilgrims [116].

In spite of these resources, the Hajj rituals take place in areas located within a 22 kilometres zone. Hajj stages require that the pilgrims travel from one location to another within a certain time frame. Considering the fact that there are 2.3 million pilgrims travelling all at the same time, this makes relocation of centres difficult, and also limits services offered by permanent centres.

These attributes make Hajj ideal for remote healthcare services. TeMaD can be deployed to remotely deal with diabetic pilgrims, assisting them in the management of their disease. This is especially necessary in Hajj where meals may not be structured, diets may be compromised, with above average physical energy exerted during the rituals. These factors may cause blood sugar levels to increase or decrease

to abnormal rates. TeMaD can assist in monitoring the blood sugar levels and help patients maintain normal levels.

In addition, the Hajj season follows the Hijri (lunar) calendar. During the next decade, Hajj season will coincide with summer, and there is no doubt that the MOH will require additional resources to deal with growing numbers of patients suffering from sun strokes, heat exhaustion and other heat related medical conditions.

TeMaD can be customized to assist healthcare givers to deal with such cases remotely.

9.3.5 Collaboration with STC

In the past few years, STC has targeted the healthcare sector, providing specialised healthcare services. Recently, the Easy Clinic service was launched, providing a "*set of specialized medical applications designed to automate and standardize patients' electronic records and work processes for paperless healthcare service providers and connect them together*" [117]. The claimed benefits include being: cost effective, high security, efficiency, performance and automation; content management; high quality; health providers' linkage; and increased productivity [117].

Furthermore, in 2009, STC launched the 'Sehhatak', meaning *Your Health*, as an STC Bouquet consisting of a number of channels, each offering medical services in a specialised area. The Diabetes channel, launched in 2010, is considered one of the main services, and offers diabetics various options such as measuring BMI, access to healthy diets and understanding Insulin levels by interacting with users through SMS. In November 2010, STC collaborated with KSU National Diabetes Centre with a nation-wide campaign, *'Careful… Diabetes is Knocking on Doors!',* to raise awareness and promote the new service. Figure 9.5 displays a campaign advertisement.

Figure 9.5: STC/KSU National Diabetes Centre Campaign 2010

Collaborating TeMaD with this program will enable us to expand the numbers of diabetic patients in Saudi under one system with the goal of establishing a diabetes database, able to present statistics and trends on a national level. This would require encouraging other medical centres and hospitals to share data, which is most likely a complicated task, only achievable with the support of the MOH.

9.3.6 TeMaD for the Gulf States

This research examines the impact of Telecare solutions on the healthcare system in Saudi Arabia. It focuses on obstacles within the society in the shape of traditions and culture, which can affect how healthcare services can be offered.

A number of social factors were researched, such as segregation between the genders and lack of adequate transportation.

As indicated in Chapter 4, the International Diabetes Federation showed that out of the top ten countries with the highest prevalence of diabetes, five are in the Gulf. In 2007, the diabetes prevalence rate was the highest in the United Arab Emirates at 19.5%, followed by Saudi Arabia at 15.7%, then Qatar and Bahrain both at 15.2%, and Kuwait at 14.4%, and finally Oman at 13.1% [54].

The other Gulf States may share some of these social obstacles covered in this research. The traditions and culture of these societies are similar to those in Saudi Arabia. Therefore, future work may involve the implementation of TeMaD in hospitals in the Gulf States. It would be interesting to study the impact of TeMaD on diabetic patients in these states and also offer a comparison of results obtained through TeMaD for diabetics in different Gulf States.

9.3.7 A Unified Front Towards Telecare

Although there are a number of serious initiatives taken in Saudi Arabia by the Ministry of Health, SAHI, and other interested organizations and healthcare institutions, there is no unified front.

A project conducted by the Whole System Demonstrator and Active Network (WSDAN) in the UK, examined the experiences of the network's twelve member sites in implementing Telecare. Results, published in a briefing paper in November 2011, indicated that three themes emerged when adopting Telecare: leadership; working practices, skills and development; and data management. For growth and

sustainability, *"collaboration within and across organisations; leadership; developing alliances and partnerships; identifying critical services; developing a shared vision; cultivating participation; building capacity; exploiting funding opportunities; and working across professional boundaries"* are key characteristics [118].

The Saudi healthcare sector must learn from such experiences in other countries and establish unified standards among all concerned bodies, and present a clear plan in order to take solid steps towards incorporating Telecare into the healthcare system.

9.3.8 Combine Telecare solutions with Social Media

There is a rapidly growing number of users in Saudi Arabia getting connected to social media networks on the Internet. Social sites such as Facebook and Twitter are growing in popularity. The healthcare sector in Saudi should start investigating how these social networking sites could act as a platform for exchanging and sharing information. In addition, they need to also assess if these sites can act as effective tools for raising awareness and promoting healthy lifestyles. An article published in The Hospitalist indicated that "*Many healthcare facilities use social media to crowd-source, or basically ask for input from users to help develop or improve products and services quickly and efficiently. Others are enabling real-time learning through podcasts of surgeries, which medical students can attend remotely*." [119].

9.4 Summary

The discussions presented in this Chapter have proven the positive impact TeMaD has had on the management of diabetes at NGHA. In addition to assisting healthcare givers (DEs) at Clinic 104 to better manage the available resources, it has offered a strong tool to identify different groups of diabetic patients, where patients in each group may require a different type of health service.

As for future work, TeMaD can incorporate additional functions to improve the system. It was built in a manner that would allow easy customization. Hence, use in other medical specialisations at NGHA can be easily arranged with minimum development required.

TeMaD would be a highly effective tool to assist in diabetes management for pilgrims during the Hajj season, due to the nature of this ritual. It could also be used as a Telecare model for other Gulf States facing similar obstacles in the healthcare sector.

CHAPTER 10: CONCLUSION

10.1 Introduction

The research presented here strives to achieve goals set earlier. In achieving our goals we are capable of slightly altering how healthcare services are offered in Saudi Arabia. We present a method that can overcome obstacles faced every day by both patients and healthcare givers. For many years, the healthcare system in Saudi has struggled with these obstacles, which include limited resources, increasing number of patients, and demand for better healthcare services.

This research presents a Telecare solution that can be used as an alternative method of managing diabetes. It allows patients to live more independently, and to pursue a more 'normal' life, away from hospitals. It allows patients to go about their daily routine, at work, at school, or elsewhere, with minimal disruption and interference. This no doubt has shown that patients become more satisfied with healthcare services, which in turn can lead to better management of their disease.

The system developed for this research has also been able to successfully raise patient awareness about their diabetes. Higher awareness levels can positively impact how patients manage their disease. The system, through both SMS and Internet, is used to raise awareness on how to prevent diabetes. It offers reminders and advice to NGHA patients to maintain a healthy diet and to regularly exert physical activity. As indicated in a study on prevention of diabetes "*prevention of diabetes is primarily dependent on altering lifestyle and increasing levels of physical activity, changing societal perceptions of health and improving knowledge about the risk factors of diabetes and steps to promote physical activity must receive urgent attention of policy makers and health care planners*" [120]. This is an important

aspect of the system given the high prevalence of diabetes in Saudi, especially among younger patients. Officials in the healthcare system already fear the negative impact this will have on the economy.

10.2 Meeting the Objectives

Before embarking on this research, a number of objectives were set. The purpose of these objectives is to be able to accomplish achievements where new knowledge in this field can be presented, and positive impact can be made on the healthcare system in Saudi Arabia.

The objectives set vary from accomplishing achievements in a focused area of research, to more general areas.

Our research objectives have been presented in Chapter 1, here we attempt to examine whether or not they have been met, and if so, to what extent.

1. ***Analysis of current diabetes management tools and techniques.***

   In Chapter 2, we present a literature review of current diabetes management tools and techniques. We focus on the solutions offered in developing countries. Unfortunately, studies conducted on the situation in developing countries are limited and sometimes contradicting. Only reliable information was incorporated into this research. More studies on diabetes management tools in developing countries need to be conducted and published.

2. ***Examination of available technology to assist in diabetes management.***

   Today the technological options that can be used for diabetes management are numerous. New technology emerges every day. However, to successfully offer alternative methods of delivering healthcare services using technology, it is essential that we adopt technology that is available to the masses, inexpensive, and familiar. This ensures minimal resistance by users. The system developed for this research therefore uses Internet, SMS, and landline as the primary methods of communication between the patient and the

healthcare giver. All three methods are common, familiar, and available to all patients. Moreover, offering three methods instead of only one ensures that each patient has the flexibility to select the most convenient one.

3. ***Devise a model to be used for Telecare implementations at the National Guard Health Affairs (NGHA) using a methodological approach.***

A model has been devised to illustrate how to develop a Telecare solution at NGHA. Due to the nature of the situation we are dealing with and the associated social and cultural factors, the Soft Systems Methodology was used for its strengths in dealing with messy situations involving social aspects of human behaviour.

4. ***Develop a Telecare solution for Diabetes Management***

TeMaD is a Telecare system which has been developed with the aid of NGHA developers, following HIS-approved standards. It is integrated into a number of HIS at both KAMC-CR in Riyadh and the Unified Messaging System at KAMC-WR in Jeddah. The system has been deployed for use at the diabetes clinic at KAMC-CR; involved clinicians and patients have received appropriate training to use the application.

5. ***Implementation of the Telecare solution and integration into existing NGHA Hospital Information Systems (HIS)'s.***

TeMaD has been integrated into a number of existing NGHA HISs. It receives demographic data of the patient from the CIMS. It then connects with the Lab system to retrieve medical information of the patient (i.e., HbA1c test results). It is also linked via WAN to the UMS in Jeddah to use the SMS module allowing communication between the patient and the healthcare giver. The application runs on a web-server which publishes the TeMaD website offering both the Admin and User interfaces. This integration is clearly depicted in the TeMaD system architecture presented in Chapter 6 (see figure 6.7).

6. ***Measure the impact the Telecare solution on NGHA Healthcare system***

Both the statistics gathered from TeMaD and the results of the questionnaires given to both patients and diabetic educators reveal the positive impact TeMaD has had on the NGHA healthcare system. TeMaD was able to reduce the HbA1c levels of most patients by 5%. It also reduced the number of visits required by these patients throughout the three month study period. This freed up some clinic time and led to better management of the resources. TeMaD was also able to raise awareness of diabetes among patients, and lead to better management of blood sugar levels by patients. Useful advice and reminders sent periodically to patients proved to be effective.

7. ***Determine level of acceptance of Telecare among healthcare professionals and patients at NGHA.***

The questionnaires distributed to participating patients in the TeMaD study and involved diabetic educators at the clinic revealed high acceptance levels of the system by both groups. A number of patients and DEs gave suggestions on how to improve the system, while a large number of patients and all DEs urged to establish TeMaD as a permanent service at the clinic.

8. ***Identify healthcare services at NGHA that can most benefit from Telecare solutions.***

Chapter 9 discusses future work in continuation to the research conducted. It suggests using the TeMaD system to manage other chronic diseases that are rapidly spreading, such as hypertension. Again the NGHA clinics treating patients with hypertension suffer from growing numbers of patients and limited resources. TeMaD can also be customized for use by other medical specialization such as dermatology.

10.3 Contribution to the Field

Over the past decades, much research has been conducted on the impact of eHealth solutions, including Telecare, Tele-medicine, and other related areas. The majority of this type of research is taking place in Europe and North America. Extremely limited research is being conducted in the Middle East, particularly in the Gulf States. The populations in this region are known to share similarities, in the culture and traditions, and most importantly, in their religious background and how it shapes their society. This setup creates a unique structure which needs to be taken into consideration when attempting to introduce new trends of healthcare solutions. If such healthcare solutions are applied without the acknowledgement of social barriers and needs, they will most likely be rejected and resisted by the population.

10.3.1 Telecare for a New Category of Patients

This research attempts to broaden the scope of which categories of patients should be targeted for Telecare solutions. Most definitions of Telecare indicate them being most suitable for 'elderly' and 'physically less able' patients, to allow them more independence in their homes. Telecare also targets patients that are hard to reach. This research suggests that patients facing societal obstacles such as lack of transportation, traditional and cultural factors could be excellent candidates for Telecare solutions. Furthermore, this research suggests that the aim of Telecare solutions is not only to allow 'elderly' patients to be more independent in their homes, but also for young patients to be more independent from the hospital and their healthcare givers, in order to maintain a more normal lifestyle.

10.3.2 A Scientifically Applied Telecare Solution

This research also focuses on using a methodological approach to apply a Telecare solution at the NGHA. This work has not been attempted at NGHA before. The first Telecare solutions offered have been products of a prototyping approach. No Telecare solution has been developed using a methodological approach and then integrated into the NGHA infrastructure, and none of the solutions have been trialled in a clinic.

10.3.3 Unique Setup in Saudi Arabia

The research concentrates on how the unique makeup of the Saudi society can impact how Telecare solutions are applied. It looks into factors not shared by any other countries such as the law banning women from driving, and the extent of segregation between the genders, which exceeds that practiced by neighboring countries. The impact of these unique factors has not been examined or researched in any published work. This research presents new findings and encourages further research.

10.3.4 Research Documented for NGHA, MOH, and Other Interested Entities

In 2009, the MOH announced its five-year program to transform healthcare delivery in Saudi Arabia. Figure 10.1 shows the structure of the program, which primarily focuses on the MOH eHealth vision [85]. The research conducted here, including statistical information and study findings will no doubt benefit MOH officials.

Figure 10.1: MOH five year program

NGHA has been one of the frontiers in eHealth. The initiative to establish SAHI initially involved NGHA policy makers. NGHA is the first entity in Saudi Arabia to offer a Masters Degree in Health Informatics, given at the King Saud bin Abdulaziz University for Health Sciences. The work presented here which involves the NGHA healthcare system and offers results on NGHA patients and clinicians will most definitely be useful to the NGHA management and NGHA university officials.

All work presented here will be published in order to provide any interested entity in Saudi Arabia or elsewhere access to information, data, and analysis. This work represents documented findings of Telecare impact on the healthcare system at NGHA, and may encourage more research in this field.

10.4 Summary

This research has met the objectives set in Chapter 1. It has successfully designed a Telecare model using the Soft Systems methodology, then designed and implemented a Telecare solution to manage diabetes at NGHA Clinic 104.

Results indicate that Telecare solutions can assist in overcoming obstacles faced by the healthcare sector. TeMaD has also been successful in addressing the conservative traditions and culture of Saudi Arabia, which may sometimes restrict how healthcare services are offered.

This research adds new contributions to the field of eHealth. It provides scientific studies applied in Saudi Arabia to develop Telecare solutions, when in fact, such research is scarce in this region. It also attempts to broaden the scope of when to use Telecare. It identifies new categories of patients that can benefit from such services. It tackles cultural obstacles that have not been scientifically addressed in Saudi Arabia. This bold move can be adopted by researchers in other developing countries to confront obstacles of a similar nature, stemming from traditions and religion.

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GLOSSARY

eHealth:	a term used to represent the incorporation of technology to assist in healthcare delivery and enhance current health services.
mHealth:	a term used to describe the use of mobile technology to deliver and enhance health services.
Telecare:	a term used to describe healthcare services offered from a remote location using available technology to enhance healthcare services and improve health-giver/patient communication channels.
Telecommunications:	Communication through the use of available technology to transmit information over a distance.
Teleconferencing:	a conference between two or more people located in different locations, communicating information using telecommunication systems.
Tele-dermatology:	a term used to describe remote healthcare services in the speciality of Dermatology offered to patients using technology.
Telemedicine:	a term used to describe the use of technology to offer curative medicine and clinical services remotely to patients.
Tele-nursing:	A term used to describe the use of technology to offer remote nursing services to enhance healthcare services offered to patients.
Tele-pathology:	a term used to describe healthcare services in the speciality of Pathology offered from a remote location to patients.
Tele-radiology:	a term used to describe healthcare services in the speciality of Radiology offered from a remote location to patients.

APPENDICES

This section displays a list of all appendices used throughout the thesis.

Appendix (A): TeMaD testing of Admin and User Interfaces.

All tasks highlighted in **Green** indicate an error that has been corrected.

All tasks highlighted in **Yellow** indicate an error that not yet been corrected.

All tasks highlighted in **Turquoise** indicate tests that need to be performed after the application is loaded onto the server.

Admin Interface

Login Page		
1. Content (Syntactic – Semantic – Structural errors)		
Error in message (Syntax)	You have 11 readings	You have 11 new readings
Error in Menu Tabs	Main menu tab should be differentiated from Menu options (highlighting and colour)	Use **BOLD** and/or other **Colour**
Error in Menu Tabs	User should not be able to click on Main menu tab	
2. Interface		
Error in interface mechanism (Link)	Retrieve SMS Readings	No link
3. Component		
(Requires developer testing)		
4. Navigation		
Not required on login page.		
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
NGHA network security applied.	TeMaD Administrator must be authorised (username added to access list) by Application Administrator	
Secure Access SSL VPN	Session times out from Internet link	Session might be too short
Login	Username and password authenticated by network	
7. Performance		
Acceptable		

Patient Information Tab

New Patient Information		
1. Content (Syntactic – Semantic – Structural errors)		
Error in message (Syntax)	Administrator Interfacee	Administrator Interface
Title	Arabic Name, Name	Should be Name (Arabic), Name (English)
Foot care information	Title next to Calendar	Appt Date
2. Interface		
Layout	Centralise title with data entry below	
Message after successful save	Successful save message displayed at top	Should be displayed at bottom near Save button
Save Option	Ensure user wants to SAVE	Message 'Are you sure you want to save this information? Y/N'
Main menu tabs	They block the page title	Make transparent
3. Component		
(Requires developer testing)		
Incorrect result	Enter correct MRN (i.e., 426154) check, then enter incorrect MRN (i.e., 8960790) still displays first MRN info	Should clear previous patient record, validate and give user clear message
Incorrect result	After new info entered and saved, update view shows old info (MRN 426154)	
Field	Mobile number field should be required	Add star
4. Navigation		
Main Page, Back, Forward buttons required at bottom of page.		
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
Validation messages clear	Entered '42615t' and 0	Both entries detected
7. Performance		
Acceptable		

Patient Information Tab

Update Patient Information		
1. Content (Syntactic – Semantic – Structural errors)		
Syntax error	Dietitian Information	Dietician Information
2. Interface		
Update Option	Ensure user wants to UPDATE	Message 'Are you sure you want to update this information? Y/N'
Validation of correct Patient required	After MRN entered, Patient name should be displayed	
Page layout	The three boxes should be adjacent	Eliminate scrolling if possible
Table layout	Edit button displays dark table	Tables should be consistent
Main menu tabs	They block the page title	Make transparent
3. Component		
(Requires developer testing)		
Update to General Box	Does not record latest entry	
Update all information	Update does not allow updates to certain boxes	
Changes to Lab Test and Dietician Boxes	Changes successfully recorded	
4. Navigation		
Main Page, Back, Forward buttons required at bottom of page.		
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

View Patient Information		
1. Content (Syntactic – Semantic – Structural errors)		
Syntax error	Dietician Information	Dietician Information
Syntax error	Under Foot Care: Gangerene	Gangrene
2. Interface		
Page layout	Rearrange boxes to make page shorter	Eliminate scrolling if possible
Add new foot care information	Insert and Cancel should be on same line	
Add new foot care information	When new date entered, ensure user wants to complete, then indicate date has been entered	Message 'Are you sure you want to insert this appt? Y/N' and 'Your date has been saved'
Lab test box	Numbers ambiguous 1, 2	Indicator should be added
Readings box view	User should be offered 'View' Options	Weekly, monthly, 3-month
Main menu tabs	They block the page title	Make transparent
3. Component		
(Requires developer testing)		
Foot care box	Allows user to 'Add New'	This is a View only page
Foot care box	Cancel button does nothing	
4. Navigation		
Main Page, Back, Forward buttons required at bottom of page.		
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

Blood Sugar Level Info Tab

New Blood Sugar Level Info		
1. Content (Syntactic – Semantic – Structural errors)		
None		
2. Interface		
MRN box	No Action box to press after MRN entered	Although pushing the 'enter' button gives result
MRN box	Verify MRN entered is correct and display patient name	To ensure that user is dealing with correct MRN/Patient
Calendar layout	Previous and Successive display of months needs to be unified throughout	Under Patient Info tab, Months indicated by arrows, here months indicated by name
Date chosen from Calendar	Chosen date should be displayed	As confirmation to user
Clear Readings after entry (Save then Additional Reading)	After reading entered and saved, table should be cleared	To avoid user confusion
Clear message when new reading entered (Save then additional reading)	When new reading entered, clear 'reading successfully added' message	To avoid user confusion
Order of 'Save' and 'Additional Readings'	First 'Additional Readings? Click here', then 'Save and Close'	To avoid user confusion
Save Option	Ensure user wants to SAVE	Message 'Are you sure you want to save this information? Y/N'
Message after successful save	Successful save message displayed at top	Should be displayed at bottom near Save button
Main menu tabs	They block the page title	Make transparent
3. Component		
(Requires developer testing)		
Incorrect result when trying to enter New blood sugar level to my existing file (MRN 426154)	Gives error message: Patient Record must be added first *(Patient Information tab > New Patient Information)* before entring any readings	

4. Navigation
Main Page, Back, Forward buttons required at bottom of page.
5. Configuration
Versions of IE, Other Browsers, ISPs
6. Security
7. Performance
Acceptable

Update by MRN		
1. Content (Syntactic – Semantic – Structural errors)		
Send SMS	Misleading	Title: SMS sent?, Default field 'No'
2. Interface		
Indicator	Readings Type (Admin)	Does this indicate the user entering reading? Add name.
Status	Should change from New to Checked automatically	Minimise user effort
Side scroll	Remove sideway scroll	To minimise user effort and for clarity
Location of Chart	Display of Chart should be at bottom	
Calendar layout	Previous and Successive display of months needs to be unified throughout	Sometimes months indicated by arrows, sometimes by name
Date chosen from Calendar	Chosen date should be displayed	As confirmation to user
Update Option	Ensure user wants to Update MRN	Message 'Are you sure you want to update this record? Y/N'
Message after successful update	Successful save message should be displayed	Should be displayed at bottom
Main menu tabs	They block the page title	Make transparent
3. Component		
(Requires developer testing)		
Error in code	When updating an MRN (changed Other reading, comment, status) error occurred *	Error description below.
Error occurred	When MRN updated reading and date, then 'Update' error occurred *	Error description below.
4. Navigation		
Main Page, Back, Forward buttons required at bottom of page.		
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

Update all Blood Sugar Level Info		
1. Content (Syntactic – Semantic – Structural errors)		
Send SMS	Misleading	Title: SMS sent?, Default field 'No'
Readings Type	If it is SMS then updated by Admin?	Misleading
Advise vs advice, should be advice		
2. Interface		
Indicator	Readings Type (Admin)	Does this indicate the user entering reading? Add name
Layout of table	Group by MRN	Colour or shading can be used here
Location of Chart	Display of Chart should be at bottom	Currently no chart is displayed
Edit Option	Ensure user wants to Edit MRN	Message 'Are you sure you want to update this record? Y/N'
Message after successful update	Successful save message should be displayed	Should be displayed at bottom
Main menu tabs	They block the page title	Make transparent
3. Component		
(Requires developer testing)		
Select MRN to Edit, then change readings, then select Update	When MRN viewed, changes did not take place	
4. Navigation		
Main Page, Back, Forward buttons required at bottom of page.		
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

User Interface

Home Page		
1. Content (Syntactic – Semantic – Structural errors)		
Syntax error	Grammar (see attachment A)	
Syntax error	To participate click on link below	No need for 'link below', just 'click here'
2. Interface		
Error in interface mechanism (Link)	Link in Option 2 takes you to same page	
3. Component		
(Requires developer testing)		
4. Navigation		
Not required on home page.		
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

New User		
1. Content (Syntactic – Semantic – Structural errors)		
Semantic error	Make message box bigger and place 'contact us' on same line (see attachment B)	
Syntax error	To participate click on link	Indicate that 'contact us' is a link
2. Interface		
Specific validation required for incorrect data	When entering incorrect MRN (429817), incorrect character (42615r), or 0	Validation message should be clear explaining cause of error.
Enter new MRN	Message instructs user to register	
Enter existing MRN	Message indicates that a password has already been requested.	
Enter existing MRN	Layout of buttons needs to be re-aligned	
3. Component		
(Requires developer testing)		
4. Navigation		
Back, Forward, and Homepage buttons need to be added to bottom of page	They also need to be aligned	
Homepage and Back buttons	Both go to same page (Homepage)	
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

*I need to test the login of a New User. One who has been entered by the Admin but is registering for the first time. Can you please create an account (say UID 3) and I will login and request a password to check if its working.

Existing User (Login)		
1. Content (Syntactic – Semantic – Structural errors)		
Ok.		
2. Interface		
Enter existing MRN	Welcome message then Name.	Reverse order. First Name then Welcome message.
Enter existing MRN	Centralise Name.	
3. Component		
(Requires developer testing)		
4. Navigation		
Back, Forward, and Homepage buttons need to be added to bottom of page		
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

Existing User (Enter Readings)		
1. Content (Syntactic – Semantic – Structural errors)		
Ok.		
2. Interface		
Clear Readings after entry	After reading entered and saved, table should be cleared	To avoid user confusion
Message displayed when new reading entered (indicate user must first Save then insert additional reading)	When new reading entered, modify 'reading successfully added' message and ask user if there are additional readings	To avoid user confusion *
Save Option	Ensure user wants to SAVE	Message 'Are you sure you want to save this information? Y/N'
3. Component		
(Requires developer testing) **		
4. Navigation		
Back, Forward, and Homepage buttons need to be added to bottom of page	They also need to be aligned.	***
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

*remove 'successful entry, once the user starts entering the new readings.

** Application accepts readings below mini (10). Application accepts readings above max. Validation on reading ranges required. Also, Application accepts entries for future dates (13 April), it shouldn't.

***Navigation problem same as other pages.

Existing User (View Readings)		
1. Content (Syntactic – Semantic – Structural errors)		
Ok.		
2. Interface		
Readings Table sorting	Sorts Oldest entry first	Should sort latest first
Chart view	User should be able to view readings in chart format	
3. Component *		
(Requires developer testing)		
4. Navigation		
Back, Forward, and Homepage buttons need to be added to bottom of page	They also need to be aligned.	
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

*Something wrong with the chart view. It only displays a chart per day not monthly and weekly?

**Same problems with navigation

Existing User (General Information about Diabetes)*		
1. Content (Syntactic – Semantic – Structural errors)		
More content needs to be added	Content used from Bader website	Approval granted from site administrator.
2. Interface		
Layout of page	Topics should be in a table format	
Display of diabetes topic	Centralised, should be right indented	
3. Component		
(Requires developer testing)		
4. Navigation	They also need to be aligned.	*
Back, Forward, and Homepage buttons need to be added to bottom of page		
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

* same problems with navigation.

Contact Us		
1. Content (Syntactic – Semantic – Structural errors)		
Ok.		
2. Interface		
Ok.		
3. Component		
(Requires developer testing)		
4. Navigation		
Back, Forward, and Homepage buttons need to be added to bottom of page	They also need to be aligned.	
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

* Back keeps you on the same page instead of taking you to the previous page you were visiting.

* scroll on left side of the screen

Who are we?		
1. Content (Syntactic – Semantic – Structural errors)		
Font size	Make larger	
2. Interface		
Ok.		
3. Component		
(Requires developer testing)		
4. Navigation		
Back, Forward, and Homepage buttons need to be added to bottom of page	They also need to be aligned.	
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

*Scroll on right side of the screen. Screen layouts should be consistent.

Help		
1. Content (Syntactic – Semantic – Structural errors)		
How to Register link	Make sentence shorter	To register click here
How to Enter link	Make sentence shorter	To Enter click here
2. Interface		
Registration and Entry demo	Shift up to eliminate scrolling	Minimise user effort
At demo completion	Display 'Close Window' button	Minimise user effort
Prolong instruction box time	To give the user more time to read the instructions	
Update Demo	Contains old screen layouts (spelling mistakes, missing features, old calendar layouts, etc…)	TeMaD demo needs to be recorded from final application version
3. Component		
(Requires developer testing)		
Link problem	Entry demo, then close window, then 'Homepage'	System hangs
4. Navigation		
Back, Forward, and Homepage buttons need to be added to bottom of page	They also need to be aligned.	
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

*these items need to be checked after the new demo is uploaded.

Site Map		
1. Content (Syntactic – Semantic – Structural errors)		
'Important info about Diabetes' or 'Useful info about Diabetes'	Consistency required	Avoid user confusion
Present content in a hierarchical layout	Clarity for user	Avoid same layout used in Homepage
2. Interface		
Screen layout too wide	Eliminate scrolling	Minimise user effort
Remove 'Goals' link	Links gives error*	
Remove 'Site Map' link	Link gives error**	
3. Component		
(Requires developer testing)		
4. Navigation		
Back, Forward, and Homepage buttons need to be added to bottom of page	They also need to be aligned.	
5. Configuration		
Versions of IE, Other Browsers, ISPs		
6. Security		
7. Performance		
Acceptable		

- Back and Front should take you 1 page back or front.

During the testing of the Admin and User Interfaces, the following comments were logged and sent to the ISID developers for discussions and incorporation into the TeMaD system.

General Comments

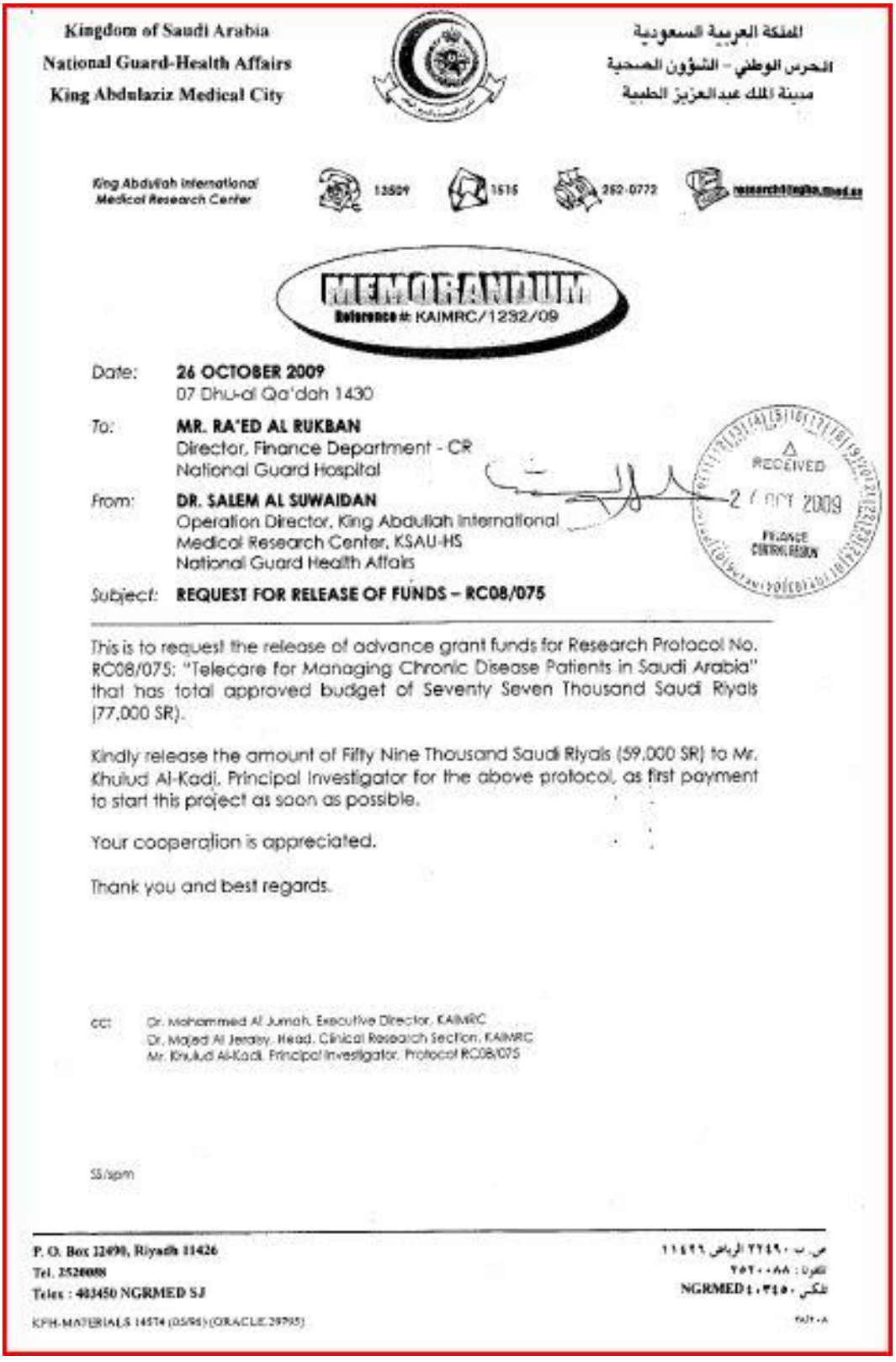
- The TeMaD administrator needs to be able to view the table that has the patient readings. This was previously available in the first version of TeMaD. It might have been replaced or overwritten with the charts, but administrators need both view options (Chart and Table).

- After the patient has completed working with the system, he/she should be able to LOGOUT to secure their account and password.

- Double entries on the same date are accepted by the application and both 7 readings for same day are listed under 'View'. User should not be allowed to do this.

- The test MRN and password are still not working. There is a delay in the SMS system in Jeddah to send patients their passwords. The SMS-Admin in Jeddah needs to look into this issue since the system cannot be used if the Internet users are not getting a password in a timely manner, and one that is working.

Appendix (B): NGHA Research Committee approval for TeMaD and fund release request.



Kingdom of Saudi Arabia
National Guard-Health Affairs
King Abdulaziz Medical City

المملكة العربية السعودية
الحرس الوطني - الشؤون الصحية
مدينة الملك عبدالعزيز الطبية

King Abdullah International Medical Research Center

13509 1515 252-0772

MEMORANDUM
Reference #: KAIMRC/1232/09

Date: **26 OCTOBER 2009**
07 Dhu-al Qa'dah 1430

To: **MR. RA'ED AL RUKBAN**
Director, Finance Department - CR
National Guard Hospital

From: **DR. SALEM AL SUWAIDAN**
Operation Director, King Abdullah International Medical Research Center, KSAU-HS
National Guard Health Affairs

RECEIVED 27 OCT 2009 FINANCE CONTROL REGION

Subject: **REQUEST FOR RELEASE OF FUNDS – RC08/075**

This is to request the release of advance grant funds for Research Protocol No. RC08/075: "Telecare for Managing Chronic Disease Patients in Saudi Arabia" that has total approved budget of Seventy Seven Thousand Saudi Riyals (77,000 SR).

Kindly release the amount of Fifty Nine Thousand Saudi Riyals (59,000 SR) to Mr. Khulud Al-Kadi, Principal Investigator for the above protocol, as first payment to start this project as soon as possible.

Your cooperation is appreciated.

Thank you and best regards.

cc: Dr. Mohammed Al Jumah, Executive Director, KAIMRC
Dr. Majed Al Jeraisy, Head, Clinical Research Section, KAIMRC
Mr. Khulud Al-Kadi, Principal Investigator, Protocol RC08/075

SS/spm

P. O. Box 22490, Riyadh 11426
Tel. 2520088
Telex : 403450 NGRMED SJ

ص. ب ٢٢٤٩٠ الرياض ١١٤٢٦
تلفون : ٢٥٢٠٠٨٨
تلكس NGRMED ٤٠٣٤٥٠

KFH-MATERIALS 14574 (05/95) (ORACLE:29795)

Appendix (C): Notification of TeMaD study commencement.

Date: December 9, 2009

To: Dr. Mohammed Al-Dakar, Consultant Endocrinology,

Head Division of Endocrinology,

From: Dr. Majed Al-Tuwaijeri

Executive Director, ISID

Subject: Telecare Study at A.C.C. Clinic 404

Mrs. Khulud Al-Kadi, Director, I.T. Security & Planning at ISID, is currently on study leave in the UK pursuing a PhD degree in Health Informatics.

As part of her primary assignments, she is currently here in Riyadh preparing to conduct a study to examine the impact of Telecare on managing Diabetes for patients at KAMC-CR, using existing NGHA technologies.

She has already discussed this study with the Diabetic Educators at Clinic 404, and they have welcomed the study that will most likely assist them in managing the large number of patients they deal with daily. She has also received an approval from the NGHA Research Committee regarding this study (see attachment).

The study will take place at Clinic 404 with Mrs. Al-Kadi and her research assistant working with the Diabetic Educators and their patients for a trial period of 4 months, starting 26th December.

I would therefore like to ask you for your support of this important study that can present beneficial results to NGHA in general and Clinic 404 in particular.

CC: Mr. Bader Al-Motair, Diabetic Educator, Nursing Division

Mrs. Khulud Al-Kadi, I.T. Security & Planning, ISID

Appendix (D): Request for SMS messaging account for TeMaD study.

Kingdom of Saudi Arabia
National Guard
Health Affairs

المملكة العربية السعودية
رئاسة الحرس الوطني
الشئون الصحية

SMS Messaging Account Request Form

Region (CR/ER/WR): CR

Requesting Department: ISID

Date: 16-Jul-2008

Department Chairman:

Signature:

Account Holder Name:

Contact No:

Account Email Address (**Mandatory**): ISID@ngha.med.sa

Monthly Required SMS: 1000

Cost Centre:

Justification:

1- To provide a communication method between Diabetes clinic DEs and patients participating in the TeMaD trial.
2- To be used as a method of immediate intervention with patients when necessary during the TeMaD trial.
3- For raising patient awareness of Diabetes during the TeMaD trial.

Approved by:

Mr. Abdullah Al-Ammari
Chief Operating Officer
National Guard Health Affairs

Appendix (E): Request for TeMaD Extension landline relocation.

Date: February 6, 2010

To: Eng. Salah Al Omair

Director, Communications Department

Thru: Engr. Jameel Mujalled

Director, Office Automation, ISID

From: Ms. Khulud Al-Kadi

Director, IT Security and Planning, ISID

Subject: Request for Telephone Extension Line Relocation

In reference to the above mentioned subject, we would like to inform you that at present we are conducting a study on Diabetic Patients to examine the impact of Telecare services on the management and monitoring of Diabetes. The study "Telecare for Managing Diabetes" TeMaD, requires a dedicated extension number to be used for monitoring patient blood sugar levels.

In addition to the above, extension 18227 has been provided last year by your department as a temporary mode to be used throughout the duration of the study. They have been situated at A.C.C. Clinic 404.

However, approximately two weeks ago, the *Diabetic Clinic has moved from Clinic 404 to Clinic 104*. We would therefore appreciate your kind assistance to relocate the mentioned extension 18227 from Clinic 404, room 4144 to Clinic 104, room 1118.

Feel free to contact Ms. Tamadher Al-Muayyad at extension no. 18521 for any further assistance regarding this matter. Furthermore, please note that the study will conclude May 2010 and the extension number will no longer be needed after that date. You will be informed once the study is completed.

Thank you for your usual support and cooperation.

Appendix (F): TeMaD Patient consent forms (in Arabic and English).

***موافقة على المشاركة بدراسة**
مدى فاعلية العناية عن بعد في التمكن في نسبة السكر بالدم في الأشخاص الذين لديهم مرض السكري من النوع الأول أو النوع الثاني مع انسولين في مدينة الملك عبدالعزيز الصحية بالحرس الوطني

أهداف الدراسة:
1- خفض معدل السكر في الدم بنسبة 5%.
2- تقديم وسيلة بديله سهله لمرضى السكري لمتابعة قراءتهم لمعدلات السكر في الدم.
3- توعية المريض باستخدام أحدث انواع التقنية
4- متابعة المريض وهو في منزله دون الحاجة الى الحضور للمستشفى (إلا في بعض الحالات)

مدة الدراسة:
ستجرى هذه الدراسة لمدة 12 أسبوع

مواصفات المرضى المشاركين:
1- أن يكون لدى المريض النوع الأول أو الثاني مع انسولين من أنواع السكري.
2- أن يكون المريض فوق سن 16 سنه ودون سن 70 سنه لحصر العوامل المؤثرة.
3- أن يكون المريض من مراجعي عيادة 404 بمدينة الملك عبدالعزيز الطبية بالرياض.

عند رفضك الاشتراك في هذه الدراسة:
بإمكانك أن ترفض الاشتراك بدون التعرض لأي جزاءات أو فقدان مزايا تستحق لك في الأحوال العادية.

مكافآت للمشترك:
في حال موافقتك على الاشتراك بالدراسة واستمرارك كمشترك حتى نهاية مدة الدراسة ، سوف تحصل على مكافأة مالية عند انتهائك من البرنامج.

الخطوات:
1- يمكنك أخذ كتيب يشرح البرنامج المعد وطرق إدخال قراءاتك.
2- سيطلب منك فحص دم بأخذ عينه في المختبر لمعرفة نسبة السكر في الدم.
3- تبدأ بإرسال قراءاتك على مدى 12 أسبوع.
4- سيكون المسؤلين بالعيادة على اتصال معك للمساعدة والرد على أي أسئلة.
5- بعد انتهاء 12 أسبوع سيطلب منك أخذ عينه دم أخرى في المختبر لمعرفة نسبة السكر في الدم.
6- أخيرا تعبئة استبيان عن مدى ارتياحك للنظام.

الآثار الجانبية:
هذه الدراسة لا تحتوي على أدوية إضافية أو جديدة، فالدراسة عبارة عن استبدال زيارتك للعيادة بنظام آلي تستخدمه وأنت في منزلك ، ولذلك لا توجد أي آثار جانبية.

السرية:
ستعامل جميع الملفات والمعلومات بسرية تامة.

إقرار الموافقة على المشاركة بالدراسة:
لقد أعطيت الفرصة لطرح أسئلة وتلقيت إجابات مرضية , وعليه أوافق على أن من الممكن مراجعة سجلاتي الطبية ضمن إطار هذه الدراسة. كما أوافق على المشاركة في هذه الدراسة.

اسم المريض:	رقم الجوال:	رقم الملف:
التوقيع:	التاريخ: \ \ 2008م	
اسم المسئول عن الدراسة:	التوقيع:	التاريخ: \ \ 2008م
اسم الشاهد:	التوقيع:	التاريخ: \ \ 2008م

Patient Consent Form
(Participation in the 'TeMaD' study)

TeMaD Application Definition:
Telecare for Managing Diabetics at NGHA KAMC-CR, A.C.C. Building, Clinic 404

Duration of Study:
The study will last for 12 weeks.

Study goals:
1- Decrease HbA1c level in Diabetics by 5%.
2- Provide Diabetics with an alternative method of managing their disease.
3- Raise patient awareness using appropriate technology.
4- Managing Diabetics at home, and reducing hospital visits, unless necessary.

Patient Selection Criteria:
1- Participating patient must be older than 16 and younger than 70 years old.
2- Participating patient must have Diabetes of Type 1 or Type 2 on Insulin.
3- Participant must be a patient at Clinic 404 at KAMC in Riyadh.

If you refuse to participate in study:
If you refuse to participate in this study, you will not be penalized in any way, and will continue to receive the benefits you are entitled to.

Incentives for participants:
If you decide to participate in the study, and complete the 12 week study, you will be eligible to receive a monetary reward. This will be awarded at the end of the study.

Study Steps:
1- You will receive educational material about TeMaD and on how to use the TeMaD application.
2- You will be required to do a blood test to determine your HbA1C level.
3- You will send your blood sugar level readings through TeMaD as instructed by the Diabetic Educator for a period of 12 weeks.
4- The Diabetic Educators at Clinic 404 will continuously be in touch with you and are available to answer any questions.
5- After completing 12 weeks, you will be required to take another blood test to determine the HbA1C level.
6- Finally, a survey must be filled out and the monetary reward granted.

Study side effects:
This study DOES NOT use any new or additional drugs. This study simply 'automates' how your blood sugar levels are recorded, sent, and monitored. It enables this process to take place from the convenience of your own home. There are NO side effects.

Confidentiality:
All medical records and patient information will be dealt with confidentially.

I agree to participate in the study:
The purpose of this study is clear to me, and I have been given the opportunity to ask questions, and have received acceptable answers. I agree to reviewing and accessing my medical record for the puepose of this study.

I agree to the participation in this study.

Patient Name:	Mobile number:	MRN:	
	Signature:	Date: / /2008	
Investigator Name:	Signature:	Date: / /2008	
Witness Name:	Signature:	Date: / /2008	

Appendix (G): TeMaD Information Booklet.

برنامج العناية عن بعد (تيماد)

توجد ٣ طرق لإرسال القراءات :

١- الرسائل النصية القصيرة:

نرسل رسالة قصيرة من جوالك إلى الرقم
٠٥٠٠٣٨٣٦٨٦

الخطوات:

١- نرسل رسالة قصيره إلى الرقم المذكور أعلاه بالنص التالي :
كلمة" سكر" ثم فراغ يليه رقم السجل الطبي ثم نجمة (*) ثم تاريخ القراءات بالميلادي(اليوم ثم الشهر ثم السنة) ثم نجمة (*)ثم القراءه الاولى : قبل الافطار ثم نجمة(*)ثم القراءه الثانيه: بعد الافطار بساعتين ثم نجمة (*)ثم القراءه الثالثه : قبل الغداء بساعتين ثم نجمة (*)ثم القراءه الرابعه: بعد الغداء بساعتين ثم نجمة (*)ثم القراءه الخامسة : قبل العشاء بساعتين ثم نجمة (*)ثم القراءه السادسه:بعد العشاء بساعتين ثم نجمة(*)ثم القراءه السابعه : أخرى ثم نجمة (*)ثم الاجابة عن السؤال التالي: هل قمت بأي نشاط رياضي اليوم؟ إن كانت نعم ضع رقم (١) و إن كانت لا ضع رقم (٢)

ملاحظة : في حالة عدم وجود قراءه ضع رقم صفر, وفي حالة التاريخ كان اليوم أو الشهر أو السنة مكون من خانه واحده ضع صفرا كما هو مذكور بالمثال أدناه :

مثال : رقم السجل الطبي ١٢٣٤٥٦, التاريخ ٩ أغسطس ٢٠٠٨, القراءة الأولى ١٢٣, القراءةالثانية ١٢٠, القراءة الثالثة ١٢, القراءة الرابعة (لا يوجد), القراءة الخامسة ٥٦, القراءة السادسة ٢٣٤, القراءة السابعة ٥, الإجابة "نعم"
ندخل كالأتي: سكر ١٢٣٤٥٦٧*٩٠٨٠٨٠١*١٢٠٠١*٢٣٠٠٥٦٠٠١*١٠٥٠٠٢٣٤٠٥

٢- الانترنت : الدخول الى برنامج تيماد

الرابط : http://www.ngha.med.sa/temad

الخطوات عند الدخول لأول مره :

١- الذهاب الى الصفحة الرئيسية لبرنامج العناية عن بعد ثم الذهاب الى صفحة التسجيل .
٢- إدخال رقم السجل الطبي .
٣- نستلم رسالة قصيره على جوالك بالرقم السري .
٤- الرجوع الى الصفحة الرئيسية ثم الذهاب الى صفحه الدخول, كتابة رقم السجل الطبي ثم الرقم السري .
٥- الدخول الى القائمة الرئيسية نوجد ٣ خيارات :
- الذهاب الى صفحه ادخال القراءات - ادخال رقم السجل الطبي والتاريخ والقراءات ثم ارسال المعلومات
- الذهاب الى صفحة عرض القراءات- عرض للقراءات والنصائح
- الذهاب الى صفحة معلومات مفيدة عن مرض السكر.

الخطوات بعد التسجيل:

١- الذهاب الى الصفحة الرئيسية لبرنامج العناية عن بعد ثم الذهاب الى صفحة الدخول .
٢- إدخال رقم السجل الطبي والرقم السري.
٣- راجع النقطة الخامسة أعلاه.

٣- الهاتف الثابت

الاتصال على رقم ٠٨٨-٢٥٢٠ خويلة ١٨٢٢٧
في الاوقات التالية : من ٩ صباحا إلى ١٠ صباحا و من ٣ عصرا إلى ٤ عصرا
من السبت إلى الاربعاء.

الخطوات :

١- تجهيز المعلومات الآتية قبل الاتصال : رقم الملف الطبي, قراءات اليوم, تاريخ القراءات بالميلادي .
٢-الاتصال على الرقم المذكور أعلاه.
٣- إعطاء المعلومات إلى اخصائي تثقيف السكر.
٤- يمكن إعطاء أي معلومات إضافيه متعلقه بالقراءات .

ملاحظة : للاشتراك في برنامج تيماد الرجاء الاتصال على رقم ٠٨٨-٢٥٢٠ خويلة ١٨٢٢٧

Appendix (H): DE TeMaD completion questionnaire

TeMaD Questionnaire

This questionnaire is designed for the diabetic educators at NGHA ACC Diabetic Clinic that have been involved in the TeMaD study, and have had their patients participate in the study.

The primary objective of the questionnaire is to gather information from diabetic educators about how they feel about the TeMaD system. Has it improved the quality of the services offered at the clinic, helped control the blood sugar levels of their patients, and been easy to learn and use. Has it also led to better management of time?

Please complete the questionnaire by putting a circle around your answer.

Date: \ \2010

Name		**Gender**	
Age		**Badge Number**	
Experience as D.E. (yrs)		**Marital status**	

D.E. demographics

1.	Where do you live?			
a.	Riyadh	b.	Other City	Specify:

2.	How long does it take you to reach the hospital?		
a.	5~15 minutes	b.	16~30 minutes
c.	31 minutes ~ 1 hour	d.	More than 1 hour

Hospital visits

3.	What is the average waiting time a patient spends to see the diabetic educator at a booked appointment?				
a.	5 minutes	b.	6 ~ 15 minutes	c.	16~30 minutes
d.	More than 30 minutes	Specify:			

4.	How often do you advise high risk patients to visit you?				
a.	Once a week	b.	Twice a month	c.	Once a month
d.	Every 3 months	e.	Other	Specify:	

5.	How often do you advise low risk patients to visit you?				
a.	Once a week	b.	Twice a month	c.	Once a month
d.	Every 3 months	e.	Other	Specify:	

6.	How often do you advise newly diagnosed patients to visit you?				
a.	Once a week	b.	Twice a month	c.	Once a month
d.	Every 3 months	e.	Other	Specify:	

7.	With patients diagnosed with diabetes more than a year ago, how often do you advise them to visit you?				
a.	Once a week	b.	Twice a month	c.	Once a month
d.	Every 3 months	e.	Every 6 months	f.	Other (specify)

8.	Are 'Request for Appointment' slips booked by the Appointments employee at actual dates you requested?		
a.	Yes (go to Q10)	b.	No (go to Q9)

9.	If 'No', how late are they booked?			
a.	Less than 2 weeks late	b.	Between 2~4 weeks late	
c.	More than 1 month late	d.	Other	Specify:

10.	Are appointment all divided into a fixed amount of time per slot?		
a.	Yes (go to Q11)	b.	No (go to Q12)

11.	If 'Yes', wouldn't you prefer tailoring the duration of a slot to the patients' need?		
a.	Yes	b.	No

12.	On average, how many **actual** patients do you see daily?		
From		To	

13.	On average, how many **booked** patients do you see daily?		
From		To	

14.	On average, how many **Walk-in** patients do you see daily?		
From		To	

15.	On average, how many **Referred** patients do you see daily?		
From		To	

Healthcare service satisfaction

16.	How would you rate the healthcare services at this hospital?		
a.	Excellent	b.	Good
c.	Acceptable	d.	Poor

17.	Select the services at the hospital that need improvement?				
a.	Appointments	b.	Number of diabetic educators at diabetes clinic	c.	Number of physicians at diabetes clinic
d.	No services need improvement	e.	Other	Specify:	

Cultural setup

18.	Has a patient of an opposite sex to yours, ever asked to be treated by a diabetic educator from the same-sex?		
a.	Often	b.	Sometimes
c.	Rarely	d.	Never

19.	Do patients ever complain about facing obstacles with regards to transportation?				
a.	Yes (go to Q20)	b.	No (go to Q21)	c.	Sometimes (go to Q20)

20.	Are patients who complain about problems with transportation **mostly** females?		
a.	Yes	b.	No

21.	What is the daily percentage of patients that are late for their appointments?						
a.	1%	b.	10%	c.	20%	d.	50%

22.	Are female patients more likely to show up late for an appointment than male patients?		
a.	Yes	b.	No

23.	Are female patients more likely to NOT show up for an appointment than male patients?		
a.	Yes	b.	No

24.	Do you think female patients would be more reluctant to use TeMaD if the systems' administrator was male? (task involves interaction via messaging and telephone)		
a.	Yes	b.	No

25.	In your opinion, why do you think Diabetes is rapidly spreading in Saudi? Please rate each factor listed below based on how relevant it is? (rate from 1='very relevant' to 5='not so relevant')				
a.	Lifestyle (lack of exercise)	b.	Diet	c.	Hereditary
d.	Low awareness about diabetes	e.	Age	f.	Other, specify:

26.	Can TeMaD help you better manage the growing number of diabetic patients against the limited resources at the clinic?		
a.	Yes	b.	No

Telecare awareness

27.	Before the TeMaD project started, have you ever heard of Telecare solutions?		
a.	Yes (go to Q28)	b.	No (go to Q29)

28.	If 'Yes', have you encountered any Telecare practices in Saudi hospitals?			
a.	Yes	Specify when and where:	b.	No

29.	After your involvement with the TeMaD system, are you now more aware of how technologies can help you manage/monitor your patients?		
a.	Yes	b.	No

Feedback on TeMaD

30.	Which entry mode of the TeMaD application do you think is most practical for patients?				
a.	Internet	b.	SMS	c.	Landline

31.	Do you feel that sending SMS's to patients for improving their awareness is effective?				
a.	Yes	b.	No	c.	Maybe

32.	Do you feel that sending SMS's to patients to quickly intervene, whenever needed, is effective?				
a.	Yes	b.	No	c.	Maybe

33.	Was the Internet mode (Admin interface) of the TeMaD application easy to use?			
a.	Yes, very easy	b.	Fairly easy	
c.	I didn't use it	d.	Difficult	Specify:

34.	Do you believe that using TeMaD as a permanent solution will help you better manage patients?				
a.	Yes	b.	No	c.	Maybe

35.	Was TeMaD more convenient than the traditional services offered?		
a.	Yes	Specify:	
b.	The same	c.	No

36.	Did TeMaD present you with requested information in acceptable response times?		
a.	Yes	b.	No

37.	Has TeMaD made it easier for you to deal with patients?		
a.	Yes	b.	No

38.	Has TeMaD made it easier to contact patients?		
a.	Yes	b.	No

39.	By using TeMaD, have patients been able to manage their blood sugar levels better?		
a.	Yes	b.	No

40.	Did you use TeMaD to send useful advice to patients?		
a.	Yes	b.	No

41.	Was contacting patients via SMS or Mobile through TeMaD effective in allowing immediate medical intervention with patients requiring so?				
a.	Yes		b.	No	

42.	Please rate each category of patients listed below based on how beneficial TeMaD can be to them? (rate from 1='most benefit' to 5='no benefit at all')				
	High risk patients		Low risk patients		Students
	Patients newly diagnosed		Patients diagnosed more than 1 year ago		Patients with access to technologies used
	Patients diligent about their readings		Patients not diligent about their readings		Patients living in rural areas/outside cities
	Female patients		Senior citizens (>60)		Other, specify:

43.	Do you believe that using TeMaD will help reduce long-term complications with diabetic patients?				
a.	Yes	b.	No	c.	Maybe

44.	Should TeMaD be used to remotely manage diabetic pilgrims during Hajj?		
a.	Yes	b.	No

45.	Should **this** hospital offer the TeMaD solution as a permanent one?				
a.	Yes	b.	No	Specify why not?	

46.	Should **other** hospitals offer similar Telecare solutions?			
a.	Yes	b.	No	Specify why not?

47.	How would you improve the TeMaD system?
a.	
b.	
c.	

Appendix (I): Patient TeMaD completion questionnaire

TeMaD Questionnaire

This questionnaire is designed for all patients that have participated in the TeMaD study, have completed the three month trial period, and have done the final blood test.

The primary objective of the questionnaire is to gather information from participating patients about how they feel about the TeMaD system. Has it improved their quality of life, helped control their blood sugar levels, and been easy to learn and use?

Please complete the questionnaire by putting a circle around your answer.

Date: \ \2010

Name		**Gender**	
Age		**MRN**	
Occupation		**Marital status**	

Patient demographics

1.	Where do you live?			
a.	Riyadh	b.	Other City	Specify:

2.	How long does it take you to reach the hospital when coming for an appointment?		
a.	5~15 minutes	b.	16~30 minutes
c.	31 minutes ~ 1 hour	d.	More than 1 hour

3.	Are there any primary health clinics within 10 kilometers of your place of residence?		
a.	Yes	b.	No

Hospital visits

4.	How many times do you visit the hospital each month?				
a.	1 or 2	b.	3 ~ 5	c.	More than 5

5.	What is the average waiting time to see diabetic educator at a booked appointment?				
a.	5 minutes	b.	6 ~ 15 minutes	c.	16~30 minutes
d.	More than 30 minutes	Specify:			

6.	What is the average waiting time to see the Physician at a booked appointment?				
a.	5 minutes	b.	6 ~ 15 minutes	c.	16~30 minutes
d.	More than 30 minutes	Specify:			

7.	How often are you advised to see your diabetic educator?				
a.	Once a week	b.	Twice a month	c.	Once a month
d.	Every 3 months	e.	Other	Specify:	

8.	Are your future appointments booked at actual dates requested by the Diabetic Educators?		
a.	Yes (go to Q10)	b.	No (go to Q9)

9.	If 'No', how late are they booked?			
a.	Less than 2 weeks late	b.	Between 2~4 weeks late	
c.	More than 1 month late	d.	Other	Specify:

10.	Are your future appointments booked at actual dates requested by the Physicians?		
a.	Yes (go to Q12)	b.	No (go to Q11)

11.	If 'No', how late are they booked?			
a.	Less than 2 weeks late	b.	Between 2~4 weeks late	
c.	More than 1 month late	d.	Other	Specify:

Healthcare service satisfaction

12.	How would you rate the healthcare services at this hospital?		
a.	Excellent	b.	Good
c.	Acceptable	d.	Poor

13.	Select the services at the hospital that need improvement?				
a.	Appointments	b.	Number of diabetic educators at diabetes clinic	c.	Number of physicians at diabetes clinic
d.	No services need improvement	e.	Other	Specify:	

Cultural setup

14.	What mode of transportation do you use?				
a.	Private car	b.	Extended family	c.	Friend
d.	Taxi	e.	Bus	f.	Other, Specify:

15.	Do you have problems arranging transportation from/to the hospital?				
a.	Yes	b.	No	c.	Sometimes

16.	Do you prefer dealing with the same-sex diabetic educators?			
a.	Yes	Specify:	b.	No

Telecare awareness

17.	Before you signed up for TeMaD, have you ever heard of Telecare solutions?		
a.	Yes (go to Q18)	b.	No (go to Q19)

18.	If 'Yes', have you encountered any Telecare practices in Saudi hospitals?			
a.	Yes	Specify when and where:	b.	No

19.	Are you now more aware of how technologies can help you manage your disease?		
a.	Yes	b.	No

Feedback on TeMaD

20.	Which entry mode of the TeMaD application did you try?				
a.	Internet	b.	SMS	c.	Landline

21.	Which entry mode of the TeMaD application did you use the most?				
a.	Internet	b.	SMS	c.	Landline

22.	Which entry mode of the TeMaD application do you prefer?				
a.	Internet	b.	SMS	c.	Landline

23.	Was the Internet mode of the TeMaD application easy to use?			
a.	Yes, very easy	b.	Fairly easy	
c.	I didn't use it	d.	Difficult	Specify:

24.	Was the SMS mode of the TeMaD application easy to use?			
a.	Yes, very easy	b.	Fairly easy	
c.	I didn't use it	d.	Difficult	Specify:

25.	Was the landline mode of the TeMaD application easy to use?			
a.	Yes, very easy	b.	Fairly easy	
c.	I didn't use it	d.	Difficult	Specify:

26.	Was TeMaD more convenient than the traditional services offered?		
a.	Yes	Specify:	
b.	The same	c.	No

27.	Did TeMaD present you with requested information in acceptable response times?		
a.	Yes	b.	No

28.	Has TeMaD made it easier for you to deal with your diabetes?		
a.	Yes	b.	No

29.	Has TeMaD made it easier to deal with and/or contact the diabetic educators?		
a.	Yes	b.	No

30.	By using TeMaD, have you been able to manage your blood sugar level better?		
a.	Yes	b.	No

31.	Did you receive useful advice from TeMaD throughout the study?		
a.	Yes	b.	No

32.	How would you improve the TeMaD system?
a.	
b.	
c.	

33.	Should **this** hospital offer the TeMaD solution as a permanent one?				
a.	Yes	b.	No	Specify why not?	

34.	Should **other** hospitals offer similar Telecare solutions?			
a.	Yes	b.	No	Specify why not?

35.	Should TeMaD be used to remotely manage diabetic pilgrims during Hajj?		
a.	Yes	b.	No

ABBREVIATIONS

BAN	Body Area Network
BMI	Body Mass Index
CIMS	Clinical Information Management System
CITC	Communications and Information Technology Commission
CPOE	Computerised Physician Order Entry
DE	Diabetic Educator
DFD	Decision Flow Diagram
eCAALYX	Enhanced Complete Ambient Assisted Living Experiment
ERP	Enterprise Resources Planning
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GPS	Global Positioning System
HCI	Human Computer Interaction
HIS	Hospital Information System
IDF	International Diabetes Federation
IMIA	International Medical Informatics Association
ISID	Information Services and Informatics Division
ISP	Internet Service Provider
IT	Information Technology
ITU	International Telecommunications Union
KACST	King Abdulaziz City for Science & Technology
KAMC-CR	King Abdulaziz Medical City – Central Region
KAMC-WR	King Abdulaziz Medical City – Western Region
KAUH	King Abdulaziz University Hospital
KFSHRC	King Faisal Specialist Hospital and Research Centre
KKUH	King Khalid University Hospital
KSU	King Saud University
LAN	Local Area Network
MENA	Middle East and Northern Africa
MOH	Ministry of Health
MRN	Medical Record Number
NGHA	National Guard Health Affairs
PACS	Picture Archiving and Communication System
SAHI	Saudi Association for Health Informatics
SPSS	Statistical Package for the Social Sciences
SSM	Soft Systems Methodology

STC	Saudi Telecommunication Company
TeMaD	Telecare for Managing Diabetes
UAE	United Arab Emirates
UMS	Unified Messaging System
WAN	Wide Area Network
WHO	World Health Organisation